



ADVANCED CONSTRUCTION TECHNOLOGY REPORT: BRYN BRAGL DEVELOPMENT



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Executive Summary

This report was commissioned to inform the company's strategic shift towards sustainable construction through an appraisal of the technologies used at the energy-positive Bryn Bragl energy-positive housing development in Bridgend.

The project, based on the Solcer design concept (Solcer House, n.d.), successfully delivered 14 dwellings that generate more energy than they consume, achieving an EPC 'A' rating (Find an Energy Certificate – GOV.UK, n.d.). This performance is underpinned by a 'fabric first' approach, utilising Structural Insulated Panels (SIPs) and triple-glazed windows to significantly reduce heat loss, minimise energy demand, and achieve high levels of airtightness.

The integration of advanced building services, including roof-integrated photovoltaic (PV) panels, on-site Tesla battery storage, and a high-efficiency Pichler PKOM₄ compact service unit providing space heating, domestic hot water, and mechanical ventilation with heat recovery, enables the energy-positive operation of the properties (Davies, M. 2021).

The Bryn Bragl development demonstrates a proven model for delivering affordable, low-carbon housing. It is therefore strongly recommended that the company adopts a fabric-first construction methodology and develops partnerships with specialist contractors experienced in integrated PV, system builds, battery storage, and MVHR systems to reduce project risk and support future sustainable residential projects.

1.1 Introduction

The construction industry in Wales is undergoing a significant transition towards more sustainable and low-carbon building practices, driven by national decarbonisation targets, rising energy costs, and increasing regulatory pressure. The Welsh Government has endorsed these projects in the Welsh Zero Carbon Housing Performance Hub (Good Homes Alliance, Wood knowledge Wales, and Building Performance Network, 2021). In response, this report has been prepared to support the company's strategic shift towards sustainable construction by examining an exemplar residential development, Bryn Bragl, an energy-positive energy-positive housing scheme in Bridgend delivered by Wales & West Housing Association and Zenergy Design.

1.2 Aims and Objectives

The aim of this report is to evaluate the sustainable construction strategies used at the Bryn Bragl development in Bridgend and to assess their relevance to the company's future projects. To achieve this aim, the report looks to evaluate the building's fabric and construction methods, assess how the overall design responds to the integration of low-carbon technologies and the local environmental context, and appraise the building services used to deliver human comfort and energy efficiency. In addition, the report critically evaluates the successes and limitations of the development and considers these approaches for future sustainable residential schemes.

1.3 Methodology and Scope

This report uses a qualitative case study approach and is based on a review of academic literature, industry guidance, and relevant policy documents relating to sustainable residential construction. Bryn Bragl is used as the primary case study, informed by the Solcer housing principles and supported by a review of planning documentation and post-completion technical information. The report is limited to information available in the public domain and, while published performance data and professional evaluations are referenced, detailed long-term post-occupancy monitoring data was requested but was unobtainable at this time and could not be included in this report.

2. Fabric First Approach and Construction Method

2.1 Fabric First

The key principle for the Bryn Bragl development is the adoption of a fabric-first approach, which prioritises minimising energy demand through the building envelope before relying on mechanical or renewable technologies. This method is widely recognised as a good foundation for sustainable construction, as it reduces operational energy use regardless of occupant behaviour or future changes in building services (*NLA Technical Explainer: Fabric First*, n.d.).

At Bryn Bragl, this strategy delivers sustainability benefits by significantly reducing space-heating demand, thereby lowering reliance on active heating systems and improving overall energy usage. This approach is reflected in measured airtightness results of approximately 1.8–1.9 m³/m².hr @50Pa across the development, alongside a target space heating demand of 15 kWh/m² per year, consistent with Passivhaus design principles (Wales & West Housing Association, 2021).

This approach also future proofs the homes by reducing exposure to energy price rises and ensuring that performance is retained over the building's lifespan, even if building services require replacement or upgrading in time.

2.2 Construction Method: Structural Insulated Panels (SIPs)

The primary construction method employed at Bryn Bragl was Structural Insulated Panels (SIPs) across all 14 dwellings (Wales and West Housing Association, no date). SIPs are classed as a Modern method of construction (MMC) and consist of a rigid insulation core bonded between two structural facings, typically oriented strand board (OSB) as seen below in fig a. SIP panels are manufactured off-site under controlled factory conditions. These panels can form walls, roofs, and floors, providing both structural support and high thermal performance.

