



KING CONSULTANCY
— RETROFIT ASSESSORS —

EnerPHit Retrofit Assessment Report

Underwood, Parkmill, Gower, Swansea, SA3 2EH



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Executive Summary

Project Address	Underwood, Parkmill, Gower, Swansea, SA3 2EH
Client	Ian Brown
Report Target	EnerPHit-informed retrofit assessment.
Assessment method	Existing building survey information, energy-use evidence, airtightness test results, PHPP modelling, WUFI outputs and retrofit guidance.
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This report assesses the potential for an EnerPHit-informed retrofit of Underwood, Parkmill, using survey data, airtightness testing, WUFI outputs and PHPP modelling. The baseline PHPP model confirms poor existing performance, with space-heating demand of 453.5 kWh/m²a, heating load of 146.8 W/m² and airtightness of 12.54 ACH @50Pa (Pulse, 2025).

The proposed fabric-first retrofit package includes breathable EWI, roof and floor insulation, triple-glazed windows and doors, airtightness improvements, MVHR and an ASHP. PHPP modelling shows a major improvement, reducing space-heating demand to 116.6 kWh/m²a, annual heating demand by approximately 27,962.5 kWh/year, and peak heating load from 12.2 kW to 3.0 kW.

Full EnerPHit certification is unlikely because space-heating demand remains above target. The project is therefore best considered an EnerPHit-informed deep retrofit, prioritising energy reduction, moisture safety, comfort, durability and low-carbon heating. This aligns with retrofit guidance that recommends a whole-building approach to reduce performance gaps and avoid moisture-related unintended consequences (Passivhaus Trust, 2024a; Morgan, 2023).

Introduction and Scope

1.1 Purpose of Report and Approach

This report assesses the existing fabric, services and energy performance of Underwood and proposes an EnerPHit-informed retrofit strategy (Passivhaus Trust, 2026a). PHPP is used to compare the existing baseline with the proposed retrofit model, supported by survey information, energy-use data, airtightness testing and WUFI outputs (Passivhaus Trust, 2023a).

The assessment follows a whole-house approach because insulation, airtightness, ventilation and heating performance are interlinked (Morgan, 2023). The report focuses on five key areas: fabric-first improvements, airtightness, thermal bridging, ventilation and heating/carbon reduction.

- Fabric-first approach: Assess walls, roof, floor, windows and doors to reduce heat loss and improve comfort.
- Airtightness: Review uncontrolled air leakage and propose a continuous airtightness strategy.
- Thermal bridging: Identify key junction heat losses, particularly at floors, roofs, windows and doors.
- Ventilation and indoor air quality: Consider MVHR to provide controlled ventilation as airtightness improves.
- Heating, carbon and energy use: Review the existing LPG system and assess ASHP suitability after demand reduction (Passivhaus Trust, 2024b).

Existing Building Assessment

2.1 Property Description

Underwood is a detached period cottage in Parkmill, Gower (The Green Room Estate Agents, 2024). The property sits within a visually sensitive rural/coastal setting, meaning retrofit proposals must respect the existing character, proportions and appearance of the building.

The conservation context is particularly relevant to external wall insulation, replacement windows, door upgrades and visible roof or wall junctions. These measures must improve energy performance while remaining appropriate to the traditional character of the dwelling (Cadw, 2017).



2.2 Existing Construction

Based on the drawings, photographs and survey information supplied by the occupant, the dwelling is assumed to be of traditional solid masonry construction with a pitched roof (Brown, 2022; Brown, 2025). The building appears to include a mixture of original solid stone walls and later masonry elements. This creates a more complex retrofit condition than a uniform modern dwelling, as different parts of the envelope will have different thermal and moisture characteristics.

The solid masonry construction presents specific challenges for deep retrofit, particularly in relation to moisture movement, airtightness, thermal bridging and compatibility of new materials with the existing fabric (Morgan, 2023; Passivhaus Trust, 2024a). The retrofit approach must therefore be carefully detailed to improve thermal performance without causing long-term degradation of the building fabric.

The main existing fabric elements and associated retrofit considerations are summarised below.

Element	Existing condition	Potential Retrofit issues
External walls	Mixture of Solid stone and Cavity masonry walls	High heat loss - moisture movement and breathability must be protected
Roof	Timber pitched roof with loft and sloped ceiling areas	Opportunity for insulation upgrade, but eaves and sloped ceiling junctions require careful detailing
Ground floor	Uninsulated existing solid floor with underfloor heating	Major heat-loss route and difficult wall/floor thermal bridge
Windows / doors	Existing UPVC Double Glazed domestic units	Heat loss, air leakage and conservation constraints
Junctions	Traditional wall/floor/roof interfaces	Thermal bridging and airtightness complexity with stone construction

(Brown, 2022; Brown 2025)

2.3 Existing Building Services

The property is served by mains electricity and water, with heating and hot water currently provided by a Worcester Bosch Greenstar 30i LPG boiler, installed on 25 April 2022 (Worcester Bosch, 2024). The dwelling also has underfloor heating to the ground floor, which may support future low-temperature heating (The Green Room Estate Agents, 2024).

However, the existing heat demand is too high for the heating system to be treated as the first retrofit measure. A fabric-first approach is required to reduce demand before the proposed ASHP is relied upon (Passivhaus Trust, 2024b).

Product Details	
Product Name	Greenstar 30i LPG
Product Serial Number	55701390001187733600032

2.4 Existing Energy Use

The recorded LPG data shows high operational energy use, with total recorded costs of £3,794.79, an average monthly spend of £237.17, and annualised LPG use of approximately 34,350 kWh/year (Brown, 2025a). Based on an assumed 90 m² floor area, this equates to approximately 381.7 kWh/m²a.

