Ampleforth

SUSTAINABILITY AND INNOVATION STATEMENT

September 2018

ethical partnership

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Approved for issue by: ARC

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Revision History

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V2	Final for Issue / Design Review	22/11/17
V3	Client Issue / Second Design Review	25/04/18
	Second Design Review (Print Copy)	01/05/18
V4	Planning Application Submission	21/09/18

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Commission Notice

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INTRODUCTION

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Executive Summary

The total thermal requirement for the new dwelling at Ampleforth has been modelled on the submitted designs. This report sets out the market's ability to provide an approach to meet the building's energy demands and a means for inter-seasonal energy storage

The energy performance figures are estimated and are based upon targeted thermal performance figures to provide and inform an overall approach. Detailed designs and energy strategy will be prepared when the fabric and architectural specification are confirmed.

A review of the suitability of the site for an Earth Energy Bank (EEB) mini-borehole solution has been undertaken based upon local geology. This technology has been identified as suitable and appropriate for the site. Heat will be transferred into and out of the concrete using a series of 1.5m thermal probes spaced at 1m centres, made from PEX pipe. This is similar to that used in conventional ground source heating systems. Thermal energy will be passed from an array of PV-T modules to the concrete using a glycol fluid medium. The same circuit will recover the heat when needed via a modulating, reversible heat pump, from which it will be passed, either to a DHW cylinder, or low temperature underfloor heating system throughout the main living areas. It is recommended that bedrooms be fitted with low voltage dc irradiant heat for occasional use when ambient temperatures are particularly cold.

Additional energy will be captured from hybrid Trombe walls and solar slabs. This will enhance the passive nature of the building and enable it to achieve a net zero-energy rating.

A review of the suitability of Trombe walling has been undertaken to ascertain the potential energy contribution to the building's overall energy requirements. This model provides an understanding of the potential level of contribution (subject to material selection and wall thickness, glass type and opacity).

The available heat contribution from the Trombe walls has been measured at **6,066kWh.**

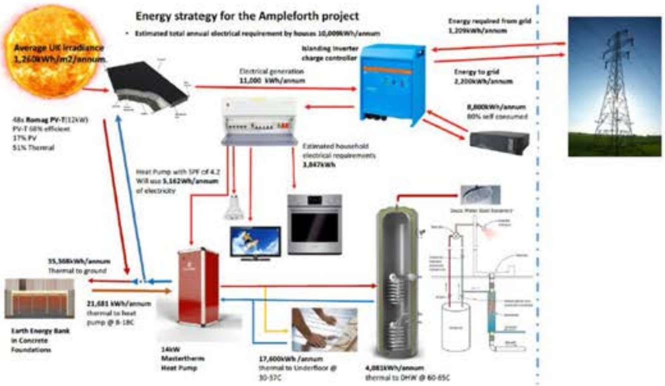
The building design will also include heat recovery ventilation, waste water heat recover, as well as low flow taps and showers, LED lamps and AAA rated electrical goods to minimize energy consumption.

Additional electrical energy will be produced via 48 x 250W Romag, ground mounted, Photovoltaic-Thermal collectors producing circa **11,000kWh/annum** electrical energy and **35,368kW** of thermal energy, meeting 100% of the buildings energy requirements.

A minimum of 9kWh of battery storage are proposed to be installed to make best use of the electrical energy produced on site.

Energy strategy flow diagram

The energy flow diagram below provides information on the technology types and estimated generation/usage of the main items of equipment designed to meet the buildings demand:



Purpose of this statement

Ethical Partnership has been commissioned by Mr Edward Fawcett to prepare an Innovation Statement to support a planning application for a new dwelling near Ampleforth Village.

The applicant has sought to maximise the scheme's sustainable development potential and is committed to the delivery of a high quality, energy efficient and low carbon building. The statement has been undertaken to provide a strategic review of the future energy demand and propose an innovative solution to meeting the energy demands and to reflect site specific opportunities and constraints.

The statement takes account of and has informed the architectural and landscape proposals. The development provides an opportunity to contemporise and demonstrate innovative self sufficiency and sustainability concepts. This statement should be read in conjunction with The Landscape Agency, Concept Masterplan and Landscape Appraisal and Sadler Brown Concept Designs.

The design seeks to satisfy the everyday needs of the family, to maximise daylight, provide natural ventilation, be energy efficient and relate to the wider landscape. The aim to create a fully responsive internal environment where the solar, thermal and compression technologies meet the energy needs of inhabitants.

