LANCASTER WEST'S FIRST LOW ENERGY HOME

VERITY CLOSE
W11 4HE

Final Project Report

September 2021

LANCASTER WEST NEIGHBOURHOOD TEAM

W11

part of Kensington and Chelsea Council

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ROLES AND RESPONSIBILITIES

Name	Organisation	Role and Responsibilities
Sharon Davies	LWNT	Programme Delivery Lead
Yasmin Bakali	LWNT	Assistant Project Manager
James Caspell	LWNT	Project Sponsor
NA	Vikfix	Appointed Contractor
NA	Cavendish Construction	Appointed Contractor for garden works
Jose Anon	RBKC	District Surveyor-Building Control
Lizzy Westmacott	ECD Architects	Architectural consultant
Hannah Jones	Greengauge	M&E consultants
Laurence Dove	RDFS	Fire rated ductwork consultant
Sarah Jones	MDA Consulting Ltd	Clerk of Works
Andrew Morrison	Keegans	Principal Designer
Tomas Larsson	Better Planet	Heat loss report
Ieman Barmaki	Kensa Heat Pumps	Heat loss report and GSHP investigation
Will Rivers	Carbon Trust	Solar analysis report
Alan Budden	Eco Design Consultants	Architectural drawings and Passivhaus options report
Richard Jack	Build Test Solutions	Monitoring zero carbon
Reuben Wilkinson	Mango projects	MVHR installer
Mike Trotter	Lindab	Supply MVHR ductwork
Heather Taylor	Paul Heat Recovery	Supply MVHR system
Richard Bacon	Eco Energy Environment Ltd	To supply and fit the ASHP and PV system
NA	Ideal Combi	To supply and fit triple glazed windows
NA	Pod Point	Supply and fit the electric car charger
NA	Cadent	Gas removal

1. PROJECT SUMMARY

1.1 Location

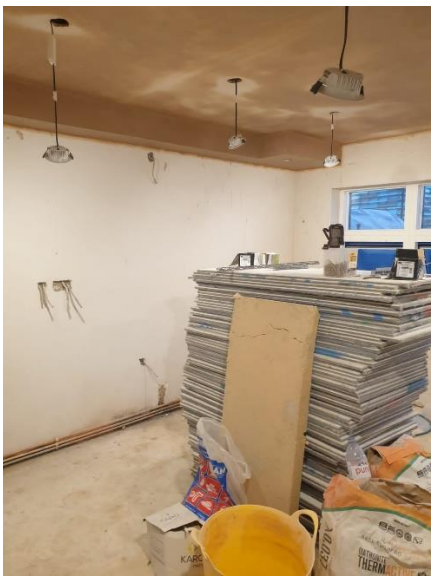
The property is situated at Verity Close, W11 4HE, in North Kensington, London. Verity Close is part of and managed by the Lancaster West Estate.

1.2 Description

The property is a 2 storey, 3-bedroom house with a large roof space, built in 1980. The house is semi-detached, with a smaller property adjoining it to the south. It has a large garden area around 3 sides, with off-street parking.

The ground floor has a recessed front door leading into a hallway, at the end of which is the stairs. There are two rooms at the north of the property, within the 'lean-to' part of the house. Each of these has a loft space above them. At the south of the property are the stairs with a room on either side, one of which also has a built-in cupboard. Timber stairs lead up to landing, onto a bathroom and a bedroom to each side. The landing overlooks the entrance hallway, with a timber balustrade providing safety. Both landing and hallway are lit by a rooflight in the lower roof of the 'lean-to'. Above the landing is a hatch into the large roof void above. Ground and first floor ceiling heights are around 2.35m. The house is mostly of brick cavity wall construction on a solid concrete floor with a tiled timber roof. The gable end wall is blockwork/brick cavity wall.

Verity Close preconstruction



Work in progress

1.3 Our aspirations

For the UK to meet its carbon reduction targets, most existing buildings need to be deeply retrofitted, and move away from the use of gas. This deep retrofit will make homes more comfortable and cheaper to heat.

Verity Close aimed to provide a family with a sustainable, gas free property that encourages low carbon living. We planned to install services that will maximise energy efficiency to

financially benefit the residents, reducing energy costs as well as alleviate safety concerns regarding gas in the home.

The project aimed to achieve the first 3 bed, gas free maisonette house on Lancaster West. The objectives were to retrofit the home, improve energy efficiency, to be gas free and complete to a full 21st century specification.

It aimed to be a show home and live pilot for the Verity Close residents as well as the wider Lancaster West Estate, to highlight the aims and potentials of these properties. Our intention was for it to serve as a model for low energy retrofits to the wider estate. The property aimed to demonstrate effectiveness, renewable technologies, and comfort before retrofitting and a tool to enhance residents understanding of the process and benefits.

1.4 A "Whole house" approach

Fabric

First, to reduce heat loss from the house it was necessary to improve the building's fabric. This involved insulating the external elements of the building to reduce heat being lost through walls, floor, roof, windows and doors. It also meant making the building more airtight, so that air that is heated inside it not immediately lost through gaps in the building, requiring more air to be heated.

Thermal Envelope

The thermal envelope was identified and every element around this needed to be considered and improved. The junctions where these elements met also needed to be carefully considered, so that there were not any gaps, or bits of the building that were in contact with the outside air that ran into the inside of the building. Otherwise, these areas of the building would feel cold, lose heat and possibly mould could form on them.

Airtightness

Typically, buildings have leaks in their fabric and air moves through these small gaps. These occur around window and door frames, at junctions, where services come in and out of the building, through walls and roofs generally, and in the case of Verity Close, through air bricks inserted in the walls. These gaps needed to be closed, so that when air is heated up inside, it stays inside.

Services

To work efficiently, services need to be sized for the retrofitted property, and a strategy set out that allows the best use to be made of renewable energy inputs. The use of electricity to provide heating and hot water will reduce the building's carbon footprint. However, the higher price of electricity compared to gas will mean heating bills could be higher. Once the building has been made airtight it is important that it is properly ventilated, so a mechanical ventilation with heat recovery system will be needed. In addition, we aimed to add solar PV, an air source heat pump, triple glazed windows and many more sustainable services.

2. PURPOSE OF THIS DOCUMENT

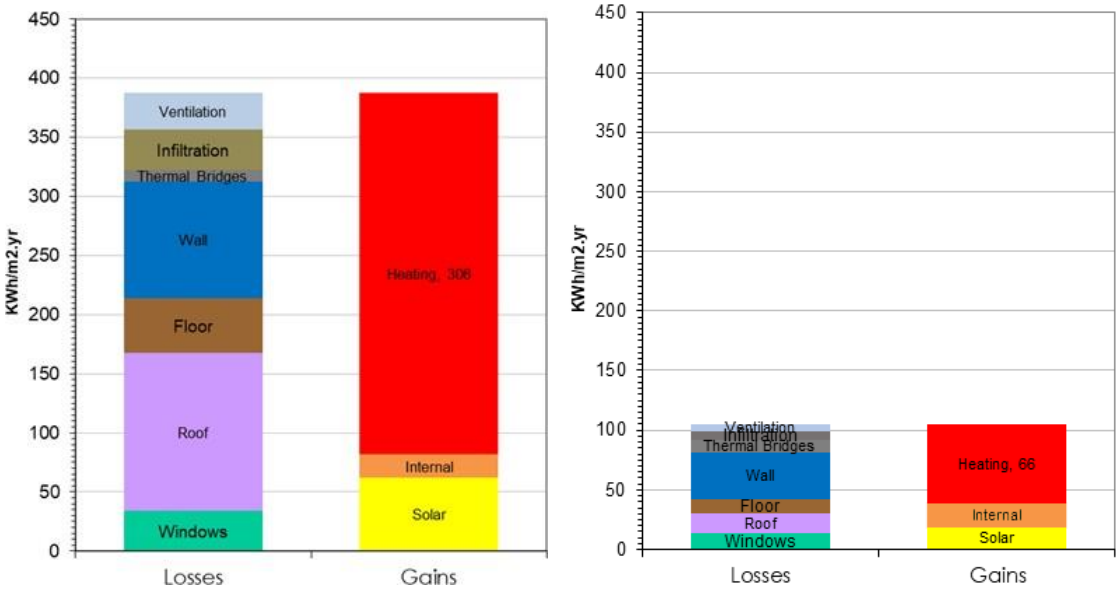
The purpose of this report is to reflect our aims and intentions for Verity Close and highlight what we have implemented to achieve this. It will include what feasibility studies and surveys we conducted to make these decision as well as highlight our strategy. This document will reflect what we have learnt and what we will take forward for the wider refurbishment programme.

3. FEASIBILITY STUDIES

To understand the exisiting building, the current performance and its problems, LWNT appointed the following companies to conduct feasibility studies: Better Planet, Carbon Trust, Eco Design Consultants, ECD Architect and Greengauge Building Energy Consultants.

The feasibility studies formed a heat loss report, solar analysis, a passivhaus options report as well as studies that examined the building and possible material options. These reports set out how the exisiting building was losing heat and a range of methods for reducing heat loss.

ECD Architects and Greengauge used this information to explain the spatial implications, pros and cons and energy reduction. Based on the reports, LWNT were able to understand the impact of each item, while ensuring that the whole house fabric improvements were prioritised with renewable technologies. ECD Architects proposed that the heat demand could be reduced from around 306kWh/m2/year to 66kWh/m2/year.



With renewable technologies at the forefront of this project, ECD Architects proposed the use of solar PV panels. To understand the cost benefit and how much sunlight the property was exposed to, Carbon Trust produced a solar analysis report. This reflected the performance ratio along with the possible savings. At an 80.3% annual performance ratio and a predicted £330 electricity saving, LWNT made the decision to implement this into the project, bearing in mind these figures would change slightly based on the product installed.

All studies were able to direct LWNT in deciding on what materials were best for the property and where best to install them. Once the products were decided, further studies were conducted to ensure correct placement and application.