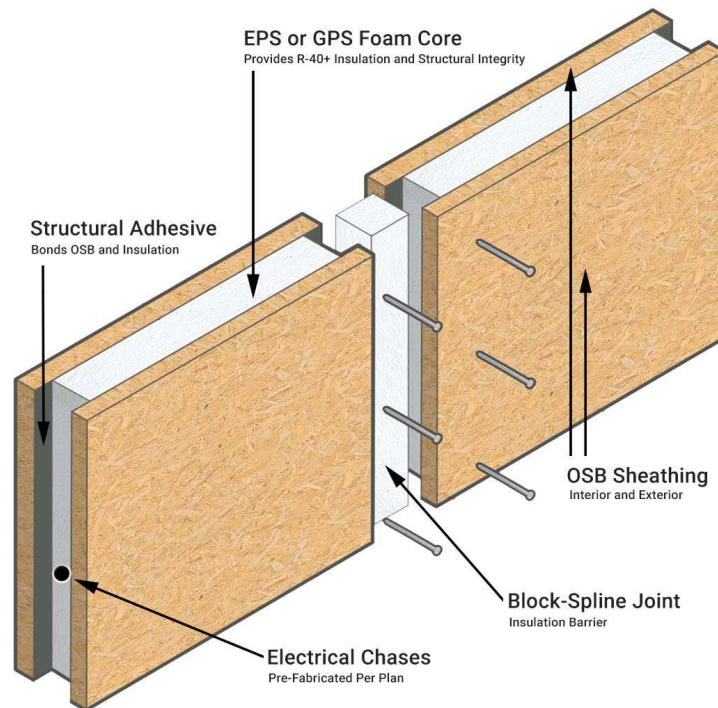


Fig a(Frame, 2022)

For efficiency purposes, SIPs offer several advantages over traditional masonry or timber-frame construction. The continuous insulation layer significantly reduces heat loss and thermal bridging, resulting in a more predictable thermal performance (Zero Carbon Hub, 2014; The importance of thermal bridging: BRE Group, no date). Factory manufacture enables higher levels of precision, which contributes to improved airtightness and reduces the risk of workmanship-related defects commonly associated with on-site construction (Davenport et al., 2021).

The speed of construction is another benefit. SIPs panels can be rapidly assembled on site, reducing programme duration and exposure to adverse weather conditions (Offsite Modular Construction, no date). This aligns well with affordable housing delivery, where programme certainty and cost control are critical. Additionally, off-site manufacture reduces material waste and improves quality consistency across dwelling types.

When compared to traditional masonry construction, SIPs generally achieve superior thermal and airtightness performance with thinner wall build-ups, allowing for improved internal floor area. Compared with conventional timber frame systems, SIPs typically provide greater structural rigidity and reduced air leakage, although both systems can perform well when properly detailed and installed.

2.3 Airtightness and High-Performance Glazing

Airtightness is a key component of the fabric-first strategy and is supported using triple-glazed windows. Triple glazing reduces heat loss through glazed areas while improving internal surface temperatures, which improves the occupant's comfort and reduces the risk of condensation.

High-quality airtight detailing around junctions, penetrations, and window interfaces is essential to achieving these benefits (Trust *et al.*, 2020). Reduced air leakage limits uncontrolled heat loss, improves the effectiveness of mechanical ventilation systems, and ensures stable indoor temperatures. In addition, triple glazing provides improved acoustic performance, reducing external noise ingress and enhancing overall living conditions (Jeans & Reeves, 2026).

Airtightness testing confirmed values below $2.0 \text{ m}^3/\text{m}^2.\text{hr @}50\text{Pa}$ for all dwelling types, indicating good construction quality and effective on-site quality control (Wales & West Housing Association, 2021).

2.4 Limitations and Risks

While Structural Insulated Panels (SIPs) offer strong thermal and airtightness performance, they also present several limitations. Initial material costs are typically higher than traditional masonry or timber-frame construction, and the precision-engineered nature of SIPs limits late design changes or unplanned service penetrations (Stevenson & Corfield, 2025). This places greater emphasis on early planning and setting-out.

The performance of SIPs is highly dependent on installation quality. This is predominantly a specialist contractor needed to install this system, again resulting in a higher cost than general labour. Poor joint sealing or inadequate protection during construction can allow moisture ingress, which may lead to long-term deterioration within the panel core. Careful detailing and on-site quality control are therefore essential.