This supports the PHPP baseline model and indicates that major heat loss is likely occurring through the building fabric, air leakage and thermal bridges (Brown, 2025).

LPG Usage Dec 23 - March 25							
Fitted with 1410L tank (only allowed 85% fill)							
05/12/2023	1132	0.549	£621.47	0.05	£31.07	£652.54	
13/02/2024	1132	0.549	£621.47	0.05	£31.07	£652.54	
09/05/2024	1089	0.549	£597.86	0.05	£29.89	£627.75	
15/10/2024	830	0.549	£455.67	0.05	£22.78	£478.45	
12/12/2024	1034	0.549	£567.67	0.05	£28.38	£596.05	
14/02/2025	94	0.599	£56.31	0.05	£2.82	£59.12	
17/03/2025	1158	0.599	£693.64	0.05	£34.68	£728.32	
Total costs						£3,794.79	
Monthly spend (/16months)						£237.17	
Total Litres							
		6469	4851.75 Litre per annum				
kWh conversion rate 1 litre		7.08					
convert LPG into kWh		34350.39 kWh per annum					
square meters							
		90	381.671 kWh/m2a				

2.5 Existing Airtightness

The Pulse airtightness test identifies significant uncontrolled air leakage in the existing dwelling. The key results are:

AP50 10.53 m³/h·m² @50Pa
N50 12.54 ACH @50Pa
Effective leakage area 0.06 m²
(Pulse, 2025)

This is significantly above the EnerPHit target of n50 ≤1.0 ACH @50Pa, confirming that airtightness is a key retrofit priority (Passivhaus Trust, 2023a). However, air leakage reduction must be paired with controlled ventilation, as improved airtightness without MVHR could increase moisture and indoor air quality risks (Passivhaus Trust, 2024a).

Extrapolated Result @ 50Pa	
AIR LEAKAGE RATE	EFFECTIVE LEAKAGE AREA
Q50	0.06 m²
2,660 m³/h	CALCULATION UNCERTAINTY
AIR PERMEABILITY	1.70 ±%
AP50	
10.53	
m³/m²h	
AIR CHANGES PER HOUR	
N50	
12.54 1/h	

Baseline PHPP Model

3.1 Purpose of Baseline Model

The baseline PHPP model represents the dwelling in its existing condition and provides a reference point for comparing retrofit improvements (Brown, 2025b). It is used to test how proposed measures affect heating demand, heating load, primary energy and EnerPHit compliance (Passivhaus Trust, 2026a).

The model should also be checked against the recorded LPG use. If there is a major difference between PHPP and actual energy use, assumptions such as floor area, occupancy, internal temperature, boiler efficiency, airtightness and ventilation should be reviewed (Passivhaus Trust, 2023a).

3.2 Baseline Geometry and Fabric Inputs

The PHPP baseline model uses a treated floor area of 83.0 m². This differs from the estate-agent floor area of approximately 90 m² because PHPP uses treated floor area rather than gross internal floor area (Brown, 2025; The Green Room Estate Agents, 2024). The baseline model confirms that the weakest fabric elements are the solid floor, solid stone walls and solid wall against rock. These elements have the highest U-values and are therefore the main fabric heat-loss risks.

Building element	PHPP area / input	Existing U-value	Retrofit priority
Treated floor area	83.0 m ²		
Solid floor on grade	68.9 m ²	3.068 W/m ² K	Very high
Solid wall against rock	Approx. - 28.8 m ²	2.763 W/m ² K	Very high
Solid masonry wall	Approx. - 69.86 m ²	2.211 W/m ² K	Very high
External door	1.7 m ²	2.300 W/m ² K	High
PVC element	16 m ²	2.041 W/m ² K	High
Block/block uninsulated wall	21.96 m ²	0.524 W/m ² K	Moderate
Block/block insulated wall	17.1 m ²	0.444 W/m ² K	Moderate
Sloped ceilings	32.4 m ²	0.430 W/m ² K	Moderate
Loft ceiling	42.0 m ²	0.158 W/m ² K	Low / already improved

The PHPP model shows that the weakest fabric elements are the solid floor and solid masonry walls. The floor has the poorest U-value at 3.068 W/m²K, while the solid masonry walls are modelled at 2.211 W/m²K and the wall against rock at 2.763 W/m²K. These areas are therefore the main heat-loss risks (Brown, 2025b).

The loft ceiling performs better at 0.158 W/m²K, so it is a lower priority. However, the sloped ceiling areas are weaker at 0.430 W/m²K and should still be reviewed. Overall, PHPP confirms that the retrofit should prioritise the solid walls, floor junctions, airtightness and sloped roof areas before heating-system replacement (Brown, 2025).

Baseline PHPP Model

3.3 Baseline PHPP Performance

The baseline PHPP model confirms that the dwelling performs poorly against EnerPHit expectations. It assumes four occupants, an extract ventilation system with 0% heat recovery, and an average heating-period air change rate of 0.44 1/h (Brown, 2025). This means ventilation heat losses remain significant and MVHR should be tested as part of the retrofit package. The model gives a space-heating demand of 453.5 kWh/m²a, with an annual heating demand of approximately 37,641.8 kWh/year. The heating load is 146.8 W/m², confirming that the dwelling requires substantial fabric improvement before low-carbon heating can operate efficiently.