4. PRODUCT ANALYSIS

4.1 Air Source Heat Pump and PV

ECD Architects proposed several new renewable technologies that LWNT had yet to decide on. To make the best choice for the property, product analysis was conducted. Quotes were collected for various products, and this was reviewed against things such as cost, accreditation, sustainable pro and cons and whether it would require planning permission. The table below summaries the information collected.

Table 1: ASHP and PV product analysis

ASHP	Energy Efficiency	Size	SCOP 35°C	SCOP 55°C	Noise	Noise at 1m	Cost of unit to install	Site survey	Can provide PV
A+++	7kW LG Monobloc R32	7kW	4.45	3.12	60dBA	50dBA	£11,799	No	No
	Nibe F2040-12	12kW	4.43	3.38	57dBA	43dBA (2m)	£12,959.38 + 5% VAT	Yes	Yes
	Daikin Altherma 3 H HT	**14kW**	**4.51**	**3.58**	**54dBA**	**43dBA**	**£10,650 +VAT**	**Yes**	**Yes**
	Vaillant Arotherm Plus 10	10kW	5.03	3.58	60dBA	52dBA	£13,659.03 + 5% VAT	Yes	Yes
A++	MITSUBISHI - Ecodan 11.2kw	11.2kW	4.06	3.11	60dBA	53dBA (46dBa at low noise mode)	£11,221.47	No	Yes
	Daikin Altherma 7kW Monobloc	7kW	4.52	3.42	62dBA	49dBA	£10,258.00 plus 5% VAT	No	No
	Mitsubishi Ecodan 8.5 UQ	8.5kW	4.12	3.27	58dBA	45dBA (42dBA at low noise mode)	£12,539.39 + 5% VAT	No	Yes

PV	Fire rating	Weight	Power output	Cost of unit to install	No. of Panels
Class A	**Solarwatt Vision 60M**	**22.8kg**	**300-320 W**	**£8,000 + VAT £5,700 + VAT (Battery)**	**20**

	Trina Solar: TSM-DE06M.08 (II) HONEY	18kg	325-340W	£4,199.54	12
Class C	LG Neon 2 PV panels	17.1kg	335-350W	£7,261.06 + 5% VAT.	10

Advice was sort from Greengauge consultants who recommended the ASHP should be A+++ with a noise of 45dBA at 1m. In order to avoid planning requirements, the unit must be a least one metre from the property and the volume of the compressor unit must not be in excess of 0.6m3. This lead LWNT to choose the Daikin Altherma 3 H HT Heat Pump. This unit was sourced from Solarwatts who also provided the best option for PV, having the highest rating in fire safety, quality, and price.

4.2 Internal Wall insulation (IWI)

Several internal wall insulation options were provided by ECD Architects in their feasibility report. Based on discussions on priority of fire safety, energy saving and timescales the below options were recommended:

Name	**Diathonite plaster** (ECD proposed option)
Thickness	**100mm thick**
Fire rating	**A1 rating**
Energy Saving	**51 kWh/m2/year, or £239 per year**
Time	Drying time of up to 1 day per 2mm. Therefore, if use 100mm as proposed in report, this could be **50 days**. (quicker if weather is kind & use dehumidifiers)
Comments	Can use thinner version on internal walls, limiting thermal bridging, provides airtightness. Deals well with any moisture issues

Name	**Diathonite plaster**
Thickness	**60mm thick**
Fire rating	A1 rated
Energy Saving	around 35-40 kWh/m2/year, or around **£150 per year**
Time	drying time of up to **30 days**
Comments	I'm suggesting this to reduce drying time compared to the 100mm version. Other comments as above

Name	**Calsitherm board**
Thickness	**30mm or 50mm board**
Fire rating	A1 rated
Energy Saving	Around 25 kWh/m2/year, or around **£125 per year**
Time	Board is adhered to wall with adhesive plaster, and finished with plaster, but thin layers so **no significant drying times**
Comments	Deals well with any moisture issues, wallpaper shouldn't be applied over the top, could use on internal walls to minimise thermal bridging. A 30mm board is available, as well as the 50mm board proposed.

Name	**Mineral wool on SWIP stud system**
Thickness	**65mm and 95mm**

Fire rating	Mineral wool = A1 rated, studs are mostly timber with a thin layer of XPS insulation to minimise thermal bridging. XPS part of stud is Class F (which is why we didn't suggest this)
Energy Saving	Approx. 50 kWh/m2/year, or around **£237 per year**
Time	**No drying time**, as it's a dry system. Plaster parge coat needed before application to provide airtight layer. Possibly could use plaster already applied as this but would need to extend to provide continuity at junctions.

4.3 Mechanical Ventilation with Heat Recovery (MVHR)

Unlike the decision making for the ASHP, the MVHR specification was provided by Greengauge. Although they had agreed the products, LWNT investigated different models and companies to see what would work best and who best to install. Further discussions and research highlighted that the specification was so specific that it would require sourcing the materials, installation, and commissioning from different companies.

As the design was already set out, many companies could not source the required materials. Three companies were used to ensure the materials were per the M&E specification: Paul Heat Recovery, Lindab and Mango Projects.

Table 2: MVHR quote breakdown

	Design	Supply	Fit	Commissioning	MVHR Unit	Ductwork	Price
Green Building Store	✓	✓		✓	Brink Renovent Sky 200	Lindab Galvanised Steel	£4,020-£4,620 + £840 commissioning
Solar Crest	✓	✓	✓	✓	Airflow Adroit DV96	Airflex pro radial (B2)	£8,579
Evolution Group	✓	✓	✓	✓	Nuaire ECO2	Plastic ductwork	MVHR - £4,549.81
Enhabit UK	✓	✓	✓	✓	Zehnder Q350	Zehnder ComfoTube and steel ducting	£9,596.39
Greengauge	✓				Paul Novus 300	Galvanised steel spiral wound Lindab Safe circular and fire rated ductwork	NA
Paul Heat Recovery		✓			Paul Novus 300	NA	£3,115.76
Lindab		✓			NA	Galvanised steel spiral wound Lindab Safe circular with fire rated valves	£4,725.26
Mango Projects			✓	✓	NA	NA	£2,177.29

5. WORKS TO THE PROPERTY AND WHY?

From the feasibility studies and product analysis, the material spec was finalised with ECD Architects and Greengauge. The table below shows what was installed along with the reasons and benefits to the property.

MEASURE	IMAGE	MATERIAL	REASON/ BENEFIT
Ground floor insulation		Spacetherm Aerogel insulation blanket bonded to a 6mm Magnesium Oxide Board to ground floor	- Reduce heat loss through floor - Warmer floor - More comfortable for residents - Potential for UFH, improving heat pump efficiency
External wall insulation on internal facing walls		100mm Diathonite Thermactive .037	- Excellent reduction in heat loss through walls - Effective way to limit thermal bridges - Really warm comfortable home
Internal wall insulation		25mm Diathonite Thermactive .037	- Reduce heat loss through walls - No change to external appearance - Warmer more comfortable home than at present
Roof insulation		Rockwool Flexi 1.1 – mineral wool insulation	- Reduce heat loss through roof - Opportunity to include carefully installed airtightness layer - Opportunity to ensure any new solar panels are adequately supported

Triple glazed windows		IdealCombi – Futura+	- Reduce heat loss through windows - No draughts near windows- more comfortable - Quieter internal environment
Skylight		Velux - GGU MK08 008230 – White PVC	- Increased natural light through the property
New doors		Internal FD30 door: Howdens Linear oak FD30 Main External FD60 door: LFS Six panel Oak Veneer Finish External door: IdealCombi Nation IC	- Reduce heat loss through doors - No draughts near doors - Opportunity to include carefully installed airtightness layer
Full building airtightness		Airtightness Sealing Adhesive Tape: Pro Clima 1.1. - Contega Solido SL-D	- Excellent reduction in heat loss - Excellent improvement in resident comfort - No draughts so more comfortable even at lower temperatures

Mechanical ventilation heat recovery (MVHR)		PAUL Novus 300	- Reduce heat loss through air while ensuring fresh air supply - Filters allow improved internal air quality
Ductwork		Galvanised steel spiral wound Lindab Safe circular/ Fire rated Ductwork	- Fire rated ductwork to ensure the highest safety strategy
Air source heat pump (ASHP)		Daikin Altherma 3 H HT EPRA14DV3 OU	- Low carbon heat source, avoiding having gas in home - In conjunction with hot water cylinder can supply all heating & hot water requirements
LED lights		LED PL Downlights	- Improved EPC rating - Energy saving - Low power and high light efficiency - Long life
Solar PV		SolarWatt Vision Style 320w	- Reduce use of heat pump, so reduce electricity use - Low carbon energy source

Battery storage		SolarWatt My Reserve 7.2kW	- You can use your own solar electricity at night when the sun is not shining (no need to use electricity from the grid) - Reduces energy bills
Energy Manager		SolarWatt Home Manager Pro	- Total transparency and total control over all your energy systems - Access at home or on the road - Optimizes efficiency
Electric car charger		Pod point - Solo Smart Charger	- Encourage electric vehicles - Smart and connected - App accessible - Universal charging - Compatible with all plug-in vehicles.
Garden works		Includes: - Hot Bin - Water butt - Veg Trugs - Greenhouse - Washing line	- Encourage sustainable living
Gate replacement		Timber gate	- To elevate the external appearance - To install a sturdier gate around the property

Garden wall replacement		Brick Wall	- To replace damaged wall to match the existing boundary

5.1 Interior design elements

Along with the building fabric and materiality of the property, it was important that the interior of the home was carefully considered. LWNT took into consideration aesthetics along with sustainability to decide on additional features for the residents. Blinds were installed to reduce the need for artificial lighting and act as a better way to control the solar glare in the home, potentially reducing energy bills.

We found that installing LED spotlights was a cost effective and easy way to improve our EPC rating as well as offering a longer life product. We also installed an A++ LED bathroom mirror which has energy saving LED strips which provides extra brightness and an energy saving automatic anti-fog state. An LED light can last for 20-30 years in comparison to a halogen bulb that has a working life of only two years. By substituting ten halogen bulbs for LED bulbs, savings of £112 a year can be made over a long-term period.