High levels of airtightness further increase reliance on mechanical ventilation to maintain indoor air quality. Without correctly designed, commissioned, and maintained ventilation systems, there is a risk of condensation and humidity build-up. Similarly, while triple-glazed windows improve thermal comfort, their higher cost and the need for accurate installation mean that poor detailing can undermine overall fabric performance.

3. Design Influences: Technology and Local Environment.

3.1 Solcer Design Principles

The design of Bryn Bragl is based on the Solcer House concept developed by the Welsh School of Architecture, which combines a fabric-first approach with integrated renewable energy systems to

deliver ultra-low or energy-positive housing (Solcer House, n.d.). Energy demand, generation, and storage were considered early in the design process rather than added at a later stage.

This approach is reflected in the compact layouts, simple building forms, and consistent house types used across the site. Reducing surface-to-volume ratios helps minimise heat loss through the building envelope, supporting the fabric-first strategy discussed in Section 2 and allowing the approach to be applied within a higher-density affordable housing development.

3.2 Local Environment and Site Constraints

The local environmental context at Bryn Bragl had a clear influence on the final design. The site sits within the settlement boundary of Bridgend but is constrained by existing residential development to the south and east, and by the Coed y Morfa Site of Importance for Nature Conservation (SINC) along the northern boundary, as identified in the planning documentation (Wales & West Housing Association, 2018). These constraints required careful consideration to limit both ecological impact and the effect on neighbouring properties.

The site slopes gently from east to west and north to south, with section drawings showing that the new dwellings are set slightly higher than the existing bungalows on Rhiw Tremaen (Wales & West Housing Association and WYG Planning & Env., 2018). This influenced both drainage design and building form, resulting in compact two-storey dwellings with asymmetrically pitched roofs to help reduce overshadowing while still providing adequate internal space and solar access (Bridgend County Borough Council, P/18/410/FUL).

Solar orientation was also a key consideration. The elevations and roof layouts show that south-facing elevations and roof planes were used to maximise PV integration and passive solar gain, while north-facing elevations are more solid, with reduced glazing to limit heat loss (Bridgend County Borough Council, P/18/410/FUL). This reflects passive design principles and shows how local climatic conditions in South Wales informed the overall building design.



3.3 Technology Integration

At Bryn Bragl, energy technologies were considered early in the design and integrated into the buildings rather than added later. Planning drawings show that the south-facing roof planes incorporate integrated photovoltaic panels, which replace traditional roof tiles and form the primary roof covering (Bridgend County Borough Council, P/18/410/FUL). This removes the need for retrofitted panels and allows energy generation to be part of the building envelope.

The front elevations combine brickwork with areas of grey cladding that incorporate solar technologies, while the north-facing roof planes use standing-seam metal roofing. This approach provides a durable roof finish with fewer penetrations, supporting airtightness and long-term weather performance. Planning approval confirmed that this level of integration was acceptable in terms of appearance and local character (Bridgend County Borough Council, P/18/410/FUL).

3.4 Planning Policy, Social Sustainability, and Design Trade-offs

The planning history of Bryn Bragl shows that sustainability considerations extended beyond environmental performance to include social and policy factors. The development involved a trade-off between delivering affordable, energy-positive housing and the loss of informal open space, which was addressed through planning negotiations and a Section 106 contribution towards off-site play provision (Bridgend County Borough Council, P/18/410/FUL). While this represents a limitation, the planning authority concluded that the wider benefits of low-carbon affordable housing justified

the scheme. This highlights the need to consider planning and community constraints alongside environmental objectives when delivering sustainable housing.

4. Building Services

4.1 Heating, Cooling, and Ventilation

The building services strategy at Bryn Bragl is closely aligned with the fabric-first approach, enabling low-energy systems to meet occupant comfort requirements efficiently. Space heating, domestic hot water, and ventilation are provided via a compact integrated service unit, combining heat pump technology with mechanical ventilation and heat recovery (MVHR). This unit is called a PKOM₄ and can be seen how the system works in *Fig b*.