PHPP output	Baseline result	Interpretation
Treated floor area	83.0 m ²	PHPP reference area
Occupants	4	Model assumption
Ventilation system	Extract air	No MVHR
Heat recovery efficiency	0%	Ventilation heat losses remain high
Average air change rate	0.44 1/h	Heating-period ventilation rate
Space-heating demand	453.5 kWh/m ² a	Extremely high compared with EnerPHit
Annual heating demand	37,641.8 kWh/year	Consistent with high LPG use
Heating load	146.8 W/m ²	Too high for direct ASHP replacement
Airtightness	12.54 ACH @50Pa	Significantly above EnerPHit target
Overheating frequency	0% above 25°C	Not currently a major risk
EnerPHit status	Fail	Existing building does not comply

The space-heating demand is far above the EnerPHit target range and demonstrates that the building is not close to compliance in its existing form. The heating load of 146.8 W/m² is also high, meaning that a heat pump should not be the first intervention. Installing low-carbon heating before reducing demand could result in an oversized system, higher electrical consumption and reduced seasonal efficiency (Brown, 2025; Passivhaus Trust, 2024b).

The baseline model therefore supports a fabric-first retrofit sequence: reduce fabric heat loss, reduce uncontrolled infiltration, introduce heat recovery ventilation, then reassess the heating load before selecting a future low-carbon heating system (Passivhaus Trust, 2024b).

Baseline PHPP Model

3.5 Baseline PHPP Conclusion

The PHPP baseline model confirms that Underwood requires a deep whole-house retrofit rather than minor efficiency upgrades. The main weaknesses are the solid floor, solid masonry walls, uncontrolled air leakage and lack of heat recovery ventilation (Brown, 2025). The model also confirms that the loft ceiling is already comparatively improved, so retrofit resources should be focused on the higher-impact elements.

The next stage of the assessment is to test retrofit scenarios in PHPP. These should include improved airtightness, MVHR, wall insulation, sloped roof insulation, window and door replacement, and floor or floor-edge insulation (Passivhaus Trust, 2026a). Each measure should be modelled separately before testing the final combined retrofit package.

Retrofit Objectives and EnerPHit Criteria

4.1 Retrofit Objectives

The primary retrofit objectives for Underwood are:



Reduce
operational
energy demand



Improve winter
comfort and
internal surface
temperatures



Reduce air
leakage and
draughts



Introduce
controlled
ventilation with
heat recovery



Reduce
reliance on LPG



Protect the
building's
traditional character
and conservation
setting

4.2 EnerPHit Criteria

EnerPHit is the retrofit version of the Passivhaus standard. It gives performance targets for areas such as heating demand, airtightness, overheating, surface temperature and ventilation. The Passivhaus Trust guidance shows that EnerPHit normally requires very low space-heating demand, an airtightness target of $n_{50} \leq 1$ ACH @50Pa, controlled overheating risk and suitable ventilation rates (Passivhaus Trust, 2023a).

For this property, full EnerPHit certification may be difficult because the building has solid stone walls, a difficult ground-floor junction, high existing air leakage and conservation constraints. For that reason, this report treats EnerPHit as a performance guide as well as a possible certification route. A component-based or step-by-step retrofit approach may be more realistic than trying to achieve all of the targets in one stage (Passivhaus Trust, 2024b; Passivhaus Trust, 2026a).

Retrofit Options Appraisal

5.1 External Wall Insulation

External wall insulation is the preferred wall strategy because it improves the thermal performance of the existing masonry while keeping the wall structure warmer. This should reduce heat loss, improve internal surface temperatures and limit thermal bridging at key junctions (Passivhaus Trust, 2026a). It also allows the recently renovated internal finishes to remain largely intact, reducing disruption.

Two broad options were considered: wood-fibre EWI with lime/mineral render and EPS EWI. The preferred option is wood-fibre EWI because it is more suitable for traditional solid-wall construction, as it improves insulation while maintaining breathability and drying potential (Morgan, 2023; Passivhaus Trust, 2024a). This should be confirmed through WUFI assessment and planning approval (Brown, 2025c; Cadw, 2017). The wall insulation options are compared in Appendix B.4.

To reduce thermal bridging at the base of the wall, a below-ground perimeter insulation detail should also be considered, using EPS or another moisture-resistant insulation suitable for plinth areas. Where existing rock is tight against the external wall, local removal may be required to allow the insulation and render system to continue. Although disruptive, this may be justified if PHPP shows that untreated junctions significantly reduce the overall retrofit performance (King, 2026).

5.2 Roof Insulation

The roof should be upgraded with a high-performance insulation strategy. The existing mineral wool loft insulation should be topped up to approximately 350mm, where space allows, to reduce heat loss through the horizontal ceiling areas (King, 2026). The roof insulation must also connect properly with the external wall insulation at the eaves, as gaps in this area could create significant thermal bridging (Morgan, 2023; Passivhaus Trust, 2026a). A continuous airtightness layer should be formed at ceiling or rafter level and sealed back to the wall airtightness layer. This is important because roof junctions are often a major source of air leakage in retrofit projects (Passivhaus Trust, 2026a).

Where standard insulation is difficult to install, aerogel could be used selectively at restricted eaves, window/door reveals and other tight junctions. Its slim build-up makes it useful for reducing local thermal bridges without requiring bulky insulation details that may be difficult to fit within a traditional cottage (Morgan, 2023). Aerogel is proposed only for restricted junctions, as summarised in Appendix B.3.

Retrofit Options Appraisal

5.3 Ground Floor

The ground floor is one of the most difficult retrofit elements. Three options should be considered:

Option	Description	Recommendation
Retain existing floor	Minimal disruption, retain UFH	Lowest cost but leaves significant thermal bridge
Perimeter insulation	Insulate floor edge externally or internally where possible	Good compromise if full excavation is impractical
Full insulated slab replacement	Excavate and install insulation below slab, reconnect UFH	Best performance but high cost/disruption

Full floor replacement gives the best thermal result, but it is disruptive and may only be practical if the occupants can move out during the works. If this is not possible, perimeter insulation could be used as a lower-disruption alternative, although it would leave some residual thermal bridging at the wall/floor junction (Passivhaus Trust, 2024a).