The property was painted bright white and recyclable flooring was installed, giving a modern and neutral look. In addition, LWNT installed a foldaway washing line to encourage healthier habits and decrease the use of water and electrical waste. Our aims were that all elements would help to prompt and assist residents to live a more sustainable lifestyle.

6. PREDICTED SAVINGS FOR THE RESIDENT

Figure1:
Predicted savings assuming electricity at 16p/kWh, COP of heat pump = 3

MEASURE	MATERIAL	SAVINGS
Ground floor insulation	Spacetherm Aerogel insulation blanket bonded to a 6mm Magnesium Oxide Board to ground floor	Specific energydemand reduction (kWh/m2/year) - **32** Total energy demand reduction (kWh/year) - **2816** Annual cost saving - **£150**

Internal wall insulation	100mm Diathonite Thermactive .037 25mm Diathonite Thermactive .037	Specific energydemand reduction (kWh/m2/year)- **51** Total energy demand reduction (kWh/year) – **4488** Annual cost saving - **£239**
Roof insulation	Rockwool Flexi 1.1 – mineral wool insulation	Specific energydemand reduction (kWh/m2/year) -**96** Total energy demand reduction (kWh/year) - **8448** Annual cost saving - **£451**
Triple Glazed windows	IdealCombi – Futura+	Specific energydemand reduction (kWh/m2/year) - **15** Total energy demand reduction - (kWh/year) -**1320** Annual cost saving - **£70**
New doors	Internal FD30 door: Howdens Linear oak FD30 Main External FD60 door: LFS Six panel Oak Veneer Finish External door: IdealCombi Nation IC	Specific energydemand reduction (kWh/m2/year)- **6** Total energy demand reduction (kWh/year) - **528** Annual cost saving - **£28**
Full building airtightness	Airtightness Sealing Adhesive Tape: Pro Clima 1.1. – Contega Solido SL-D	Specific energydemand reduction (kWh/m2/year)- **24** Total energy demand reduction (kWh/year) - **2112** Annual cost saving - **£113**
Mechanical ventilation with heat recovery (MVHR)	PAUL Novus 300	Specific energydemand reduction (kWh/m2/year) -**47** Total energy demand reduction (kWh/year) – **4136** Annual cost saving - **£221**
Air Source Heat Pump (ASHP	Daikin Altherma 3 H HT EPRA14DV3 OU (Outdoor Unit)	Specific energy demand reduction (kWh/m2/year) - **36** Total energy demand reduction (kWh/year)- **3168** Annual cost saving - **£169**

Note. Table based on document 200326 Verity Close Feasibility study_ECD

6.1 Predicted heating and energy bills

With all the above services and measures implemented, ECD Architects have proposed heating and energy savings. The feasibility report indicated that if all the measures are implemented the PHPP model suggests a heating demand of 66 kWh/m2/year.

Figure 2 below reflects the predicted heating and energy bill under the new system. It also assumes that the house is heated to 20°C and that residents do not leave windows and doors open excessively when it is cold. It also does not consider the possible further savings that can be achieved using photovoltaic panels. In addition, it reflects the bigger saving being the roof insulation which is something we can take forward for the internal refurbishment programme.

Figure 3 highlights the predicted cost of gas which is cheaper. We must however bear in mind the following:

- We will be saving money on annual gas safety checks which are approximately £60 per year
- This doesn't include standing charges, and by being all-electric there's now no standing charge for gas
- This is heat demand only, not including hot water or other electrical demands
- The electric / heat pump solution is better from a carbon emissions point of view
- The heat demand figure used was predicted, not actual.
- This doesn't include for the PVs. Going forward we will feed PV data into the rest of the home energy to give a better representation.

Figure 2:
Predicted heating and energy bills based on all services and measures being installed

Current heating bill - around £1,436 per year
New heating bill - around £309 per year

Total heat demand (Greengauge PHPP) = 5,808 kWh

Assume ASHP has coefficient of performance of 3.58 (for every 1 unit of electricity put in, 3.58 units of heat are put out)

Energy needed to meet heat demand = 5,808 kWh / 3.58 = 1,622 kWh
Assume electricity costs 16p/kWh

1,622 kWh x 16p / kWh = 25,952p = £260 for space heating alone

Assume a further £250 worth of electricity required for hot water, lighting, extraction fans, kettles, cooking, fridge, computer use, hairdryers etc

£260 + £250 = £510 Total energy bill

Note. Data based on document 200326 Verity Close Feasibility study ECD

Figure 3:
Price comparison to Gas heating

Gas at 2.85p/kWh

If that heat demand was met with gas
5808 kWh x 2.85p/kWh = £165

£165 + £250 = £415 Total Energy bill

Predicted heating and energy bills Per Year	Predicted cost for space heating alone (ASHP) Per Year
£510	**£260**

7. WHAT PROBLEMS CAME UP AND WHY?

MEASURE	PROBLEM	REASON	RESOLUTION
Ground Source Heat Pump (GSHP)	Borehole drilling	Originally a GSHP was recommended. After the proposed driller came to site, he deemed the boundaries to be too tight Risk factors: physically fitting the drill, storing a mud cleaner as well as a pump and skips, running a 3" hose to the property. Issues: closing the footpath around Verity Close and the zebra crossing on Lancaster Rd as well as using the Verity car park to accommodate the equipment. Noise issue: Drilling and the generator	Due to site restrictions the GSHP could not be used. Issues with drilling and road closures meant that we would use an ASHP as it is more practical and appropriate (per ECD's recommendation)
Air source heat pump (ASHP)	Bore pipe	Not the appropriate size	Ecovolt Environment Ltd managed to overcome the long runs by running at a slightly higher temperature.

			The radiators will need to be the correct type for maximum efficiency, rather than the standard heating radiators. When it comes to any repeat projects, it will be beneficial to have larger bore pipe work, 22mm not the current long runs of 15mm as in Verity Close.
Mechanical ventilation heat recovery (MVHR)	Design and installation	Greengauge produced the M&E specification which includes the design of the MVHR system. This specification consist of the design of the system and what materials should be used based on fire safety. It proved very difficult to find MVHR installers that would produce our spec. Many installers would have a set package and would not work to another company's design.	Greengauge emphasised the importance of the specification. They provided the 3d model and drawings so we could source the products and installers separately. Providing them with a set material list. This made the process harder to manager but meant we could get the desired spec. For future projects, it would be beneficial to get a materials spec and brief but the design and installation to be complete by one company.
Mechanical ventilation heat recovery (MVHR)	Missing filter	The commissioning team picked up that the design was missing the filtration system in the kitchen	This was easily resolved by contacting Lindab and ordering the correct attachable piece.
Ductwork	Uncertified installer	Greengauge specification includes fire rated ductwork. This meant that it must be installed by a certified installer. The installer they recommended however was not certified.	We commissioned RDFS to inspect and ensured ductwork, framing, and fixing of dampers to framing aspects of the install were as per their design. Then we created a sign off form for all members to sign to ensure the system was compliant.

Ductwork	Non-fire rated ductwork	Lindab could not provide fire proofed ductwork in time. This resulted in our contractor continuing the works and not considering the required void space. What we installed was not fireproof, so we needed to redesign the system.	RDFS suggested two options on how to alter the current system. Considering the progression of the project including the preinstalled ductwork services; they felt it would be very difficult for us to now install a fire rated ductwork system without a redesign to the attic plant and ductwork, removal of preinstalled services and adaptions to the current building construction including joist spacings and void depths. On this basis and on the approval of Greengauge we went for option 1, using additional fire rated grilles and fire dampers. This did not include insulation as again, the space would not account for this.
Performance monitoring report	High U-Values	The reason is currently unknown, but investigations will be done. As per the performance measurement report, we must note that only samples were taken. Heat flux plates only measure the heat flux over a small area in the middle of the plate, so a single measurement cannot be representative of the performance of the whole wall, for this reason the U values reported in the summary table in the introduction is the mean of these measurements from the two heat flux plates.	ECD will share the external thermographic survey which may help reveal areas where cavity wall insulation is saturated. They will also use a borescope to investigate the cavity (drill a small opening from outside and push in the borescope head) to establish whether cavity wall insulation appears wet. If the insulation was wet when the measurements were taken the U values would appear higher. It may be that walls will dry out more over time and the U values will improve. However, we will do some investigating to

			find the root of the problem.
Performance of windows	Windows not providing the anticipated level of improvement	The thermographic survey revealed the windows are not performing to the anticipated level of improvement. (i.e., U value of 0.92W/m2K). It has also been reported that we have had some condensation on the inside of the windows. The reason is currently unknown but suggests an issue with the overall building envelope.	ECD Architect and Ideal Combi have explained it is difficult to say for sure why the windows are not performing as expected. In terms of heat loss, the window can only perform as well as the building fabric envelope allows. The only way to test would be in a lab. If misting is within the glass panes, the glazing units have broken down and will need replacing. Moving forward, it would also be important to investigate if the uninsulated ductwork could be a factor.
EPC rating	Unable to achieve "A" rating	After research and discussions with different energy performance companies, it came to light that achieving an "A" rated EPC on a retrofit property would be very difficult.	Once we receive the first EPC, if aiming for an "A" rating it is important to ask how this can be achieved. In this case, it would be with solar water. Changing this at such a late stage would have affected the property but this is something we can learn from for future projects and look further into

8. COST ANALYSIS

8.1 Potential costs

With all the services and technologies implemented into this property, the potential costs for council will fall under the maintenance and annual checks. After the commissioning stage, it has been noted that the ASHP system, MVHR system, fire dampers and fire rated valves will need to be maintained. Mango projects have quoted a 2-yearly maintenance service for £90 plus materials. Filters in the machine and the kitchen valve will need changing yearly at a

cost of £62. It has been advised that the filters need to be cleaned every 6 months. This maintenance can be conducted by the W11 team. RDFS are scheduled to visit in January 2022 to maintain the fire dampers and valves. This visit could range from £200 plus materials. This would be an annual check. Going forward, a schedule will be produced and monitored by our refurbishment team.