Initial proposals were presented to the members of the **Integreat Plus design review panel** on 29th November 2017. The observations and comments made by members during the panel have informed the revisions to the scheme which were then the subject of a second design review which took place on 3rd May 2018.

In response to the comments of the Design Review Panels, the design team have spent considerable time further assessing and analysing the needs of the client with the fundamental objective of designing a new dwelling that is exceptional in the quality of the design and innovative in its approach.

The Design Panel response in December 2017 noted:

> *'that it is becoming increasingly difficult to demonstrate innovative sustainable design as the benchmark is constantly being raised. What was once considered innovative is becoming more mainstream, as these technologies or principle are being applied to other projects'*

The panel considered that demonstrating a strategy which is comprehensive would be more appropriate.

Design Review Panel confirmed that the second review should be innovative in its design approach.

"Paragraph 79" (Former Paragraph 55)

The section in the National Planning Policy Framework (NPPF) relating to isolated homes in the countryside was previously covered by Paragraph 55. A revised NPPF was published in July 2018 where Paragraph 55 became Paragraph 79. The wording of the policy remains the same.

> *'the design is of **exceptional quality**, in that it: - is truly **outstanding or innovative**, reflecting the highest standards in architecture, and would help to raise standards of design more generally in rural areas; and - would significantly enhance its immediate setting, and be sensitive to the defining characteristics of the local area.'*

This statement demonstrates that the scheme satisfies the tests and in demonstrates innovation in the integration of **building services and building performance**.

The development will demonstrate how to reduce carbon emissions, reduce exposure to external price volatility and aim for self sufficiently in meeting its water and power needs. In so doing it will employ;

- Passive and active solar architecture
- Locally sourced building materials
- Net zero energy rating
- Innovative 'designing out' of thermal bridging
- Innovative heat recovery systems linked to passive solar techniques
- Appointment of highly skilled trades with continuous supervision to deliver the required performance for airtightness

Evolution and Innovation

The evolution of the design has been informed by an assessment of the natural resources of the site and of the location. The proposals are for the construction of a dwelling which creates a balance between the landscape and architecture. This sensitively introduces sustainable building forms and solutions to the site. The new home and immediate landscape improve the ecological health of the eco-system through integration of eco-system services, supporting (biodiversity), regulating (storing carbon), provisioning (crops), cultural (recreation).

All available natural resources on site have been reviewed to effectively utilise the immediate site and wider site's resources. The principles of biotecture drive the design with vegetation integrated into the architecture with technological innovations integrated into the building form.

The focus is on realising the synergy between the aesthetics building planning, functioning systems for comfort and healthy internal environment and the landscape.

This statement describes the development of an inter-seasonal solution to harvest energy from the sun, the ground and the pond water to result in net zero energy rating.

Sustainability

"Creating communities that are economically, environmentally and socially sustainable, and which meet the challenges of population growth, migration and climate change will be one of the biggest tasks of this century" (Design for Social Sustainability, 2012)

Social sustainability should be seen as creating sustainable successful places that promote wellbeing, by understanding what people need from the places they live and work.

For more than 200 years the Benedictine monks of Ampleforth Abbey have been growing apples in the Abbey Orchards. Primarily this was to feed the community and the school, but as the years went by and the trees developed the supply of apples started to overtake the demand.

Not to be wasteful, the monks tried their hand at cider production, which was a great way to increase the lifespan of the fruit. It turned out the monks weren't that bad at making proper North Yorkshire Cider, so they decided to offer it to the public in order to generate revenue for the community

Sitting on the foothills of the North Yorkshire Moors, Ampleforth Abbey Orchards boasts over 50 different varieties of heritage apples, populating over 2,000 trees which span over seven acres.

The artisan range of ciders and apple products are produced onsite in a cider mill which is nestled within the Ampleforth Abbey Orchards.

Given the history of apple growing in the area it is considered that the proposals for an orchard are appropriate and reflect the economic and social character of the locality.

The applicant will look to supply the mill with apples grown in the proposed orchard. The applicant will also look to produce cider themselves and sell it in three pubs which they own and manage.

The three pubs are The White Swan and the White Horse in Ampleforth and the Fairfax Arms in Gilling East (The first Design Review was held here).

Economic sustainability refers to practices that support long-term economic growth without negatively impacting social, environmental, and cultural aspects of the community.

It is considered that the creation of a substantial orchard on site will assist in supporting long term economic success both for the applicant, for Ampleforth and the surrounding area. The apples grown will contribute to the supply for Ampleforth Abbey which is an established brand.