The PHPP model uses a renewed insulated slab with 120mm PIR insulation and a vapour-resistant barrier. This improves the floor U-value from 3.068 W/m²K to 1.007 W/m²K, an improvement of approximately 2.061 W/m²K (King, 2026). If the floor is replaced, the new membrane should also connect to the wall airtightness layer to improve airtightness continuity.

Moisture and ground-gas risk must also be considered. The floor detail should avoid trapping moisture in the base of the solid masonry walls, and because the GOV.UK radon map indicates a 10–30% radon risk, a radon barrier, sealed service penetrations and potentially a radon sump should be included (UKHSA and BGS, 2022; UK Radon, n.d.). Refer to Appendix C.2.

Floor replacement also allows the existing underfloor heating to be reviewed or renewed, supporting the proposed ASHP by enabling lower flow temperatures and improving heating efficiency (Passivhaus Trust, 2024b).

Retrofit Options Appraisal

5.4 Windows and Doors

The PHPP model uses Harbin Sayyas Windows Stock Co. Ltd. – PAZEN 111 triple-glazed timber-aluminium composite windows, with insulated external doors (King, 2026). Sayyas produces high-performance aluminium-clad timber window systems and has confirmed that products can be imported into the UK.

This window type is suitable because it offers improved thermal performance, slim frames, clean detailing and a durable aluminium external finish, while the timber element helps maintain a warmer and more traditional appearance internally (SAYYAS, n.d.). Harbin Sayyas windows are listed with installed U-values of around $0.80 \text{ W/m}^2\text{K}$, supporting their use within an EnerPHit-informed retrofit.

As Underwood is in a conservation-sensitive setting, the replacement windows should match the existing proportions, opening style, sightlines and external appearance as closely as possible (Cadw, 2017). Installation quality is also critical: the frames should be positioned close to the EWI layer, with insulated reveals and airtight/wind tight sealing to reduce thermal bridging.



5.5 Airtightness Strategy

The existing airtightness result is poor, with the Pulse test recording $N50 \text{ } 12.54 \text{ ACH @ } 50\text{Pa}$, which is significantly above the EnerPHit target of $n50 \leq 1.0 \text{ ACH @ } 50\text{Pa}$ (Pulse, 2025; Passivhaus Trust, 2023a). A continuous airtightness strategy is therefore required, with the air barrier clearly shown on drawings and followed around the full treated floor area.

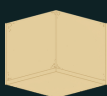
The main leakage points are likely to include:



Window/Door
junctions



Wall-to-roof
junctions



Wall-to-floor
junctions



Service
penetrations



Chimneys and
flues



Loft hatches
and ceiling
voids.

For the proposed retrofit, airtightness should be improved using wet plaster/parge coats, airtight membranes, service seals and specialist tapes. Around new windows and doors, Pro Clima CONTEGA SOLIDO SL or equivalent could be used to seal frames back to the masonry or airtightness layer (Pro Clima, 2026a). For membrane laps, service penetrations and difficult junctions, Pro Clima TESCON VANA or equivalent could be used (Pro Clima, 2026b).

Airtightness testing should be carried out during the works and at completion so leaks can be repaired before finishes are closed. This strategy must also be coordinated with the proposed MVHR system to maintain indoor air quality and manage moisture risk once uncontrolled air leakage is reduced (Passivhaus Trust, 2024a). The proposed airtightness products and treatment areas are summarised in Appendix B.1.

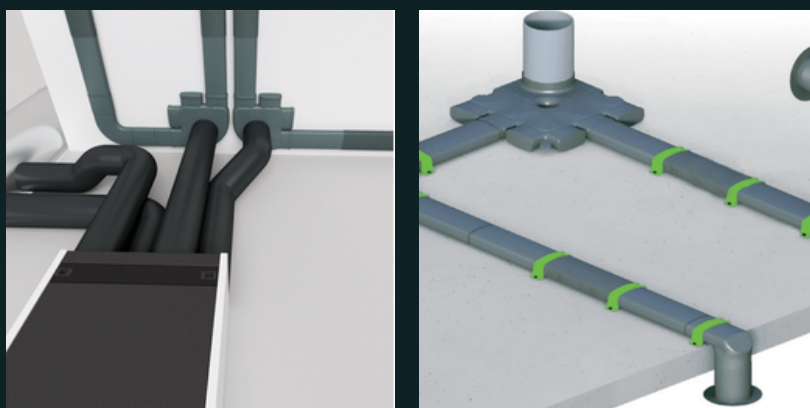


Retrofit Options Appraisal

5.6 Ventilation

The proposed ventilation strategy uses a Vasco D275 III MVHR unit with wireless RF control and Vasco EasyFlow flat ductwork (King, 2026; Vasco, 2026). This is suitable for Underwood because the cottage has limited service voids and restricted space for conventional circular ductwork. The EasyFlow duct has a slim 126mm x 60mm profile, is made from HDPE, allows bends up to 135°, and is rated airtightness class D (Vasco, 2023a).

The system would replace the existing PHPP extract ventilation input, which has 0% heat recovery (Brown, 2025). Extract air should be taken from wet rooms such as the kitchen, bathroom, WC and utility, with supply air delivered to bedrooms and living spaces. Duct routes should be designed early, with pressure losses, noise, maintenance access and commissioning airflow rates checked before installation (Passivhaus Trust, 2024a).



(Vasco, 2023a).