Service	Annual cost
ASHP system	TBC
MVHR Service	£90 + Materials
Filter change	£62
RDS visit	£200 + Materials
Total	£352 + Materials

Approximate maintenance cost for council
Per Year
£352 plus materials

8.2 Estimated savings for the wider Verity Close refurbishment

Reviewing the financial tracker of our pilot property along with the lessons learnt, we can estimate where we can reduce costs based on previous quotes, reworking and property size.

Stock Breakdown of Verity Close

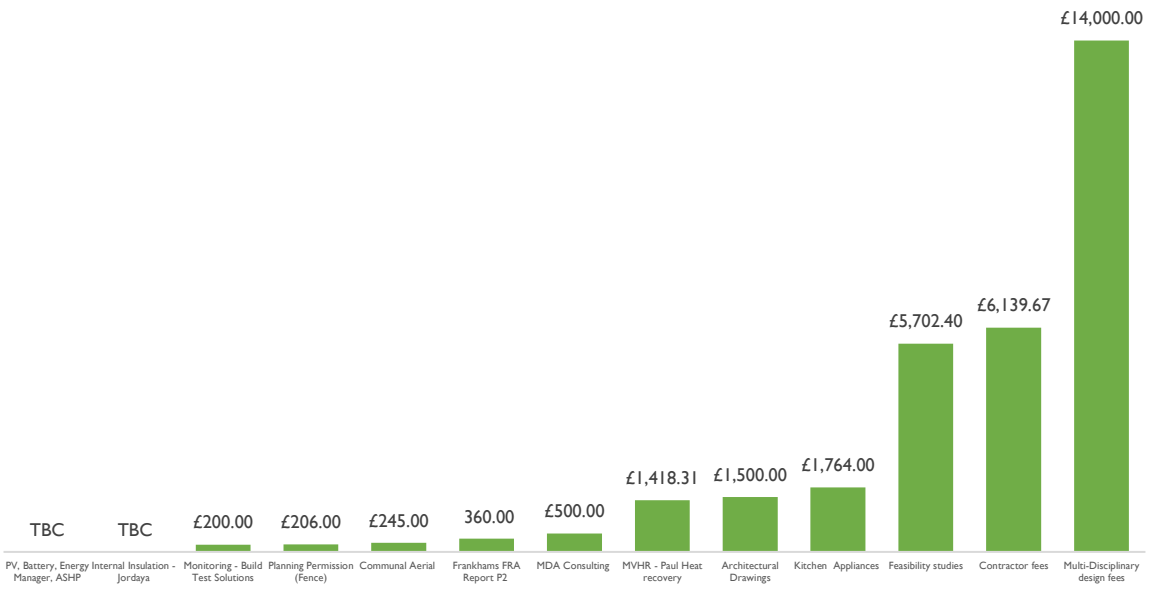
	Total	1 bed	2 Bed (2 storey terrace)	3 bed (2 storey end of terrace with lean-to) (2 - 2.5 storey terrace with front dormer)	4 bed (2.5 storey terrace with front & rear dormers)
Flats 8-25	18	18		-	-
Flats 26-43	18	18		-	-
Houses	32	-	8	17	7
Total	68	36	8	17	7

Below highlights where we could make at least 15 % of savings on the wider refurbishment with a brief explanation of how this was derived. This will increase once we have the costs for the ASHP, PV and external wall insulation, making a larger saving. Below reflects an estimate of where we could save approximately £32k on items such as reworking, feasibility studies and working to a communal approach.

Item	Pilot Property Costs	Estimated Savings for 2+	How we would reduce costs next time

Contractor fees for refurbishment works	£73,793.68	£6,139.67	Due to the pilot nature of this project, a number of interventions and building elements were undone due to not performing in the way as originally planned. This learning has been embedded and as a result we would estimate we would spend ~£6k less on rework
Feasibility study	£5,702.40	£5,702.40	Due to the nature of the pilot, we were keen to make sure we had multiple opinions to test the initial assumptions made. We are now clear on the best way to approach this so we would only pay once for the expertise which would fall under the architect's work.
PV, Battery, Energy Manager, ASHP	£17,321.18	TBC	Efficiencies to be gained by having a communal approach rather than an individual approach.
MVHR - Paul Heat recovery	£10,018.31	£1,418.31	The MVHR was split into supply, fit and design. Moving forward if this was assigned to one company, we can cut some costs. The proposed saving is based on an average of previous quotes (design, supply, fit and commissioning - £8,600) -
SPD - Drawings	£1,500.00	£1,500.00	To source from the architects. Then they can also produce the as-builts at the end of the project
FRA Report P2	360.00	360.00	To be done at the right time in the project to avoid revisit
Multi-Disciplinary Team	£19,325.00	£14,000	Now that the feasibility study has been conducted at Verity along with ECDs Lot 6 investigation, this could be £14k cheaper
Monitoring - Build Test Solutions	£1,200.00	£200.00	Avoid revisit
Internal Insulation	£43,204.35	TBC	Considering EWI - price TBC
Planning Permission (Fence)	£206.00	£206.00	Will not need to be done
MDA Consulting	£500.00	£500.00	Investing in our team to conduct post works inspection
Communal Aerial	£245.00	£245.00	Removed accidently - To be kept avoiding cost
Kitchen Appliances	£5,040.00	£1,764	Now that we have gone into contract and are buying into scale, we will make a saving. Fixed discounted pricing secured for contract length. 35% saving on appliances

Estimated Saving 2+ Bed **£32,035.38**	**Saving at least 15%** on the wider refurbishment



9. LEARNING OUTCOMES

9.1 Lessons learned

Throughout this project, we have kept a lesson learned log where we have tracked all our learning from retrofitting the property to how it is monitored. As a pilot property, one of the motivations were to create a low energy home where we could learn some lessons ahead of retrofitting the rest of the estate. Some of these lessons learnt are:

Ensure all partied have a **full understanding of the building fabric** before starting work

Be selective on the studies conducted and ensure all parties have access to this data

To understand the monitoring data and what we aim to achieve

Create a **plan for the whole house** before starting work

To **agree the cost of specialised items** in the schedule of works to avoid large variations

Close oversight of works is crucial to ensure that details that will later be hidden are built properly. This is particularly important where airtightness is concerned

Using non-combustible products limits the available systems, potentially adding cost and time

Internal wall insulation can be very invasive – while acceptable in a vacant property this won't be the right solution everywhere. We must also **consider application, drying time and a high chance of thermal bridging**

To consider a ductwork system to be designed and installed by one company to ensure reliability and compliance

If considering **fire rated ductwork ensure this is designed by an expert** in this field as designers do not necessarily take into account the physical spacing required not only for the ductwork but the bracketry, fixings and in some instances fire rated insulation – an issue we had to overcome by installing regular ductwork and installing fire dampers. **The system is larger and less flexible than another ductwork**

A deep retrofit will take longer than a standard refurbishment and using products that are new to the team may take even longer to understand and install

To decide if we want the property to be EnerPHit certified as it would impact the decisions and logging process

If the property is to be EnerPHit, to **ensure the PHPP model is considered from the start**

To understand the current U values and how to achieve the required

To plan for an A rated EPC before the scope of works are finalised

Insulating the Ductwork to prevent condensation issue arising

9.2 BTS Performance Measurement report

Build Test Solutions (BTS') carried out a series of energy performance measurements on our pilot property and another Verity Close residence during December, January, and February 2021. The table below reflects the results of the monitoring:

Table 3: Results summary for the building performance measurements.

Equipment used	Pilot Property	Another house on Verity Close	Did the pilot perform better?

Heat Transfer Coefficient (HTC, W/K)	SmartHTC	246 [-46, +48]	172 [-38, +34]	×
Heat Loss Parameter (HLP, W/m2K)	SmartHTC	2.4 (Average)	1.5 (Good)	×
Air Permeability (m3/m2h@4Pa)	BTS' Pulse equipment	1.03 (c.5.4@50Pa)	1.31 (c.6.7@50Pa)	✓
External Wall U-Value (W/m2K)	BTS' U-Value Measurement System	0.79±14%	0.83±14%	✓

The building performance measurements show that **our pilot property has slightly better air permeability and external wall U-value than the comparison property**, but comparative property has slightly better overall thermal performance as demonstrated (lower HTC and HLP).

SmartHTC

SmartHTC measures the overall thermal performance of buildings, a cloud-hosted algorithm applies an energy balance informed by measurements of internal temperature and energy consumption. Effectively, by measuring the heat input, internal and external temperature the rate of heat loss is calculated.

The outputs are the 'Heat Transfer Coefficient' and 'Heat Loss Parameter'. The Heat Transfer Coefficient (HTC) is a measure of the overall rate of heat loss from a property, with units of Watts per Kelvin, a higher HTC means more heat loss and hence worse thermal performance. The HTC is not normalised by any 3 50 & 54 Verity Close Performance Measurements measure of the size of a building, so a large building would typically have a larger HTC, to allow comparison between building the Heat Loss Parameter (HLP) is used, it is calculated by dividing the HTC by the total floor area of the building.

For the pilot property, the SmartHTC measurements started on 10th December 2020 and were collected on 17th February 2021 due to continuing retrofit works being extended. **The HTC was 246 with a HLP of 2.4W/m2K giving an average score.**

The comparative property was conducted on the 10th December 2020 and collected on the 22nd January 2021. **The HTC was 171 with a HLP of 1.5W/m2K, giving a good score.**

Airtightness

Airtightness was measured using BTS' Pulse equipment. Pulse is a low-pressure airtightness testing method, air is compressed into an air receiver and then released in a series of short pulses of air. The airtightness is calculated based on the pressure response in the building to the release of air. Pulse is controlled with a touch screen controller, allowing simple data entry and push-button testing.

The pilot property performed slightly better but not enough considering the specification

U-value Measurement

U-values were measured using BTS' U-Value Measurement System and according to ISO9869-11 . In each house two heat flux plates were installed on an external wall that was as close to north-facing as possible. Heat flux plates only measure the heat flux over a small area in the middle of the plate, so a single measurement cannot be representative of the performance of the whole wall, for this reason the Uvalues reported in the summary table in the introduction is the mean of these measurements from the two heat flux plates.