The reduction in food miles is an environmental benefit. The maintenance of the orchard and the harvesting of apples has the opportunity to create job opportunities for locals.

It is considered that the proposals are **environmental sustainable** as the Apples and other tree fruit crops inherently have a minimal environmental footprint. The process can have a positive environmental impact because trees remove carbon dioxide from the air and store it in the wood. Inputs such as fertilizer, irrigation systems, trellis materials, and the use of equipment all affect the environment. The wider proposals for the site means that there is the opportunity for rainwater harvesting providing irrigation and for the animals on site to provide fertiliser.

The proposals seek to establish the house and the proposed landscape in the community of Ampleforth. The applicant wishes to reinforce their connection with Ampleforth and to create further links that will strengthen the sense of community. These proposals emphasise how the proposals can be seen as socially sustainable.

Location

The application site is located at the western extent of Ampleforth Village south of Jerry Car Bank / Carr Lane, within the district of Ryedale.

Part of the site is know as Knoll Hill, The site is opposite the southern border of the North York Moors National Park, within the Howardian Hills Area of Outstanding Natural Beauty (ANOB)

It is proposed to position the new house at the southwestern corner of the site to protect the setting of the AONB and VIUA (Visually Important Undeveloped Area)of Knoll Hill. The new house will be sited to nestle into the existing landscape enjoying the views north up to Knoll Hill and connecting the new building with the wetland area.

- Water body, isolated pond within a dense natural regenerated woodland area to the south of the site. (Area 1)
- Marsh grass land (Area 2)

Designing for seasons / time

A full site appraisal and engagement with the client has identified the opportunities and constraints that the seasons present to the design. The effects of seasonal changes on the internal and external living environment can be predicted. These changes will be accommodated in the design and managed through passive and active systems.

As the gardens and wider landscape matures the succession in the eco-systems will alter the living environments. By understanding how eco-systems change over time we can accelerate the process and create productive ecosystems. This can be applied in the systems for the home in the understanding of the sun paths, transfer of heat using systems to accelerate processes to make the design productive.

Location

Following the constructive comments from Integreat Plus, a review was undertaken to provide justification on the proposed siting. The chosen location interacts well with the landscape and offers the opportunity for the house to engage with the landscape and have a relationship with the water body to the south to be incorporated in the energy strategy.

Site Opportunities

The opportunities afforded by the site include those related to;

- **Orientation;** making use of existing features; exploiting the benefits of the water body; Passive solar heating / cooling
- **Water:** Recycling of waste and rain water through filtration tank, reed bed system and surface infiltration
- **Manure**: Recycling' of manure (waste) for plant production [stables > orchard]
- **Natural capital**: enhancing; isolated pond and adjacent naturally regenerated woodland area to the south of the site; protecting and enhancing damp marginal grass land

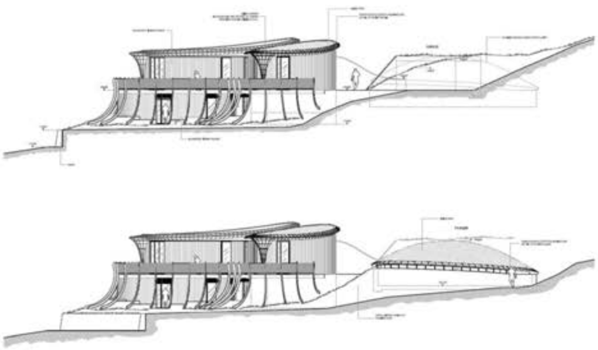
Natural and Bio-resources

SOLAR	→	ELECTRICITY / HEAT
SOLAR ENERGY IN GROUND	→	HEAT
WATER BODY	→	HEAT
RAINWATER	→	NON-POTABLE WATER
ANIMAL WASTE	→	ORCHARD, PLANTS

BUILDING SERVICES & SYSTEMS

2

Integration of Strategies



Schedule Estimation of Total Power and Electricity Requirement (Based upon an average annual heat load of 20kWh/m²/annum)	
Approximate GIA of living area = **800m²**	
Total annual heat load of living area @ 22kWh/annum = **17,600kWh/annum**	
Total DHW demand assuming low flow fittings and waste water heat recovery = **4,081kWh/annum**	
Total Thermal Energy Requirements = **21,681kWh/annum**	
Estimated Peak Heat Load = 8.15kW + 3kW for DHW = **11.15kW requirement**	
Total Estimated Electrical Load = **5,847kWh/annum**	
Total Estimated Electrical Load (as above with heat pump and solar charging) =**11,009kWh/annum**	
Total Estimated Electrical Load including gains from Trombe wall = **6,066kWh/annum**	