5.7 Heating and Hot Water

The proposed retrofit model replaces the existing LPG boiler with an air source heat pump. After the fabric, airtightness, ventilation and window upgrades, PHPP reduces the peak heating load to approximately 3.0 kW, based on 35.9 W/m² across an 83.0 m² treated floor area (King, 2026).

The heat pump should therefore be sized for the post-retrofit condition, not the existing dwelling. A Vaillant aroTHERM plus in the 5 kW range is proposed, subject to final MCS heat-loss calculation and installer design (Vaillant, 2026; MCS, 2024). This provides a reasonable margin above the PHPP-modelled load while avoiding oversizing (Passivhaus Trust, 2024b).

The existing underfloor heating is beneficial because it can support lower flow temperatures, helping the ASHP operate efficiently. Any remaining radiators should be reviewed or upsized where required, and domestic hot water should be provided through a compatible heat-pump cylinder sized to suit the household demand (Passivhaus Trust, 2024b). A summary of the full proposed retrofit package is included in Appendix A.1.

PHPP Retrofit Results

6.1 PHPP Retrofit Results

The proposed retrofit package was modelled in PHPP and compared with the baseline model (Brown, 2025; King, 2026). The results show a major improvement: space-heating demand reduces from 453.5 kWh/m²a to 116.6 kWh/m²a, annual heating demand reduces from 37,641.8 kWh/a to 9,679.4 kWh/a, and peak heating load reduces from 12.2 kW to 3.0 kW. Airtightness also improves from 12.54 ACH to 1.00 ACH, with MVHR providing 89.3% heat recovery (King, 2026). Although full EnerPHit is not achieved because space-heating demand remains above target, the results support an EnerPHit-informed deep retrofit approach (Passivhaus Trust, 2023a; Passivhaus Trust, 2026a). The supporting visual comparison charts included in Appendix C.4.

PHPP output	Existing baseline	Proposed retrofit	Result
Treated floor area	83.0 m ²	83.0 m ²	No change
Space-heating demand	453.5 kWh/m ² a	116.6 kWh/m ² a	74.3% reduction
Annual space-heating demand	37,641.8 kWh/a	9,679.4 kWh/a	27,962.5 kWh/a reduction
Heating load	146.8 W/m ²	35.9 W/m ²	75.5% reduction
Peak heating load	12.2 kW	3.0 kW	ASHP load significantly reduced
Airtightness n50	12.54 ACH	1.00 ACH	Meets EnerPHit airtightness target
Heat recovery efficiency	0%	89.30%	MVHR included
PE demand	573.8 kWh/m ² a	53.6 kWh/m ² a	90.7% reduction
PER demand	858.4 kWh/m ² a	41.4 kWh/m ² a	95.2% reduction
Overheating	0%	0%	Passes overheating limit
Excess humidity	0.27%	15.98%	Below 20% PHPP limit
EnerPHit status	Fail	Not achieved	Space-heating demand remains above target

6.2 EnerPHit Feasibility

Full EnerPHit is unlikely due to residual floor/wall thermal bridges, the rock-edge condition, practical insulation limits and conservation constraints (King, 2026). Further PHPP refinement could test improved floor detailing, reduced thermal bridges or component-route assessment (Passivhaus Trust, 2026a).

Moisture, Comfort and Carbon

7.1 Moisture, Comfort and Carbon

Moisture risk is central because Underwood is a traditional solid-wall building. The existing masonry needs to absorb and release moisture, so vapour-closed materials could trap moisture and increase the risk of damp, mould or decay (Morgan, 2023; Passivhaus Trust, 2024a). WUFI outputs should therefore be used to compare EPS and wood-fibre EWI. Wood-fibre with lime render is preferred because it improves thermal performance while maintaining breathability and drying potential (King, 2026; Passivhaus Trust, 2024a). The WUFI moisture analysis supports the need to consider drying capacity and vapour permeability when selecting the wall insulation system. Refer to Appendix C.3.

Risk should be reduced through pre-works fabric inspection, repair of rainwater goods, breathable insulation, careful reveal/plinth detailing, airtightness testing and correctly commissioned MVHR. This ensures that energy upgrades do not compromise the long-term durability of the building fabric (Morgan, 2023; Passivhaus Trust, 2024a).

The retrofit should improve comfort by reducing draughts, increasing internal surface temperatures and providing more stable indoor conditions. MVHR will help manage humidity and indoor air quality. Operational carbon should reduce through lower heating demand and replacement of LPG with ASHP heating (King, 2026; Passivhaus Trust, 2024b). Although the retrofit has a high upfront cost, its value should be judged on whole-life benefits, including comfort, durability, energy reduction and resilience (Passivhaus Trust, 2026b).

Financial Assessment

8.1 Financial Savings and Value

The retrofit package has a high capital cost due to the extent of fabric works required, particularly the external wall insulation, ground-floor replacement, triple-glazed windows, MVHR and ASHP installation. Using Spon's 2023 as a benchmark, the estimated construction subtotal is approximately £105,000–£156,000, increasing to around £117,000–£187,000 once contractor preliminaries are included (AECOM, 2023). This excludes VAT, professional fees, planning costs and any additional contingency.

The highest cost items are likely to be the external wall insulation and the floor replacement. These are also the most disruptive elements, but they provide important benefits by reducing heat loss, improving airtightness continuity and supporting the move to low-temperature ASHP heating. The PHPP model shows that annual space-heating demand reduces by approximately 27,962.5 kWh/year, meaning the investment should be assessed on whole-life value rather than simple payback alone (King, 2026; Passivhaus Trust, 2026b). Indicative cost allowances for the main retrofit measures are included in Appendix C.1.