The measured U-values for the two locations in the pilot property were slightly different, with the U-value at location 2 slightly higher than that at location 1 although the measurements are within their confidence intervals of each other.

	Location 1	Location 2	Mean
U-Value (W/m2K)	0.70 ±14%	0.88 ±14%	0.79 ±14%
Start Date	04/02/21		
End Date	10/02/21		

Thermal images were taken of the section of wall where the U-value measurements were carried out. They show that the wall surface was slightly cooler towards the left-hand side of the wall where it meets the internal wall. This may indicate why the U-value at location 2, which was the left-hand of the two sensors, is higher (a higher U-value refers to higher heat transfer, i.e., worse thermal performance).

Again, the pilot property performed slightly better but not to the aspired value.

These results are very different to the predicted performance measurements in ECD's feasibility studies. After reflection, we learnt that it is important to understand the following:

- Although the properties are similar in construction, they are different in form factors. This means that care should be taken comparing the thermal performance between houses. From the external view, it is not possible to see things like thermal bridging or how complete a wall cavity is filled with insulation
- A mid terrace house will always have better results so it would have been better to measure like for like (an end of terrace property).
- A caution with retrofitting a property is that it cannot be directly comparable
- The pre retrofit of our pilot was unknow and only predicted
- The pilot property has more area for heat loss

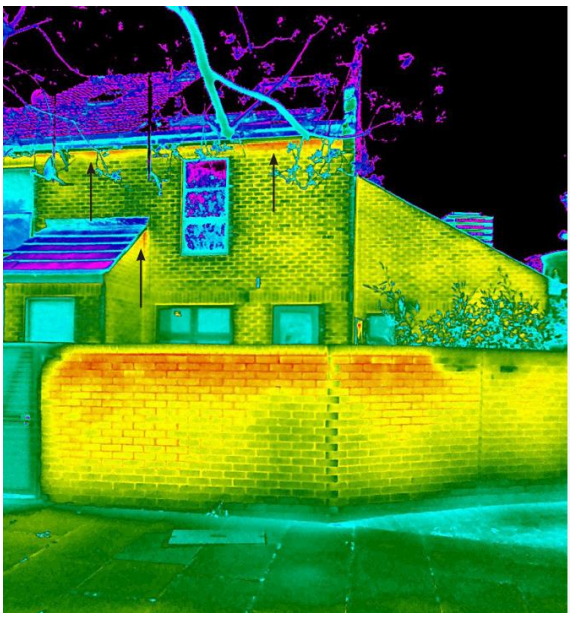
9.3 Thermographic Survey

The biggest concern with the results from BTS' were the U values. ECD Architects have commissioned IRED Remote Sensing to conduct a thermographic survey to help reveal problematic areas. The aim was to improve how we move forward on the wider estate and understand why the anticipated level of improvement was not achieved.

Thermal Imaging Report Heat Loss & Insulation Survey - 16/03/21

The criteria that will determine the rating given are as follows:

5 –Very Good (Used only for passive house type building & not likely to feature on an established site)
4 –Good; Little evidence of heat loss or any other thermal anomaly.
3 – Fair; Some evidence of heat loss or other thermal anomaly.
2 – Inadequate
1 – Poor
0 – Undetermined - NA; No clear evidence available from the thermograms to make an assessment

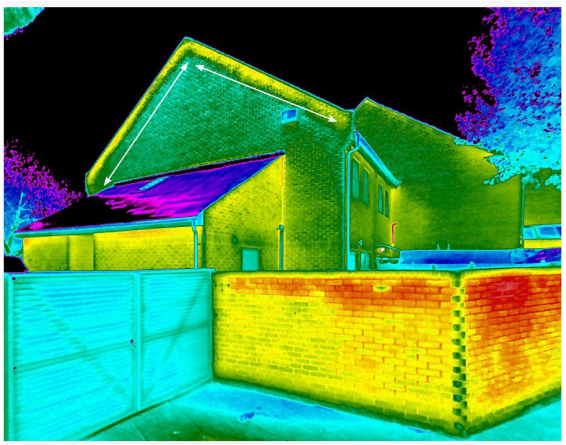


East Elevation

Observations

Roof Performance Rating 4
Elevation Performance Rating 3
Window Performance Rating 3
Door Performance Rating 4

Arrows indicate potential areas of minor heat lost

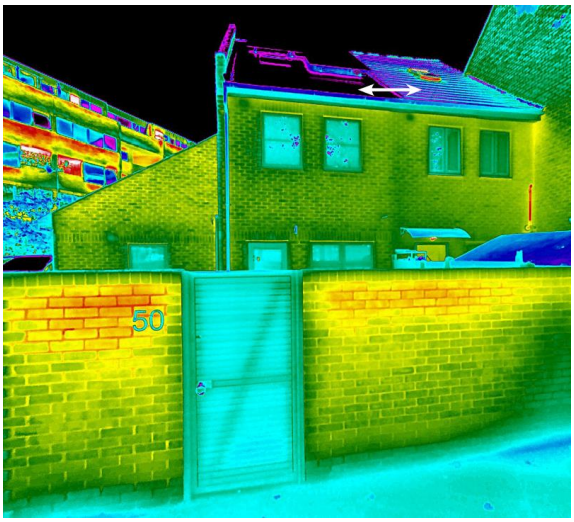


Northwest corner

Observations

Roof Performance Rating 4
Elevation Performance Rating 3
Window Performance Rating 4
Door Performance Rating 4

There is some evidence of heat loss from the gable end as indicated, however this may also be partly a geometric caused by solar radiation during the day



West Elevation

Observations

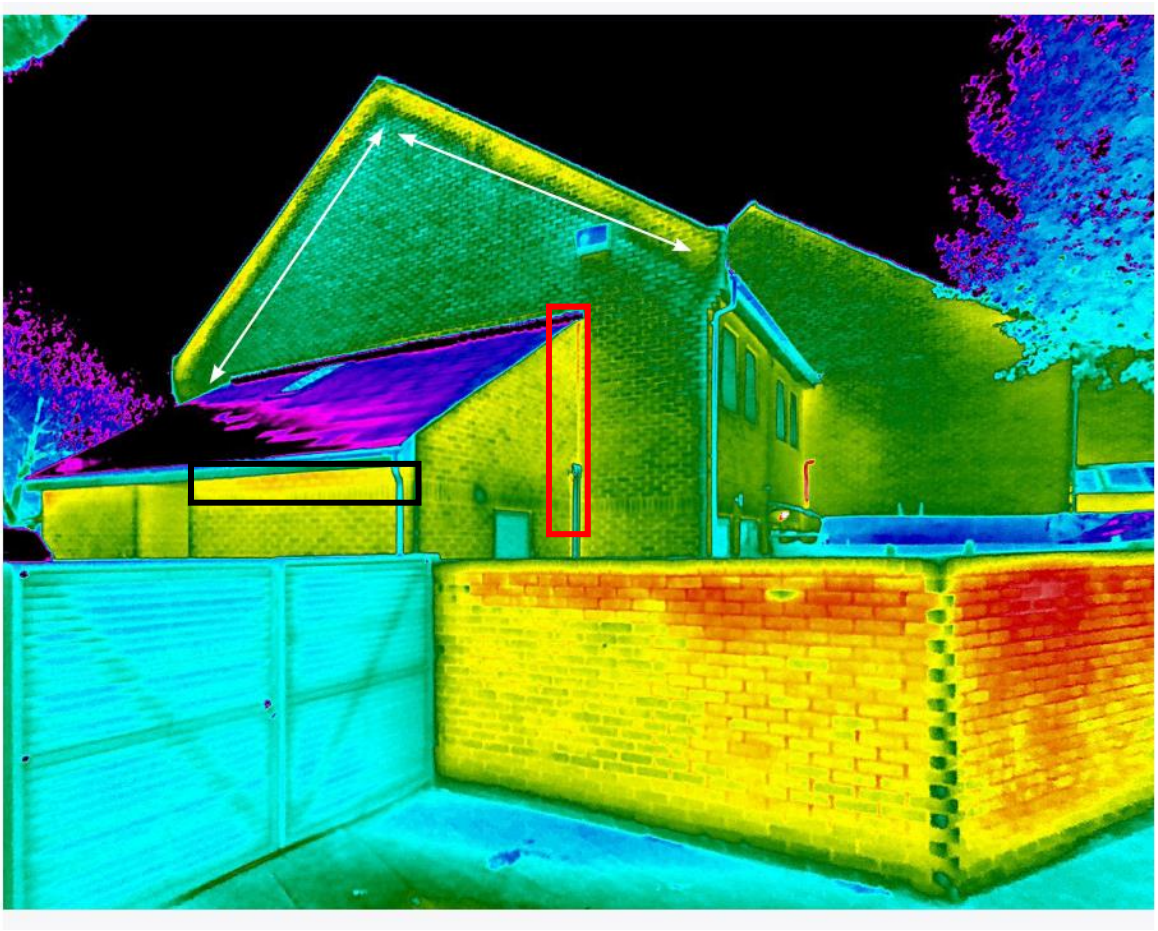
Roof Performance Rating 4
Elevation Performance Rating 4
Window Performance Rating 4
Door Performance Rating 4

The difference between the roofs, white arrow, is very noticeable. This is partly down to the difference in finish to the tiles and the thermal performance, with the pilot property clearly performing better. The elevations also appear to show a more constant temperature across them

The thermal imaging report supports the U-values measured from the BTS report. The results suggest the internal wall insulation is not providing the anticipated level of improvement (i.e., U value of 0.30W/m2K). The thermographic results show evidence of heat loss from the gable end and highlight the corner with the higher U-value rating (see the red box below).

The results suggest there is possible thermal bridging occurring in certain locations. This is a known and inherent issue for internal wall insulation systems as it is not always possible to provide the thermal break due to existing construction. Nevertheless, there may be workmanship issues which could further reduce performance of the building.

For example, just below the eaves of the lean-to area we have a particular thermal bridge (see the black box below). This area was not the easiest to get to so the insulation may not have been installed correctly between and below the rafters.