WATER
- RAINWATER HARVESTING
- GREEN ROOF
- REED BEDS

ENERGY
- PHOTOVOLTAIC—THERMAL
- SOLAR THERMAL
- GEOTHERMAL ENERGY
- GROUND-AIR EXCHANGERS

WASTE
- RE-USE
- RECYCLING

Assessment of Appropriate Technologies

An initial assessment of the thermal and electrical demands of the new dwelling the has been carried out. The energy demand consumption data and assumptions are based upon; the electrical usage patterns of similar sized buildings; an estimation of peak thermal demand based upon total kWh; and calculated using client-approved energy performance data. These assumptions will be further tested during; the preparation of construction stage drawings and specifications; full building performance analysis; and FSAP and room-by-room heat loss calculations.

Satisfying the thermal demands of the building is essential to ensure adequate levels of comfort. It is also central to understanding the how the thermal demand can be met from on site resources and consideration of the likely potential for on site electrical generation.

The principles of a 'Fabric First' approach have been used in assembling the preliminary specifications and technologies. This minimizes the need for energy generation for cooling and heating. The detailed fabric first design of the home to satisfy 'low /zero energy standards' will utilize best practice in avoiding cold bridging delivering an airtight building envelope.

The detailed design will take account of the fact that a fabric first approach can lead to potential overheating through excessive solar gain. The ventilation design and specifications will provide an ability to cool, as well as heat, the living spaces.

Reducing the need for artificial heating and cooling within the dwelling whilst controlling the air changes, enables an accurate prediction of the energy needed to heat the building. This makes a highly efficient low temperature heating system much more viable.

Electrical energy generation model

Meeting the thermal requirements of the property is an absolute priority. As PV-T modules produce both heat and electric. It is standard to size a PV-T array to cover the annual thermal requirements, whilst making up an shortfall in electrical generation with the use of photovoltaics, to reduce cost.

In this specific dwelling design however, only PV-T panels are required. 48 x 250W Romag PV-T modules, field mounted. They will provide **12kW(pk) electrical generation**, meeting both the thermal and electrical needs.

A 3 phase connection will be required but as the peak generation is only 4kW 16A/phase, the connection process to grid will be less onerous and can be done under a simple G83 generation license, saving cost and complexity in the application process.

The PVGIS model below provides an estimation of the electrical generation potential at the site location. These numbers are indicative, as a full sun cast model will need to be conducted as part of a detailed energy assessment.

A line of vision site analysis and recommend the correct positioning and array layout at detailed design stage.

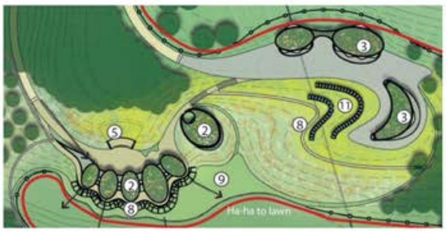


Figure 2.1 Extract from The Landscape Agency Dwg No. 1132-001 Concept Masterplan. Item 11 locating the ground mounted solar panels.

PVGIS ESTIMATES OF SOLAR ELECTRICITY GENERATION

Location: 54°11'57" North, 1°6'34" West, Elevation: 90 m a.s.l.,

Solar radiation database used: PVGIS-CMSAF

Nominal power of the PV system: 12.0 kW (crystalline silicon)

Estimated losses due to temperature and low irradiance: 6.4% (using local ambient temperature)

Estimated loss due to angular reflectance effects: 3.2%

Other losses (cables, inverter etc.): 14.0%

Combined PV system losses: 22.5%

Fixed system: Inclination = 35°, orientation= 0°				
Month	E_d	E_m	H_d	H_m
January	12.10	375	1.21	37.4
February	19.20	538	1.95	54.5
March	34.40	1070	3.58	111
April	40.60	1220	4.38	131
May	46.70	1450	5.11	158
June	43.70	1310	4.87	146
July	42.90	1330	4.82	149
August	38.10	1180	4.23	131
September	33.50	1010	3.63	109
October	23.10	716	2.43	75.3
November	15.70	471	1.59	47.8
December	10.60	327	1.05	32.6
Yearly average	**30.1**	**915**	**3.24**	**98.7**
Total for year		**11000**		**1180**

Ed: Average daily electricity production from the given system (kWh)

Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the m2) given system (kWh/m2)

Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

TOTAL ANNUAL GENERATION = 11,000kWh

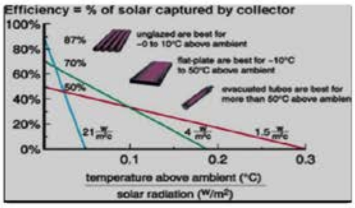
Exceeding total electrical energy requirements, taking the development to **net zero carbon**

Taking into consideration the energy input from the Trombe walls and use of a solar slab (discussed later), this technology approach would satisfy circa100% of the energy demand. There is the potential to export energy making it a net energy positive building.