Overall, the retrofit is unlikely to be a low-cost intervention, but it delivers wider value through reduced operational energy, improved comfort, lower carbon emissions, moisture-risk reduction and improved long-term resilience of the building fabric. Final costs would need to be confirmed by contractor quotations due to the conservation setting, bespoke detailing, rock-edge condition and specialist product choices (AECOM, 2023; Cadw, 2017).

Conclusion and Recommendations

9.0 Conclusion and Recommendations

Underwood is a challenging retrofit project due to its traditional solid-wall construction, high LPG energy use, poor airtightness and difficult floor/wall junctions. The baseline PHPP model confirms poor existing performance, with space-heating demand of 453.5 kWh/m²a, heating load of 146.8 W/m² and airtightness of 12.54 ACH @50Pa (Brown, 2025).

The proposed fabric-first retrofit package significantly improves performance. PHPP shows space-heating demand reducing to 116.6 kWh/m²a, annual heating demand reducing by approximately 27,962.5 kWh/year, and peak heating load reducing from 12.2 kW to approximately 3.0 kW. Airtightness also improves to 1.00 ACH, with MVHR introduced at 89.3% heat recovery (King, 2026).

Full EnerPHit certification is unlikely because space-heating demand remains above the target. The main limiting factors are the traditional stone construction, residual thermal bridges, ground-floor junctions, the rock-edge condition and conservation constraints.

The recommended approach is therefore to proceed as an EnerPHit-informed deep retrofit rather than a fully certified EnerPHit scheme. The proposed package should prioritise breathable EWI, careful floor/perimeter detailing, improved roof insulation, high-performance windows and doors, airtightness, MVHR and a suitably sized ASHP. This would deliver a major improvement in energy performance, comfort, moisture control and long-term resilience.

References

Retrofit guidance and technical standards

- Morgan, C. (2023) Sustainable renovation: improving homes for energy, health and environment. 2nd edn. The Pebble Trust / SEDA. Available at: <https://www.thepebbletrust.org> (Accessed: 7 May 2026).
- Passivhaus Trust (2023a) EnerPHit and PAS 2035/2030. London: Passivhaus Trust. Available at: <https://passivhaus.uk> (Accessed: 7 May 2026).
- Passivhaus Trust (2024a) Moisture and EnerPHit: Good Practice Guide. London: Passivhaus Trust. Available at: <https://www.passivhaustrust.org.uk> (Accessed: 7 May 2026).
- Passivhaus Trust (2024b) The right time for heat pumps: Decarbonising home heating in a staged retrofit. London: Passivhaus Trust. Available at: <https://www.passivhaustrust.org.uk> (Accessed: 7 May 2026).
- Passivhaus Trust (2026a) Passivhaus retrofit in the UK. 2nd edn. London: Passivhaus Trust. Available at: <https://passivhaus.uk> (Accessed: 7 May 2026).
- Passivhaus Trust (2026b) A retrofit costs comparison: translating expenditure to value. London: Passivhaus Trust. Available at: <https://passivhaus.uk> (Accessed: 7 May 2026).
- UK Health Security Agency and British Geological Survey (2022) UKHSA and BGS publish updated radon map for Great Britain. Available at: <https://www.gov.uk> (Accessed: 7 May 2026).
- UK Radon (n.d.) UK maps of radon. Available at: <https://www.ukradon.org> (Accessed: 7 May 2026).
- Cadw (2017) Managing Conservation Areas in Wales. Cardiff: Welsh Government. Available at: <https://cadw.gov.wales> (Accessed: 7 May 2026).

Project-specific evidence

- Brown, I. (2025) Underwood PHPP baseline model. Unpublished PHPP workbook.
- King, L. (2026) Underwood retrofit PHPP model. Unpublished PHPP workbook.
- Pulse (2025) Ians House Pulse airtightness test results. Unpublished test report, 19 March 2025.
- OVO Energy (2025) Electricity use 2023 and 2024. Unpublished utility records.
- The Green Room Estate Agents (2024) Underwood, Parkmill, Gower, SA3 2EH property particulars. Unpublished property sales particulars.
- Worcester Bosch (2024) Guarantee registration: Greenstar 30i LPG. Unpublished boiler registration document.

References

Product references

- Passive House Institute (n.d.) Harbin Sayyas Windows Stock Co. Ltd. manufacturer listing. Passive House Component Database. Available at: <https://database.passivehouse.com> (Accessed: 7 May 2026).
- Passive House Institute (n.d.) Harbin Sayyas Windows Stock Co. Ltd. Passive 120-C window component. Passive House Component Database. Available at: <https://database.passivehouse.com> (Accessed: 7 May 2026).
- SAYYAS (n.d.) SAYYAS Windows Co., Ltd. Available at: <https://www.sayyas.net/> (Accessed: 7 May 2026).
- Pro Clima (2026a) CONTEGA SOLIDO SL: window-sealing tape. Available at: <https://proclima.com> (Accessed: 7 May 2026).
- Pro Clima (2026b) TESCON VANA: adhesive tape. Available at: <https://proclima.com> (Accessed: 7 May 2026).
- Vaillant (2026) aroTHERM plus: air-to-water heat pump technical data. Available at: <https://www.myvaillantpro.co.uk> (Accessed: 7 May 2026).
- Vaillant (2024) aroTHERM plus specification sheet. Available at: <https://professional.vaillant.co.uk> (Accessed: 7 May 2026).
- Vasco (2026) D275 III technical data sheet. Available at: <https://vasco.eu> (Accessed: 7 May 2026).
- Vasco (2023a) EasyFlow air duct technical data sheet. Available from: Vasco EasyFlow technical data sheet, supplied project document.
- Vasco (2023b) EasyFlow plenum horizontal technical data sheet. Available from: Vasco EasyFlow technical data sheet, supplied project document.
- Vasco (2023c) EasyFlow plenum vertical technical data sheet. Available from: Vasco EasyFlow technical data sheet, supplied project document.
- Vasco (2023d) EasyFlow horizontal bend 90° technical data sheet. Available from: Vasco EasyFlow technical data sheet, supplied project document.