The image above also suggests the windows are not providing the anticipated level of improvement (i.e., U value of 0.92W/m2K). However, they do appear to be more insulating than the walls. After the installation of the windows, condensation was found which should not happen. This could be a reason for the low rating and has been flagged with the installers.

The survey however does show the west elevation to have the best performance. There is an evident difference in the roof of the pilot compared to the neighbouring property (see table above).

Moving forward, ECD architects have contacted the window and internal wall insulation manufacturer to seek clarification on the reasons and causing factors that could be producing these results. All these challenges will be considered for the wider estate and are great lessons learnt for choosing how to insulate the home.

If using internal wall insulation, we must consider the application, drying time and the inherent issues that come with IWI such as thermal bridging. It has also highlighted the importance of conducting the monitoring test before and after works. All U-values were predicted so moving forward it is important we measure this for an accurate comparison.

Issues to address moving forward

- Is internal wall insulation needed? If so, how can we prevent thermal bridging and low U values?
- Monitoring Workmanship

- Why the windows did not perform to the expected level of improvement
- Why the ductwork was not insulated?
- Monitoring from the start of the project and having accurate data

9.4 EnerPHit standard

Another important lesson learned was through understanding the concept of the EnerPHit standard. When carrying out an EnerPHit, there will be a list of measures required in order to meet the standard. These will involve:

- High levels of insulation — either internal or external, although internal needs more care in terms of moisture risk
- High performance triple-glazed windows and external doors.
- Careful consideration of window installation
- An airtightness reading of 1.0
- A Mechanical Ventilation with Heat Recovery (MVHR) system

Although the property includes all these measures, if the property had been intended to be EnerPHit certified we would have needed to make more careful records of the products installed as we went along, as well as designing it to achieve this standard, which would have required more invasive works (cutting back joist ends and re-hanging for example).

As the standard is a recognised benchmark, in order to receive EnerPHit certification, the process is the same as working towards Passivhaus certification. To meet these requirements, the project must be designed using the PHPP and must be certified by an accredited Passivhaus certifier. Although the products included within the house do not need to be certified for Passivhaus, it does help, especially with MVHR equipment.

To make EnerPHit retrofit more accessible, the Passivhaus Institute has introduced a step-by-step certification process called the EnerPHit Retrofit Plan. This means that payments for certification can be made in stages, helping funding for a retrofit project.

There are two standards to meet when looking at EnerPHit Certification. The first being based upon a performance criteria, and the second based upon individual components.

According to the Passivhaus Trust the performance criteria is as follows:

Criteria	New Build	Retrofit
QH Specific Space heat demand	max. 15kWh/ (m^2a)	max. 25kWh/ (m^2a)
Pressurisation test result n50	≤ 0.6 air changes/ hr @ n50	≤ 1.0 air changes/ hr @ n50
QP Entire Specific Primary Energy Demand	max. 120kWh/ (m 2a)	max. 120kWh/ (m^2a) +((QH – 15kWh/(m^2a)) *1.2)
Frequency of overheating (over 25 degrees)	max. 10%	max. 10%
Water activity of interior surfaces aw		max. 80%

The criteria required for individual components is:

Building Component	Retrofit Criteria
External Wall	External insulation U ≤ 0.150W/(m²K) Internal insulation U ≤ 0.300W/(m²K)
External Door	UD installed ≤ 0.80W/(m²K)
Roof or top floor ceiling	U ≤ 0.120W/(m²K)
Windows	UW installed ≤ 0.85W/(m²K)g -1,6W/(m²K) ≤ Ug
Ventilation	[Symbol]HR,eff ≥ 75% / ≤ 0.45Wh/m3
Thermal Bridges	No linear thermal bridges with [Symbol] > + 0.01W/(m²K) or punctiform thermal bridges with [Symbol] > + 0.04W/(m²K)

The criteria above would be generated by the Passivhaus Planning Package (PHPP) model. Greengauge have prepared a (PHPP) model of the property to assess the impact of the various improvements. Survey drawings have been used to prepare this, but it does include some assumptions about airtightness and existing build ups which would need to be confirmed to provide greater accuracy.

This model is based on 20°C internal temperature and doesn't include hot water, lighting, cooking and plug loads etc. This shows a 'treated floor area' of 88m2 and a heat loss of around 390 kWh/m2/year and a heat demand of 306 kWh/m2/year once solar and internal gains are allowed for.

As we did not intend EnerPHit certification from the start, we could not test if our pilot property passed these criteria. However, below is a summary taken from the PHPP model which can indicate how close the property is to EnerPHit.

Figure 4:
Greengauge PHPP model showing how close the property is to EnerPHit.

Specific building characteristics with reference to the treated floor area — The PHPP has not been filled completely; it is not valid as verification

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	88.1				
Space heating	Heating demand	kWh/(m²a)	81	≤	-	-	-
	Heating load	W/m²	36	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	0	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result n_{50}	1/h	5.0	≤	1.0		no
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	253	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	131	≤	154	154	yes
	Generation of renewable energy	kWh/(m²a)	0	≥	-	-	

EnerPHit (refurbishment): Component characteristics

Building envelope to exterior air[1] (U-value)	W/(m²K)	0.23	≤	0.3	yes
Building envelope to ground[1] (U-value)	W/(m²K)	0.94	≤	0.33	no
Wall w/int. insulation in contact w/exterior air (U-value)	W/(m²K)	-	≤	0.5	-
Wall w/interior insulation in contact w/ground (U-value)	W/(m²K)	-	≤	0.61	-
Flat roof (SRI)	-	-	≥	-	-
Inclined and vertical external surface (SRI)	-	7	≥	-	-
Windows/Entrance doors ($U_{W/D,installed}$)	W/(m²K)	1.06	≤	1.15	yes
Windows ($U_{W,installed}$)	W/(m²K)	1.17	≤	1.20	yes
Windows ($U_{W,installed}$)	W/(m²K)	-	≤	1.30	-
Glazing (g-value)	-	0.62	≥	0.19	yes
Glazing/sun protection (max. solar load)	kWh/(m²a)	315	≤	-	-
Ventilation (effective heat recovery efficiency)	%	75	≥	75	yes
Ventilation (humidity recovery efficiency)	%		≥	-	-

[1] Without windows, doors and external walls with interior insulation

[2] Empty field: Data missing; '-': No requirement

The PHPP model shows that the criteria passed on:

- Frequency of overheating
- Frequency excessively high humidity
- Primary Energy Renewable
- The building envelope to exterior air
- Windows/entrance doors
- Glazing
- Ventilation (effective heat recovery efficiency)

Greengauge also highlighted that the thermal performance values are slightly different to what is in the table. However, as this is not completely accurate this is to be expected. Moving forward with retrofitting the estate, we have taken note of this to ensure we get the right sequencing for each project.

9.5 Performance summary

Performance	Before (Predicted value)	Predicted	After
EPC	D	B	**B**
Heat loss Parameter	1.31 (c.6.7@50Pa)	Not measured	**1.03 (c.5.4@50Pa)**
Heat demand	306 kWh/m2/year	66 kWh/m2/year	**81 kWh/m2/year**
Roof	3.0 W/m2K	0.37 W/m2K	Not measured
External wall	0.68 W/m2K	0.27 W/m2K	0.79±14%
Ground floor	0.7 W/m2K	0.13 W/m2K	Not measured
Windows	2.6 W/m2K	0.8 W/m2K	1.17 W/m2K
Heat Transfer Coefficient	172 W/K	Not measured	254 W/K
Air Permissibility	1.5 (Good)	Not measured	2.4 (Average)

10. FUTURE DIRECTION

One of the main aims of this property was to produce as a live pilot for the Verity Close residents as well as the wider Lancaster West estate. It currently sits as a proven example of what is possible, together with lots of learning to ensure that moving forward we can achieve an exemplar 21st century estate that is comfortable, affordable, and low energy.

Monitoring equipment and smart technology in the home mean that with time we can gather data to see what services are saving the most energy and money for the residents. Moving forward we aim to retrofit the many buildings across the estate with our design teams and residents to achieve our carbon neutral goals.

Thing we would do again:

Developing a set of feasibility studies to help guide decision making on materials and services

Working with a team of architects to **choose the best materials** for the property – **keeping fire safety at the forefront**

Conducting energy performance measurements to learn what material and services made an impact – pre and post inspection

Use energy saving services to **encourage low carbon living** as well as the **removal of gas**

Installing external equipment such a water butts and composters to **encourage lifestyle changes**

Installing a digital shower meter so residents can make conscious decisions on water saving

Things we would do differently:

Ensure a full project plan is complete and all parties have a full understanding of the building before starting work.

Before starting the project, **getting accurate measurements of the property** for the purpose of monitoring, and understanding improvement levels. For example, U Values and Thermal performance rating

Provide and obtain **one set of measurements** to all parties involved to ensure consistency. For example, collecting and using one set of heat loss calculations throughout

All services to be designed before the works start to save time and allow room for structural changes (if needed)

If installing an **MVHR** system, to have **one company design, install and commission**

Have the **architects produce all drawings** for the project from inspection to as-builts

Decide if the EnerPHit certification will be applied for at the start

MVHR ductwork to be insulated to prevent condensation issues

10.1 Maintenance works

A maintenance schedule will be produced and monitored by our refurbishment team. Below is a list of data collected from suppliers and consultants on the checks to be done.