Production and storage of thermal energy

Unglazed PV-T solutions have relatively low zero-loss collector efficiency and stagnate at a low 'delta-T', typically 45K above ambient. If a system can be designed to minimise 'delta-T', keeping the fluid temperature within the panel to as close to ambient as possible, this can dramatically drive up collector efficiency. This is amply demonstrated with simple swimming pool collectors, which can have an efficiency of up to 87%.

The graph to the right is showing different collector types, their stagnation temperatures against efficiency. Given that there will be an air gap between the zinc and the PEX pipe collecting heat, the proposed system, would perform somewhere between a standard flat plat collector and that of an unglazed swimming pool collector.



If the low temperature energy harvested from the solar thermal can be captured and stored in the ground, it can be used to drive up the efficiency of a heat pump.

The below graph shows actual test data from a system monitored by John Moors University, Liverpool, where solar charging has been applied to a 90 meter borehole, after an initial monitoring period of 12 months.

Figure 4 - Ground Temperatures recorded at weekly intervals from August 2009 to November 2012. For three successive seasons, the summer high has been nearly 14°C. For three successive winters, the winter low was higher than 10.0°C, and when there was no solar charging the winter low was below 5°C. The line and arrow indicates the date of installation of the solar augmentation system.

As can be seen, the resulting effect is an increase of winter ground temp of 9ºC. This resulted in a 25% increase in heat pump performance. This, effectively, takes the annual SFP (seasonal performance factor) from 3.8 to 5.

The graph below shows the diurnal effect of ground charging over a 12-month period. The data is from a live EEB (Earth Energy Bank). This has 1.5m bores densely packed within the footings of a building. The EEB is totally reliant on solar charging. The figure below provides a good graphic illustration of the charging effect. It should be noted that the minimum ground temperature is reached in March. This means that collector efficiency is at its maximum as the season heads into the peak irradiance period. This particular system below has been in continual operation since 2013 and has been monitored through this period. During this time, an interesting observation has been made – as the residual background heat has climbed throughout the period, the resulting wintertime minimum temperature has increased. It is anticipated that it will reach equilibrium after 3-5 years, but the effect means year-on-year efficiency gains should be possible (for the first few years, at least).

It is possible, to accurately predict the performance of the Romag PV-T collector, but, as its efficiency is a variable, proportional to the buildings thermal characteristic, additional data and detailed modeling will be required in order to produce actual thermal characteristics.

An estimation of system outputs have been provided using average data from houses of similar size and construction. The main purpose for undertaking this top level modeling is to assess the amount of solar thermal contribution to the overall system to ensure that the amount of solar thermal energy being provided to the system is more than that being withdrawn by the heat pump.

The sizing of the heat pump and corresponding array will be as per MCS guidelines. A fully modulating reversible heat pump would be specified to take advantage of any system gains provided by the PV-T system and the option for comfort cooling during summer months.

The heat pump solution should be coupled to a low temperature (below 37ºC) underfloor heating emitter to maximise any efficiency gains.

Inter-seasonal Energy Storage

A potential issue faced by ground source heat pump technology is geology risk. There are solutions on the market that can counter any geology and technology risk.

One such solution is the "Zero-Carbon Solution", which combines solar charging using Photo-Voltaic Thermal (PV-T) technology with inter-seasonal energy storage using shallow bores within the footings of the building; a system called an Earth Energy Bank (EEB). The innovative approach has been successfully demonstrated on a number of projects and comes with full academic support from De Montfort University, Leicester.

Figure 2.2 *The Earth Energy Bank (EEB) is a patented energy storage method. Heated fluid is pumped from the roof through a series of pipes underneath the house, warming the surrounding earth. Reference - http://zerocarbonsolution.co.uk/technology/earthenergybank/*

The EEB uses the medium directly under the building to store excess solar thermal energy from summer, to be recovered with the use of a heat pump to provide the demands for winter. Clay is an ideal medium for this approach, with a relatively high specific heat capacity and good moisture retention properties. Ampleforth sits on a clay basin named after the area the Ampthill clay basin making the site perfect for this proposed approach. A light top layer geographical survey will be required at detailed design stage but only the same information is required as will be needed as part of the ground surveys for the structural engineers.