Appendix A – Proposed Retrofit Package

Appendix A.1: Proposed retrofit package summary

This table summarises the recommended retrofit measures for each building element, including the expected performance benefit. Refer to this from your main retrofit options section.

Element	Proposed intervention	Purpose / expected benefit
External walls	Wood-fibre EWI with 12mm lime render. EPS or suitable moisture-resistant insulation below ground level and to perimeter/plinth details, including the elevation facing the rock edge where feasible.	Improves wall U-value, maintains breathability, reduces thermal bridging and protects traditional solid-wall fabric.
Roof	Top up loft insulation to approximately 350mm. Connect roof insulation to EWI using aerogel at restricted eaves/junctions, with a continuous airtightness layer.	Reduces roof heat loss and improves continuity between roof, wall insulation and airtightness layers.
Ground floor	Replace existing floor with insulated slab including 120mm PIR, vapour/radon control layer and perimeter insulation upstand.	Reduces floor heat loss, improves wall/floor junction performance and supports airtightness/radon control.
Windows	High-performance triple-glazed timber-aluminium composite units, conservation-sensitive in appearance.	Reduces heat loss, improves airtightness and maintains visual character.
Doors	Insulated external doors, part triple-glazed where required, using timber-aluminium composite conservation-sensitive units.	Reduces infiltration and heat loss while maintaining appearance.
Airtightness	Continuous air barrier using plaster/parge coats, airtight tapes, service seals and junction detailing.	Reduces uncontrolled air leakage and supports EnerPHit airtightness target.
Ventilation	Whole-house MVHR system using slimline ductwork.	Provides controlled fresh air, heat recovery and moisture management.
Heating and hot water	ASHP with compatible heat-pump cylinder, subject to final MCS heat-loss design.	Replaces LPG with lower-carbon heating and hot water system.
Controls	Smart zoned controls suitable for low-temperature heating.	Improves heating efficiency, comfort and user control.

Appendix B – Product Information

Appendix B.1: Airtightness product strategy

This table identifies the proposed airtightness treatments for key leakage areas, including window/door junctions, service penetrations and wall/floor junctions.

Airtightness area	Proposed treatment
Window and door junctions	Pro Clima CONTEGA SOLIDO SL or equivalent airtight window sealing tape
Membrane laps and roof junctions	Pro Clima TESCON VANA or equivalent airtight membrane tape
Wall surfaces	Wet plaster or parge coat used as airtight layer where suitable
Service penetrations	Proprietary airtight grommets or taped collars
Loft hatch	Insulated airtight loft hatch with compression seals
Chimneys/flues	Seal redundant openings or detail active flues separately
Wall/floor junction	Connect floor membrane or slab edge detail to wall airtightness layer

Appendix B.2: Vasco MVHR and EasyFlow ductwork

This table summarises the proposed MVHR unit, duct system and supply/extract strategy.

Ventilation item	Proposed approach
MVHR unit	Vasco D275 III with wireless RF control
Duct system	Vasco EasyFlow flat ventilation duct
Reason for selection	Slimline ductwork suitable for limited service voids
Duct material	HDPE
Duct profile	Approx. 126mm x 60mm
Airtightness class	Class D to NEN-EN 1507 / NEN-EN 12237
Extract rooms	Kitchen, bathroom, WC, utility
Supply rooms	Bedrooms and living spaces



Appendix B – Product Information

Appendix B.3: Aerogel insulation use

This table explains why aerogel is proposed only as a targeted insulation product for restricted junctions, rather than as a main insulation layer.

Feature	Relevance to retrofit
High thermal performance	Aerogel has very low thermal conductivity, so a thin layer can improve insulation where standard materials are too thick.
Slim build-up	Useful in restricted areas such as eaves, window reveals, door frames, meter boxes and tight roof/wall junctions.
Thermal bridge reduction	Can be used locally to treat cold spots where the main insulation layer cannot continue uninterrupted.
Lightweight material	Adds minimal load to existing fabric, which is useful for older masonry or timber roof structures.
Moisture-conscious detailing	Some silica aerogel products are water-repellent but vapour-permeable, helping maintain breathability in sensitive retrofit areas.
Selective use only	Due to higher cost, aerogel should be used as a targeted detailing material rather than as the main insulation system.

Appendix B.4: Wall insulation option comparison

This table compares wood-fibre EWI and EPS EWI in relation to performance, cost and moisture risk.