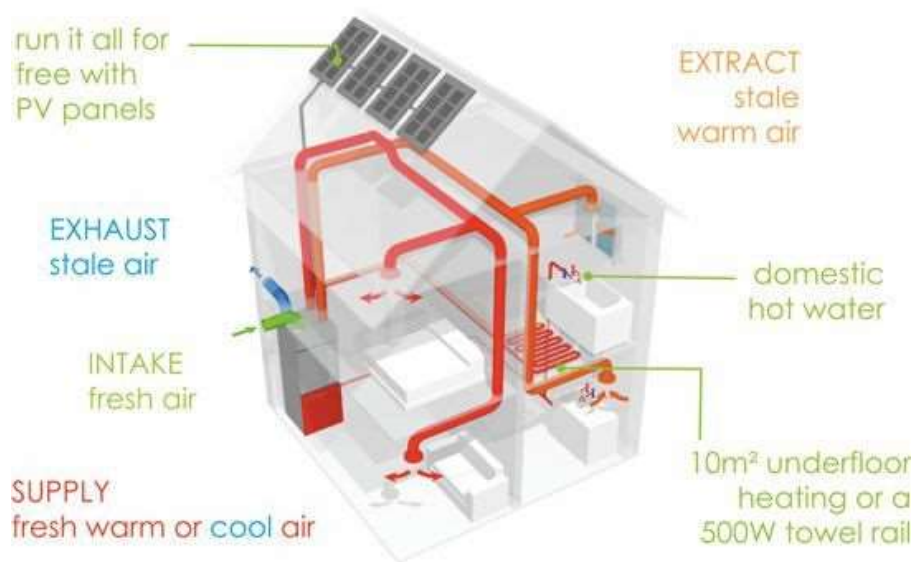


Fig b (PKOM₄ Compact Service Unit, no date).

The use of MVHR is essential in airtight dwellings, as it ensures continuous supply of fresh air while recovering heat from exhaust air that would otherwise be lost. This maintains indoor air quality and thermal comfort without significantly increasing energy demand. By integrating heating and ventilation into a single system (see Appendix B), plant space requirements are reduced, and system efficiency is improved, making the approach well suited to compact affordable housing.

Post-completion feedback from Wales & West Housing Association indicates that the PKOM₄ compact service unit has performed reliably in use, with measured coefficient of performance (COP) values of approximately 3.2 under operational conditions. However, the project team identified that the system controls were initially complex for residents, requiring the housing association to produce simplified user guidance to support effective operation (Davies, 2022).

4.2 Energy Generation and Storage

Energy-positive performance at Bryn Bragl is achieved using roof-mounted PV panels. PV capacities range from approximately 3.7 kW to 7.4 kW per dwelling, paired with 13.5 kWh of on-site battery storage (Wales & West Housing Association, 2021). Electricity generated on site is prioritised for household demand and building services (Davies, M. 2021).

Post-occupancy monitoring also identified that some system settings, including factory default boost functions and heated towel rail operation, led to higher-than-expected electricity use in certain dwellings. These issues were addressed through monitoring and adjustment, highlighting the importance of commissioning and ongoing performance review in energy-positive housing (Davies, 2022).

Battery storage plays an important role by storing excess electricity generated during periods of high solar output for use later in the day. This time-shifting of energy reduces reliance on grid electricity, increases self-consumption of renewable energy, and supports the development's energy-positive target. The combination of PV generation and battery storage also provides greater resilience to fluctuations in energy demand and increasing grid constraints.

4.3 Controls and User Interaction

Control systems play an important role in ensuring that the designed performance of low-energy homes is achieved in practice. At Bryn Bragl, occupants are provided with digital interfaces to monitor and control heating, ventilation, and energy use.

However, post-completion experience showed that resident understanding had a direct impact on system performance. Wales & West Housing Association identified that some occupants were unintentionally overriding efficient settings, which reduced system efficiency. These issues were addressed through revised control strategies and clearer user guidance, highlighting the importance of occupant support and post-occupancy monitoring in achieving the intended performance of low-energy housing (Davies, 2022).

4.4 Limitations and Risks

While the integrated services strategy offers high efficiency, it also introduces potential risks. The performance of compact service units is sensitive to installation quality and maintenance, and inappropriate user adjustments can reduce system efficiency. In addition, the capital cost of integrated renewables and battery storage may present a barrier to implement on a larger scale without external funding or incentives from the Welsh Government.

5. Critical Evaluation, Case Studies, and Recommendations

5.1 Overall Appraisal

While the dwellings were not formally certified to the Passivhaus standard, the building schedule confirms that Passivhaus-level design principles were achieved in practice, balancing performance with cost and delivery constraints (Wales & West Housing Association, 2021). The development shows that a fabric-first approach, combined with integrated renewable energy systems and compact building services, can significantly reduce operational energy demand while maintaining occupant comfort. Delivering energy-positive performance across a range of dwelling types is particularly significant within the social housing sector.

Post-completion review by the client identified several issues during early occupation, including airtightness detailing, foam application, window sealing, and system commissioning. These findings highlight that high performance depends not only on design intent, but also on workmanship quality and effective post-occupancy management (Davies, 2022).