Heat distribution mains

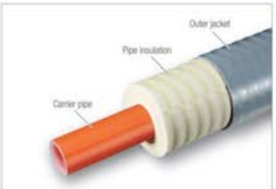


Figure 2.3 Rehau Rauthermex pre-insulated pipe.

The heat distribution is to be achieved using a mains pipe network via a pre-insulated heat mains (Please see Figure 2.9) The distances involved require pipe runs to be insulated with low thermal conductivity PU foam insulation (e.g. Rehau Rauthermex). This will minimise heat losses from the heat mains and maximise efficiency. The corrugated LDPE outer jacket around the foam provides durability and robustness. Rauthermex is thermally efficient and has a lambda value (thermal conductivity, is a value indication how well a material conducts heat.) 0.0216 W/mK.

Water Source Heat Pump (WSHP)

The proximity of the water body in the form of a pond may offer an opportunity to harvest additional energy and backup in the event that ground conditions do not provide the necessary heat source.

The pond has the potential to provide an ideal thermal environment as water is an excellent thermal conductor. The scheme will employ a water source heat pump to take advantage of consistent temperature of the pond. Water source heat pumps have a high Coefficient of Performance (Ratio of useful heating or cooling provided to work required. Higher COPs equate to lower operating costs.).

Figure 2.4 Water Source Heat Pump showing flexible heat collector pipes located on the base of the pond shown on the extract from The Landscape Agency Landscape Concept Masterplan.

Battery Storage

With the addition of 9kWh of battery storage, the property would be capable of managing up to circa 85% of its demand from onsite renewables and energy storage technologies. The building, by definition, will be zero-carbon, generating more power on site than would be consumed. It would be possible to become completely self-reliant (off grid), but the associated technology cost with additional battery storage would not pay for itself within the lifetime of the batteries. Therefore, this approach is deemed to be not viable at the time of writing.

Energy strategy

The supporting energy usage data and assumptions have been based upon the electrical usage patterns of similar sized buildings and estimation of peak thermal demand based upon total kWh, calculated using client approved energy performance data. This information will be subject to further refinement to follow a full building performance analysis, FSAP and room-by-room heat loss calculations, which would be undertaken at the detailed design stage.

Meeting the thermal demands of the building to ensure adequate levels of comfort is the primary focus. Once the total thermal requirement is known and how that is to be met using onsite renewable sources of energy, the focus shifts to the electrical generation potential. The national grid will be a standby option to provide any shortfall in power, this offers flexibility in how the demand is met and any potential energy storage solutions.

An Earth Energy Bank (EEB) is proposed for inter-seasonal thermal storage. Heat will be transferred into and out of the EEB using a series of 1.5m thermal probes spaced at 1.5m centers, made from PEX pipe. These are similar to those used in conventional ground source heating systems. Thermal energy will be passed from an array of PV-T modules to the concrete using a glycol fluid medium; the same circuit will recover the heat, as and when needed, via a modulating, reversible heat pump.

Low temperature heat underfloor emitters would be used in the main areas of the building and heat re-distributed through the use of Heat Recovery Ventilation. Low voltage electric irradiance heating will be considered in bedroom spaces, where a small amount of periodic top-up heat may be required.

Additional electrical energy will be produced with 48 x 250W Romag Photovoltaic-Thermal collectors producing circa 11,000kWh/annum electrical energy and 35,368kW of thermal energy, meeting 100% of the buildings energy requirements.

It is recommended that a minimum of 9kWh of battery storage be installed to make best use of the electrical energy produced on site and to minimize spill to the grid.

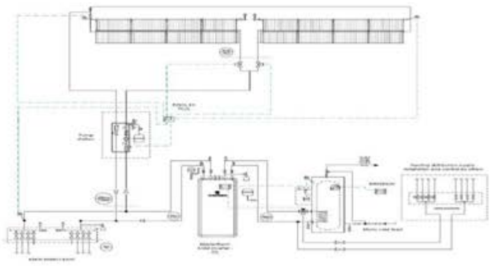


Figure 2.5 An example of the hydraulic arrangements, coupling the PV-Thermal collection system with the ground source heat pump.

Meeting the Electrical Demand

The majority of the demand will be met by 12kW of Photovoltaic-Thermal which is to be ground mounted.

Below shows the monthly estimated heat load, electrical generation and projected heat pump demand, showing monthly generation excess/shortfall in demand.