Maintenance works						
Item	ASHP and PV	MVHR	Fire dampers	Fire valves	Fire alarms	MVHR Filters
Responsible	Eco Energy Enviroment LTD	Mango Projects	RDFS	RDFS	Resident	W11 team

Item	Model	Suggested Maintenance	To be Maintained by
ASHP	Daikin Altherma 3 H HT EPRA14DV3 OU	Annual check - if the battery and inverter are connected to the internet they will know when it is due for a service	To be maintained by Eco Energy Environment Ltd
PV	SolarWatt Vision Style 320w	Include: indoor unit, cylinder, battery, and inverter (full install system)	
Fire Alarms	Aico 3000 series	To be tested by the resident once a month	Resident
Electric Charge Point	Pod point - Solo Smart Charger	No maintenance required - do not open unit as it will void the warranty	NA
MVHR	Paul Novus 300	Scheduled 2 year detailed check (Reuben - £90 a time) Once a year there should be a technical housekeeping maintenance, e.g. checking the heat exchanger for dust and if need be washing it with dish wash liquid in a bath tub. The fans should also be looked at and cleaned every 5 years. Filters will need changing every year on the machine and in the kitchen valve. They will need to be cleaned every 6 months (approx £62))	Reuben Wilkinson-Mango Projects (MVHR) W11 (Filter change)

Fire Dampers	FD-C Series Circular Fire Dampers - Lindab	Inspection should be undertaken annually. Local regulations/conditions may override this with periodic Inspection being carried out more frequently where corrosive or dirty conditions prevail. The maintenance log should be reviewed at each inspection and the frequency adjusted as required dependent upon findings. (BSB recommend a maximum of 1 year between inspections starting more frequently initially and reduce frequencies only if conditions are proven to allow). See manual	RDFS scheduled for January/February 2022 and will be in contact closer to the time to organise access etc.
Fire rated Valves	The valve body (AIRYB) and the flat front plate (AIRYFP)	The visible parts can be wiped off with a damp cloth.	RDFS - As part of the damper inspections they will check and clean the fire rated valves.

10.2 Project Summary

Feasibility Studies

- ECD feasibility studies
- ECD retrofit report
- Heat loss report
- Solar analysis
- PHPP options report
- Zero carbon strategy
- Architectural & Passivhaus Design

Heat Demand Reduction
225 kWh/m2/year

Current Heat Demand
81 kWh/m2/year

Overall cost of project
£214,099.57

Verity Close

Schedule of works

- GFI
- IWI
- Roof Insulation
- Triple Glazed Windows
- New doors
- Skylight
- Airtightness layer
- MVHR
- ASHP
- LED lights
- PV
- Battery storage
- Energy Manager
- Garden Works

Maintenance Works

Approximate maintenance cost for council Per Year
£352 plus materials

- ASHP and PV
- MVHR
- Fire ducts
- Fire Valves
- Fire alarms
- MVHR filter

Wider Refurb

Saving at least 15% on the wider refurbishment

Estimated Saving
2+ Bed
£32,035.38

Energy Bills

Predicted heating and energy bills Per Year
£510

Predicted cost for space heating alone (ASHP) Per Year
£260

EPC B

Heat Loss Parameter
1.03 (c.5.4@50Pa)

Monitoring

BTS Performance Report

Thermographic Survey

APPENDIX 1

Table 1: ASHP and PV product analysis

ASHP SUPPLY ONLY		
Company	**Rushton Renewables**	**Daikin**
Model	**7kW LG Monobloc R32**	**Daikin Altherma 7kW Monobloc**
Website	https://www.lg.com/uk/monobloc	https://www.daikin.co.uk/en_gb/product-group/air-to-water-heat-pump-low-temperature.html
Manual	https://www.lg.com/gr/download/resources/CT32004443/CT32004443_1641.pdf	https://my.daikin.eu/dam/dauk/document-library/Brochures/Heating/Heating%20Installer%20brochures/Daikin%20Altherma%20monobloc_Installer%20brochure_English.pdf
Image		
Pros	Top 10 ASHP Smart Grid Ready Energy Efficiency A+++ > Reliable operation even when -25°C outside > Powerful heating leaving water up to 65°C > Quick and easy installation > Smart control > No need for refrigerant piping work - flash gas injection > Data logging > Input 1.56 / 2.04KW > Power supply 1-phase / 220-240V / 50Hz > SCOP 35°C - 4.45 >SCOP 55°C - 3.12 (Seasonal Coefficient of Performance (Output)- The more efficient a heat pump is the more cost-effective)	Top 10 ASHP Recommended by Kensa Smart Grid Ready > Everything combined in one outdoor unit > Quick and easy installation as only water pipes run indoors from the outdoor unit > Limited installation space required as only outdoor space is required > Freeze protection of hydraulic parts > Quiet, compact outdoor unit > Easy installation out of the box, with no refrigerant handling > COP up to 5* with typical annual efficiencies of up to 300% > Quick-to-commission, user friendly controller > Reliable operation even when -25°C outside > Input 1.55 / 2.02KW > Power supply 1-phase / 230V / 50Hz > SCOP 35°C - 4.52 >SCOP 55°C - 3.42

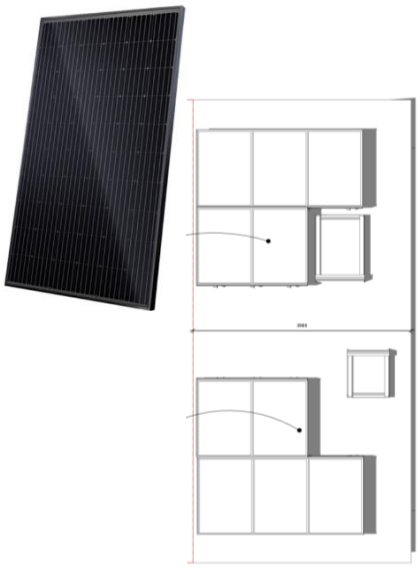
Cons	Sound 60 dBA 1M distance 50 dBA	Sound 49/62 bBA (1m from the unit) Energy Efficiency A++
Quote	New Heat Pump ready Hot Water Cylinder (this needs to be installed as it has a 3m² coil, normal cylinders will take a long time to get to desired temperature. No radiators included – these are priced at £120.00 a radiator if required. All pipework, electrical work etc. supplied and installed	Carry out pre and post EPC Supply and install 7kw Daikin Monobloc ASHP Supply and install 210 litre pre insulated Daikin cylinder Supply and install 10 radiators throughout property Supply and install interconnecting pipework Supply and install base for ASHP Commission and Test System on completion We have included Congestion charges for duration of installation All works in accordance with MSC requirements We have assumed adequate parking is available Installation would be in accordance with latest Covid-19 government and APF Health & Safety requirements. We have assumed client will provide a suitable asbestos report prior to works commencing on site.
RHI return	RHI Return would be roughly £7k over 7 years. However, the property needs an EPC to determine this for sure but from looking at the documents we can give a rough estimate.	
Accredited	MCS registered for RHI payments HIES and EPVS registered	Altherma range of ASHP are MCS listed, fully UK certified and compliant with all UK legislation
Require planning	No - Smaller than 0.6m3	No - Smaller than 0.6m3
Survey	**£250**	Based on floor area of 99.7m2, approximate heat loss of 50w/m2
Price	**£11,799**	**£10,258.00 plus 5% VAT** **Subject to site survey**

ASHP AND PV SUPPLY		
Company	**Elite renewables**	
Model	**Nibe F2040-12**	**Mitsubishi Ecodan 8.5 UQ**
Website	https://www.nibe.eu/en-gb/products/heat-pumps/air-source-heat-pumps	https://les.mitsubishielectric.co.uk/homeowners/our-heat-pumps

Manual	https://www.nibe.eu/assets/documents/24601/M12015-2.pdf	https://les.mitsubishielectric.co.uk/products/heating/domestic/outdoor/ecodan-puhz-monobloc-air-source-heat-pump
Image		
Pros	Top 10 ASHP Sound 57 dBA 2M distance - 43 dBA Energy Efficiency A+++ Smart Grid Ready > Compact heat pump that adapts to your home's requirements. > High capacity even down to -20°C and effective cooling function. > Energy saving smart technology with user friendly control > Input 1.09 / 3.27KW > Power supply 1-phase / 230V / 50Hz > SCOP 35°C - 4.43 >SCOP 55°C - 3.38	Top 10 ASHP Sound 58 dBA 1M distance 48 dBA low noise mode 42 Ultra Quiet Smart Grid Ready > Self-contained unit, only requiring water and electric connections > Single phase power supply with a low starting current (3 phase available for 14kW) > Low maintenance and quiet operation > Operates with outside temperatures as low as -25°C > Metering and monitoring app (additional fee) > Input 2.86 KW > Power supply 1-phase / 220-240V / 50Hz > SCOP 35°C - 4.12 >SCOP 55°C - 3.27
Cons		Energy Efficiency A++

Quote	To supply and install a Nibe F2040-12 Air source heat pump and buffer vessel, To supply and install a 250-Litre high gain Hot Water Cylinder, To supply all pipework, expansion vessels, low loss header and isolators required, To connect new heat pump and hot water cylinder to the existing electrical and heating system, Carry out full design, provide all MCS paperwork, commissioning and certification.	To supply and install a Mitsubishi Ecodan 8.5 UQ Air source heat pump and buffer vessel, To supply and install a 250-Litre high gain Hot Water Cylinder, To supply all pipework, expansion vessels, low loss header and isolators required, To connect new heat pump and hot water cylinder to the existing electrical and heating system, Carry out full design, provide all MCS paperwork, commissioning and certification.
RHI return	£8,400 back over a 7-year period (Index linked) based on 15,000 kWhrs/annum See Report The exact amount of heat generation will be based on the EPC of the property	
Accredited	MCS accredited for heat pumps and solar PV	
Require planning	No - Smaller than 0.6m3	
Survey	Already surveyed site for GSHP	
Price	**£12,959.38 + 5% VAT**	**£12,539.39 + 5% VAT**

ASHP AND PV SUPPLY		
Company	**Elite renewables**	
Model	**Vaillant Arotherm Plus 10**	**LG Neon 2 PV panels**
Website	https://www.vaillant.co.uk/homeowners/products/renewables-solutions/air-source-heat-pumps/	https://www.lg.com/uk/neon-2
Manual	https://www.vaillant.co.uk/specifiers/products/arotherm-plus-heat-pump-74048.html#specification	http://www.lg-solar.com/downloads/spec-sheet/DS_NeON2_60cells.pdf