However, the project also highlights a number of limitations. Performance remains partly dependent on occupant behaviour and understanding of control systems, creating a risk of performance gaps. In addition, the use of integrated technologies and specialist systems increases capital cost and requires a higher level of technical expertise during design, installation, and commissioning. Without appropriate skills development and supply chain support, these factors may limit immediate replicability.

5.2 Comparative Case Studies

The approach adopted at Bryn Bragl aligns with other Solcer-based and fabric-first housing developments in Wales. The Solcer Houses in Neath, delivered by Pobl Housing Association in collaboration with the Welsh School of Architecture, applied similar principles of high-performance building fabric alongside integrated photovoltaic generation and battery storage. Post-occupancy monitoring reported reduced energy demand and low running costs, supporting the view that the Solcer approach is transferable within the social housing sector when energy performance is considered early in the design process (Pobl, 2021).

A comparable fabric-first strategy can also be seen at Goldsmith Street, Norwich, a Passivhaus-certified social housing development delivered by Norwich City Council. The project demonstrates that prioritising fabric performance and airtightness can deliver consistently low energy use and high levels of occupant comfort (Passivhaus Trust, 2019). However, it also highlights increased capital cost and design complexity, reinforcing careful planning and execution taken at Bryn Bragl, which applies similar principles without full Passivhaus certification.

Conversely, industry reviews of earlier low-energy housing schemes incorporating MVHR systems have shown that poor commissioning, inadequate airtightness detailing, and limited occupant

guidance can lead to underperformance. Reviews by the Zero Carbon Hub emphasise that technology alone does not guarantee performance and that quality control and user understanding are critical to achieving design intent (Zero Carbon Hub, 2014). These findings reflect issues identified during early occupation at Bryn Bragl, where post-completion monitoring was required to address system settings and occupant use (Davies, 2022).

5.3 Recommendations for the Company

Based on this evaluation, it is recommended that the company adopts a fabric-first construction strategy as a baseline for future residential projects. Investment in training related to airtight construction and off-site manufacturing methods, such as SIPs, would reduce delivery risk. Early collaboration with experienced mechanical and electrical specialists is essential, particularly where integrated heat pump, MVHR, and PV-battery systems are proposed. Finally, the inclusion of clear occupant guidance and post-occupancy support should be prioritised to ensure that designed performance is achieved in practice.

6. Conclusion

This report has shown that the Bryn Bragl development provides a practical example of how energy-positive, affordable housing can be delivered through an integrated approach to design and construction. The use of a fabric-first strategy, SIPs construction, and well-coordinated building services has significantly reduced energy demand while maintaining acceptable levels of occupant comfort.

The project also highlights the importance of early design coordination, good workmanship, and ongoing support for residents in achieving the intended performance of low-energy homes. For the company, Bryn Bragl offers a useful benchmark for future sustainable residential projects in South Wales, provided that appropriate investment is made in skills, specialist collaboration, and post-occupancy monitoring.

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8. Appendices

Appendix A – Building Performance and Energy Systems Data

This appendix provides supporting technical information relating to the building fabric and energy systems installed at Bryn Bragl. It includes extracts from the Wales & West Housing Association building schedule showing house '1' photovoltaic system capacities, battery storage provision, and airtightness result for the development. This information supports the discussion of energy-positive performance and the fabric-first strategy presented in Sections 2 and 4 of the report.

House Type	No. Bedrooms	Air Tightness Test Result (m3/m2.hr @50pa)	EPC Score	PV	PV capacity (kW)	Electric Battery Tesla Powerwall	Electric Battery Capacity (kWh)	Heating System Combined Exhaust ASHP	Heating System Capacity
Semi Detached House	2	1.89	A	Yes - Roof integrated panels	5.4	Li-ion battery	13.5	ASHP	1.3kW Heat Pump 1.25kW Duct Heater 2 x 0.12kW Towel Rails

Figure A1: Extract from Bryn Bragl Building Schedule – Airtightness and Energy Systems