Additional to the heat pump demand shown above, the building will use an estimated 5,847kWh of electricity per year.

The amount of "spill" (over generation from the photovoltaics) available for onsite diurnal, or inter-seasonal storage = 3,899kWh/annum. The over-generation will predominantly occur during summer months leaving a shortfall in the winter to be bought back from the grid.

It is recommended that a 9kWh 3phase Lithium Iron / Lithium Iron Phosphate battery solution is used to meat peak power requirements. This system will be prioritised in terms of charge/discharge cycles, as the round trip efficiency of modern Li solutions is in excess of 97% and the rate of discharge is able to modulate to keep up with the peaks and troughs in demand.

	Thermal					Electric		
	Heating Requirement kWh	Hot Water Requirement kWh	**System thermal Requirement kWh**	**Solar thermal Output kWh**	Thermal difference kWh	**System electrical output Energy AC**	Heat pump Electric requirement kWh	Electric difference kWh
January	3677	422	**4099**	443	**-443**	375	976	-601
February	3145	370	**3515**	1032	**-2483**	538	837	-299
March	1646	382	**2028**	2884	**855**	1070	483	587
April	1084	332	**1416**	4377	**2961**	1220	337	883
May	302	320	**622**	5205	**4583**	1450	148	1302
June	0	276	**276**	5236	**4960**	1310	66	1244
July	0	256	**256**	4988	**4732**	1330	61	1269
August	0	292	**292**	4297	**4005**	1180	70	1110
September	106	298	**404**	3748	**3343**	1010	96	914
October	1406	346	**1752**	2002	**250**	716	417	299
November	2665	378	**3043**	846	**-2197**	471	725	-254
December	3567	410	**3977**	310	**-3667**	327	947	-620
	17,600	**4,081**	**21,681**	**35,368**	**16,900**	**11,000**	**5,612**	**5,835**

Trombe Wall

The use of the Trombe walls to cut down winter heating costs in cold climates is currently a subject of great interest. In this passive solar design, a concrete wall is placed next to an outside layer of glass. The outside surface of the wall absorbs the sun's heat during the day and sets a heat wave flowing through the wall which warms the adjacent room.

This project proposes a hybrid Trombe wall integrated at the flowing footprint a near horizontal glazed outer layer (See Figure 2.8 Location of Trombe Walls). Convection currents will draw the warmed air through the living spaces . The air will gradually cool and will recirculate through an integrated MVHR (Mechanical Ventilation Heat Recovery) system and ducts in the floor back into the Trombe wall and solar slab for re-heating.

Figure 2.6 Trombe wall examples

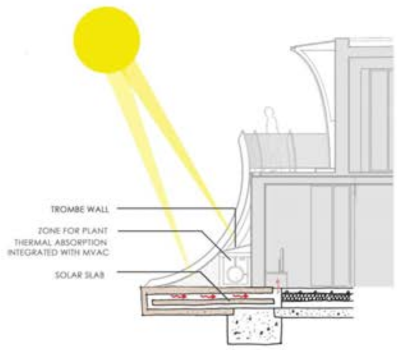


Figure 2.7 Location of Trombe Walls where all the principles shown in Figure 2.6 have been translated to an near horizontal plane to optimize the performance in the location.

The detailed design of Trombe walls will be focused on the relationship with the properties (thickness and thermal properties) to the location within the new dwelling. Based on the principles of solar engineering the system will operate passively using convection currents to drive the air movements. During winter the weaker convection currents will be assisted by the MVHR system incorporated beneath the Trombe walls. The design incorporates two connecting systems with the external solar slab closed off during winter months.

The air will flow by convection or with aid of fans into sub-slab storage system. Cavities will be positioned running north to south creating a continuous flow of air which will be drawn on by the MVHR unit.

Figure 2.8 Location of Trombe Walls

Each hybrid Trombe will be connected to a main MVHR unit and heat exchanger .

- During the day, sunlight passes through the glazing being absorbed by the thermal mass of the wall, which stores the heat and releases the heat at night for thermal heating.
- Warm air between the glazing and the wall rises into the living space through vents at the top of the wall while cool air from the living area and corridor enters the solar slab through vents and ducts near the bottom of the wall.

Solar slab

The goal in designing a passive solar slabs thermal mass is to be able to store midday solar heat until the early evening, when it will passively return to the living space.

The south-facing glazing design standard for a passive solar home is a window area between 7% and 12% of floor area. This ratio can be applied to the entire house if all stories are to be passive solar designed, or just to the primary living floor.