Image		
Pros	Top 10 ASHP Energy Efficiency A+++ Smart Grid Ready > Quick and easy to install > Smart control > High Performance and low running costs > Most efficient on the market currently > Power supply 1-phase / 230V / 50Hz > SCOP 35°C - 5.03 >SCOP 55°C - 3.58	> 25 years Performance and Product Warranty > Roof Aesthetics - thin and appears black > Better performance on a sunny day > Perform at minimum 90.08% of initial performance. > ASHP and PV installed and supplied together > Weight 17.1kg > 1686 × 1016 × 40 mm > Power output range 335-350W
Cons	Sound 60 dBA 1M distance - 52 dBA > Oversized option > Cost	Fire rating - Class C

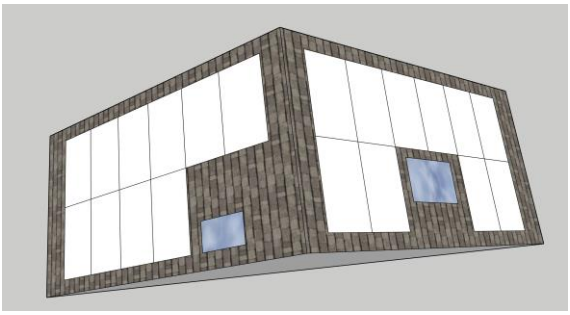
Quote	To supply and install a Vaillant Arotherm Plus 10 Air source heat pump and hydraulic module, To supply and install a 250-Litre high gain Hot Water Cylinder, To supply all pipework, expansion vessels, low loss header and isolators required, To connect new heat pump and hot water cylinder to the existing electrical and heating system, Carry out full design, provide all MCS paperwork, commissioning and certification.	Solar PV Supply and Installation To supply and install 10 x 340wp LG Neon 2 PV panels with a 3.4kW 1ph Inverter, To supply and install all mechanical fixings, brackets, isolators and meters, Connection, isolation, metering of full system ready to connect to CCU, Carry out full design, commissioning and certification.
RHI return	£8,400 back over a 7-year period (Index linked) based on 15,000 kWhrs/annum See Report The exact amount of heat generation will be based on the EPC of the property	
Accredited	MCS accredited for heat pumps and solar PV	
Require planning	No - Smaller than 0.6m3	
Survey		See doc - 10 Panels (both sides)
Price	**£13,659.03 + 5% VAT**	**£7,261.06 + 5% VAT.** **Allow £500 for scaffolding**

ASHP and PV supply		
Company	**Solarwatts**	
Model	**Daikin Altherma kit + World Heat cylinder 210ltr**	**Daikin Altherma 3 H HT Heat Pump**
Website	https://www.daikin.co.uk/en_gb/energy-for-change/homeowners/all-about-our-heat-pumps.html?gclid=EAIaIQobChMI8qONxOCQ6wIVSYBQBh1bGA5hEAAYASAAEgIrOfD_BwE	https://www.daikin.co.uk/en_gb/products/EPRA014-018DW.html

Image		
Pros	Recommended by Greengauge and Kensa Top 10 ASHP Smart Grid Ready > Power supply 1-phase / 230V / 50Hz > SCOP 35°C - 4.74 > Low running costs: high heat pump efficiencies at all outdoor and water temperatures > Guaranteed performances: high heating capacities down to low outside temperatures > Minimum energy consumption: Daikin inverter compressor with high modulating range > Smart heating control > Optimal use of energy limiting electrical inputs of Auxiliary components > Space saving: compact indoor unit with sleek design- space reduced more than 30% > Easy serviceability > Room temperature control functionality > Energy saving calculator	Recommended by Greengauge and Kensa Top 10 ASHP Smart Grid Ready > Power supply 1-phase / 230V / 50Hz > SCOP 35°C - 4.51 > SCOP 55°C - 3.58 > Sound 43/54 dBA Energy Efficiency A+++ Daikin is a global pioneer: the first to have launched heat pumps using R-32. With a lower Global Warming Potential (GWP), R-32 is equivalent in power to standard refrigerants but achieves higher energy efficiency and lower CO2 emissions. Designed for lower acoustic levels to meet the needs of urban areas and homeowner expectations.
Cons	Sound 49/62 dBA (advice from site visit: enough space to not cause concern) Energy Efficiency A++	Over Specified The need for an internal unit, a similar size to a wall mounted gas boiler.

Quote	Daikin Altherma kit (£7,500 + VAT) World Heat cylinder 210ltr Design, Supply, Installation, Commissioning, Certification and 10 Year Workmanship Warranty Notes: The ASHP will need the site electrician to run supplies for the outside unit and associated connections internally and the site plumber will need to plumb in cold water feed, size and fit radiators internally – the radiator thermal sizing will need calculating for a low temperature system (45 – 48 degrees). Recommend adding the battery as this will help to cover the electricity used by the ASHP and allow the house to run during the evening/ night time when sufficient stored.	Daikin Altherma kit (£10,650 + VAT) World Heat cylinder 210ltr
Accredited	RECC Code - MCS Registered	
Require planning	No - Smaller than 0.6m3	
Survey	Based on Site visit	
Price	**£7,500 + VAT**	**£10,650.00 +VAT**

ASHP and PV supply	
Company	**Solarwatts**
Model	**Solarwatt Vision 60M**
Website	https://www.solarwatt.com/solar-panels
Manual	https://www.solarwatt.com/downloads/pv-modules

Image	 
Pros	Recommended by Greengauge > Produced the first Glass/Glass module in the world – current market leader in Europe. > 30 years product warranty and 30 years performance warranty, 87% output guaranteed after 30 years vs. foil typically at 80% after 25 years (although not valid after the product warranty period is over). > Extremely resilient, very strong, withstanding highest mechanical loads: up to 9000Pa. https://www.youtube.com/watch?v=9-wruIIXU88&t=19s > Extremely weather proof and certified resistant against heavy salt, ammonia, sandstorms, wind, hail, etc. > Increased Fire protection, no back sheet – only glass which does not burn. > Fire Safety Class A (best rating) according to IEC. Storage (My Reserve): > Most innovative storage system, designed by the leading battery scientists in Germany. > Safest storage system on the market. > 1 man install, compact & lightweight. > 1,680 x 990 x 40mm > Power output range 300-320W
Cons	> Weight 22.8 kg
Quote	> The SolarWatt panels measure 990mm x 1680mm Solarwatt Vision 60M x 20 Mounting System - Renusol "On Roof" Fixtures & Rails x 20 Inverter Make and model - Fronius 3.6 x 1 Battery - SolarWatt My Reserve 7.2kW - £5,700+VAT Electrical Circuit AC & DC Isolators, Gen Meters, Required Wiring etc Services Design, Supply, Installation, Commissioning, Certification and 10 Year Workmanship Warranty inclusive
Accredited	RECC Code - MCS Registered
Require planning	NA
Survey	Based on site visit - See doc - 20 Panels

Price	**£8,000 + VAT** **£5,700 + VAT (Battery)**

ASHP and PV supply		
Company	**Ecolution group**	
Model	PUHZ-(H)W50-140VHA(2)/YHA2(-BS) MITSUBISHI - Ecodan 11.2kw Monobloc Air Source Heat Pumps	Trina Solar: TSM-DE06M.08 (II) HONEY
Website	https://les.mitsubishielectric.co.uk/homeowners/our-heat-pumps	https://www.trinasolar.com/en-glb/product/Tianjing60-de06mII
Manual	https://les.mitsubishielectric.co.uk/products/heating/domestic/outdoor/ecodan-puhz-monobloc-air-source-heat-pump	https://static.trinasolar.com/sites/default/files/EU_TSM_DE06M.08%28II%29_datasheet_A_2019_Web.pdf
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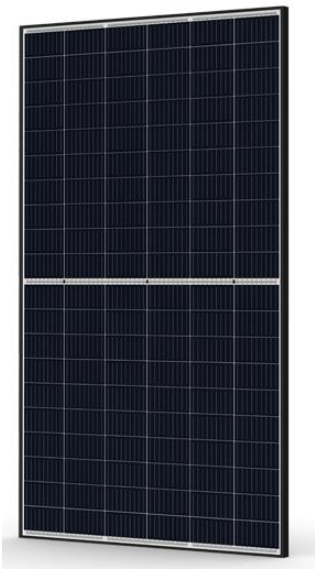
Image		

Pros	Top 10 ASHP Smart Grid Ready > Self-contained unit, only requiring water and electric connections > Single phase power supply with a low starting current (3 phase available for 14kW) > Low maintenance and quiet operation > Operates with outside temperatures as low as -25°C same spec as Ultra Quiet ? > Input 1.63 KW > Power supply 1-phase / 220-240V / 50Hz > SCOP 35°C - 4.06 >SCOP 55°C - 3.11	> 19.9% maximum efficiency > 0/+5W positive power tolerance > 3.2 mm, High Transmission, AR Coated Heat Strengthened Glass > 35mm Black Anodized Aluminium Alloy > 10 Year Product Warranty · 25 Year Linear Power Warranty > Available sizes: 330 / 335 Wp > Sizes: 340 Wp – different module size > Fire Safety Class A (best rating) according to IEC. > Weight 18kg > 1690 × 996 × 35 mm > Power output range 325-340W
Cons	Energy Efficiency A++ Sound 60 dBA 1M distance 53 dBA (46dBa at low noise mode)	Recognised potential issues with shading & orientation of panels
Quote	Option 1: Ecodan 11.2kw with 250L Cylinder Included • Wireless Controller • Fernox 25L Excluded • Radiators • Discharge pipe Distance between external unit to cylinder assumed 15m Max Quotation subject to final design Option 2:Ecodan 11.2kw with 250L Cylinder + 9 Rads Included • Wireless Controller • Fernox 25L • Radiators/ Full heating system Excluded • Discharge pipe Distance between external unit to cylinder assumed 15m Max Quotation subject to final design	Design Supply & materials Installation & labour Testing & commissioning Handover 12 x 340w Mono
Accredited	MCS registered	

Require planning	No - Smaller than 0.6m3	NA
Survey	Sent drawings - may need a site visit if going forward	See doc - 12 Panels
Price	**Option 1: £11,221.47** **Option2: £15,757.47 (+ 9 Rads)**	**£4,199.54**