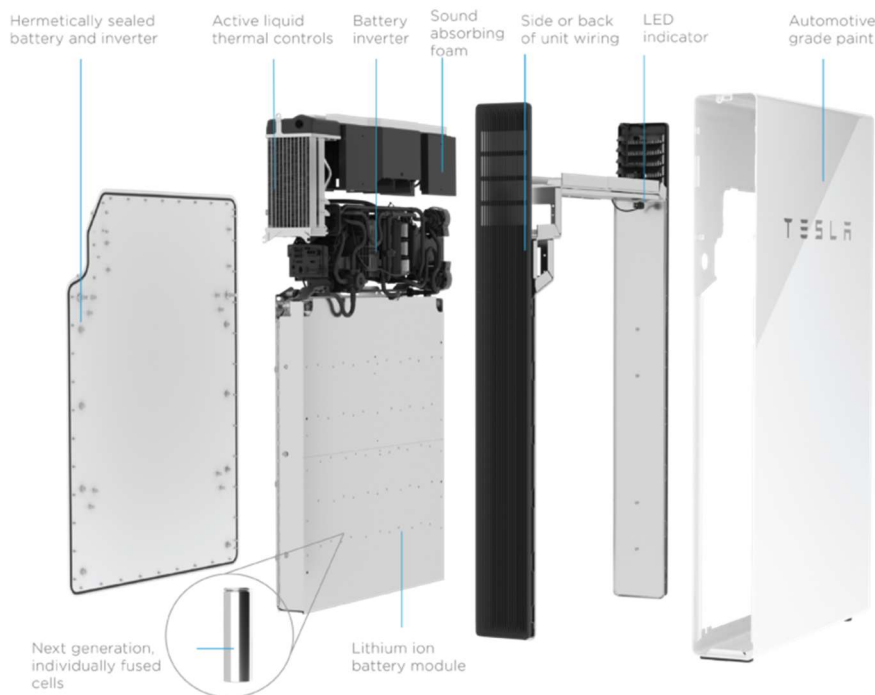


Figure A2: Exploded view of Tesla Powerwall battery illustrating internal components and integrated inverter used for domestic energy storage (Tesla, n.d.)

Appendix B – Energy Systems and Services Layout

This appendix contains manufacturer information illustrating the compact service unit used at Bryn Bragl and the typical integration of heating, hot water, and ventilation systems within a single unit. These images support the discussion in Section 4 but are illustrative rather than site-specific.

Functional diagram PKOM⁴ classic

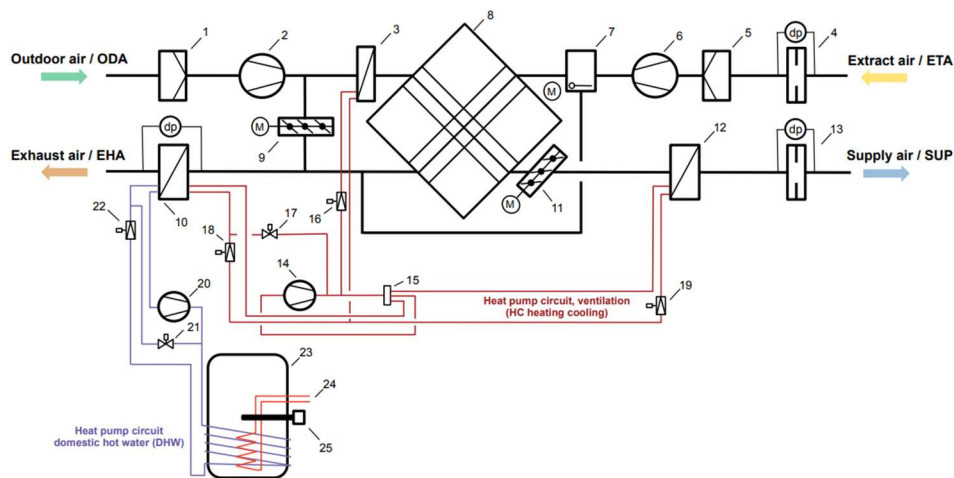


Figure B1: Functional diagram of the Pichler PKOM₄ compact service unit illustrating the integration of heat pump, domestic hot water, and mechanical ventilation with heat recovery (Pichler, n.d.).

Mounting example



PKOM⁴ system solution

Figure B2: Example mounting arrangement of the Pichler PKOM₄ compact service unit illustrating typical space and services requirements (Pichler, n.d.).

Appendix C – Site Layout and Orientation Extracts

This appendix includes selected planning drawing extracts showing dwelling orientation, roof layouts, and photovoltaic integration. These drawings provide visual support for the discussion in Section 3 relating to site constraints, solar orientation, and technology integration, and demonstrate how environmental considerations informed the final design



Figure C2: Site Section Showing Orientation and Topography



Figure C1: Roof Layout Showing Integrated South-Facing PV