Option	Advantages	Risks / limitations
Wood-fibre EWI with lime/mineral render	Vapour open, capillary active, compatible with traditional walls, lower embodied carbon	Higher cost, thicker build-up, detailing required
EPS EWI	Lower cost, good thermal performance, thinner build-up	Less vapour open, less compatible with traditional masonry, greater moisture caution needed

Appendix C – Financial and PHPP Supporting Information

Appendix C.1: Indicative retrofit cost assessment

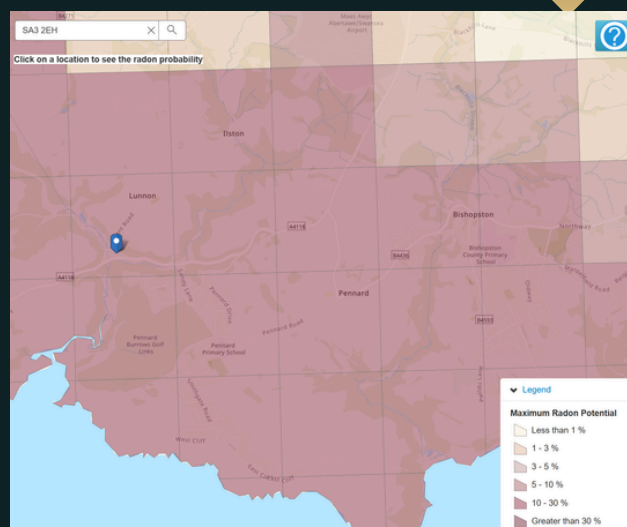
This table provides an outline cost assessment for the proposed retrofit measures. The costs are approximate only and should be confirmed by contractor quotations.

Element	Quantity basis	Indicative rate / allowance	Rough cost
External wall insulation	Approx. 160 m ² external wall area	£220–£300/m ²	£35,000–£48,000
Plinth / below-ground EPS / rock-edge detailing	Provisional allowance	Lump sum	£4,000–£8,000
Roof / loft insulation upgrade	Approx. 74 m ² roof and ceiling area	£40–£70/m ² incl. difficult junctions	£3,000–£5,000
Aerogel to restricted junctions	Targeted use only	Provisional allowance	£1,500–£3,000
Ground-floor insulated slab	Approx. 68.9 m ²	£300–£450/m ² incl. excavation, PIR, slab, radon/vapour layer	£21,000–£31,000
Windows and external doors	Approx. 18 m ² windows + doors	£800–£1,200/m ² / allowance for imported triple glazing	£17,000–£25,000
Airtightness works	Whole dwelling	Provisional allowance	£3,000–£6,000
MVHR system	Vasco unit, EasyFlow ducting, commissioning	Provisional allowance	£8,000–£12,000
ASHP and hot-water cylinder	5 kW ASHP + cylinder	Provisional allowance	£10,000–£14,000
Smart controls / heating alterations	Allowance	Provisional allowance	£2,000–£4,000

Appendix C –

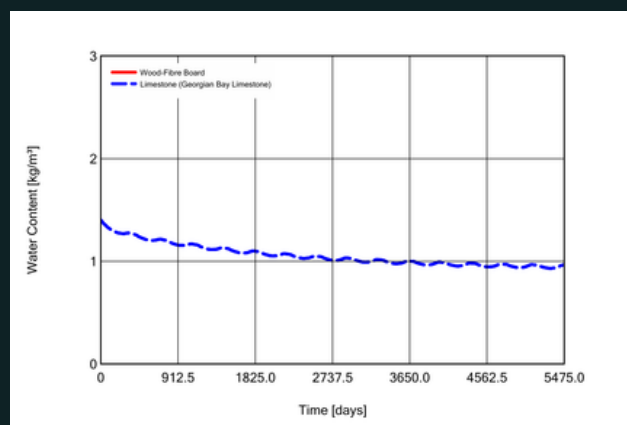
Appendix C.2 – Radon Risk Map

This appendix shows the GOV.UK / UKHSA radon map for the area surrounding Underwood, Parkmill. The map indicates that the property is located within a 10–30% radon risk area, which supports the recommendation for radon protection measures if the ground floor is excavated and replaced.



Appendix C.3 – WUFI Moisture Analysis

This appendix shows the WUFI moisture analysis for the proposed wall build-up at Underwood. The chart illustrates moisture content within the wall over time and is used to support the selection of a breathable wall insulation strategy. The results should be read alongside the moisture-risk discussion in Section 8.1.

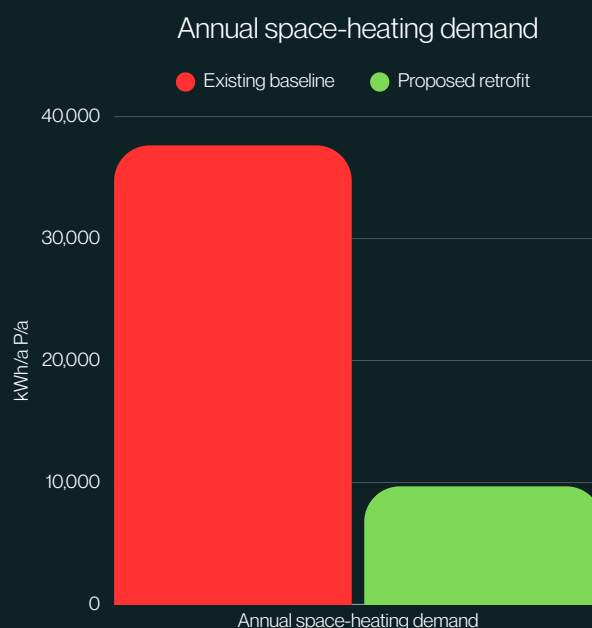


Appendix C.4 – PHPP Performance Charts

This appendix presents visual comparisons between the baseline PHPP model and the proposed retrofit PHPP model. The charts show the reduction in annual space-heating demand and the improvement in key performance indicators following the proposed retrofit package.

Figure C.4.1 : Annual space-heating demand comparison

This chart shows the reduction in annual space-heating demand from 37,641.8 kWh/year in the baseline model to 9,679.4 kWh/year in the proposed retrofit model.



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Figure C.4.2 : Baseline and retrofit PHPP performance comparison

This chart compares key PHPP outputs before and after retrofit, including space-heating demand, heating load, peak load, airtightness, PE demand and PER demand. The results show substantial improvement across the main performance indicators, although full EnerPHit certification is not achieved.