Beyond 12%, the active solar range is entered, in which direct-gain thermal mass is not sufficient to maintain a uniform and comfortable indoor temperature. This has led to the inclusion of pumps to move the heat to remote storage and retrieve it on demand.

Heat Pump

The system proposed is a reversible modulating heat pump, coupled with solar charging and low temperature underfloor heating/cooling.

Emitters would only be situated in the main living areas, supported by MVHR (Mechanical Ventilation Heat Recovery) supplying fresh filtered air throughout the building and ensuring adequate distribution of heat. Bedroom spaces would have low voltage irradiant heating, for periodic use. Bedrooms tend to be a degree or two cooler than the main living areas, and the MVHR will meet the needs of bedroom spaces by balancing temperature from the heated spaces.

A heat pump solutions is highly suited for applications such as the proposed dwelling. However, their efficiency drops as their energy source becomes depleted during winter months, when heat is required. Typical Seasonal Performance Factor's (SPF's) of ground source heat pumps are 3.8 (i.e. one unit of electrical energy is used to create 3.8 units of heat), in order for a heat pump to outperform a conventional gas boiler in terms of carbon efficiency and running cost, it needs to exceed an SPF of 3.2.

Trombe Wall Assessment

A review of the suitability of Trombe walls has been undertaken to ascertain the potential energy contribution to the buildings overall energy requirements.

The Design Panel endorsed the proposed Trombe wall and solar slab as being innovative in a domestic environment.

It is considered that the changes to the architectural design to the main dwelling including the change to geometry and location of the Trombe walls, solar slabs and MVHR pods in response to Design Review Panels comments offers the opportunity to significantly increase the amount of solar gain available for these innovative building techniques in the domestic setting. This will optimize the overall energy performance of the passive proposals. The design development is discussed in detail in the Architectural Design and Access Statement, September 2018 prepared by Sadler Brown.

A model has been developed taking into account the amount of annual solar energy (hourly contribution), the seasonal angle of incidence, reflection/refraction of glass and summer shading/ bypass, to provide an understanding of the level of contribution the solution may provide. At the detailed design stage the model will consider final material selection, wall thickness and glass type.

The use of Trombe walls will reduce the total energy requirements by as much as **6,000kWh/annum**, this addition will reduce the overall electrical requirements by up to 1,000kWh/annum resulting in a net energy positive building. This further reduction opens up the possibility of achieving net zero-carbon using only the PV-T and EEB solution, without need for further electrical generation.

Without the Trombe wall, it would be marginal that the onsite energy would meet all the demand, without some additional Photovoltaics.

The standard design analysis is based on extensive numerical simulations of various case studies. However, an alternative approach based on non-steady heat conduction has been utilised for this initial study. If monthly behavior is to be reviewed, rather than daily behavior of the wall, and the wall is heavy, then it is sufficient to consider the solar heat flow into the wall to be sinusoidal in time.

Using some basic results from transmission line theory, it is possible to give a simple model in which all the various parameters affecting the wall performance can be easily compared without resorting to complex numerical simulation. The results provide good agreement with the more complex models. The designing detailing of the wall to maximize the heat flow into the building at a specified time will also be considered. A full model will be developed at the detailed design stage, for the purposes of this study a general indication of the amount of energy contribution from Trombe walls has been calculated.

As well as wall thickness, thermal mass, wall color and glazing type/opacity are important factors. Typically, low G glass (i.e. glass with high opacity) allowing high transition of solar gain are recommended, also the use of double glazing to maximize on thermal retention should be considered.

For the purpose of this study, a more simple model has been developed to understand potential energy gain from the Trombe wall taking into consideration shading, reflection/refraction/ transmittance, wall area and location. The model shows energy contribution on an hour by hour basses, through the year, with an assumption that a combination of venting and shading are used to prevent energy contribution between the months of March to October.

The Trombe walls have been assessed and a total potential contribution calculated, showing a total of 6,066kWh energy provided to the building from the 8 groups of hybrid Trombe walls.

SUMMARY ASSUMPTION AND RESULTS:

27 Trombe walls in 8 groups = 33.89 m²

Transmittance = 98.52% (Low G double glazing, U Value 1.2)

Reflectance = 5.8%

Heating start = October 1st

Heating stop = March 31st

Potential Available Energy = 6,066Wh*

**NB: The useful energy will be less than this number and determined by final material selection and design.*

Canadian Well and heat recovery ventilation system

A Ground-air exchanger is proposed to be linked to the MVHR, providing a full ventilation solution for the home and taking advantage of the large land areas. The air arrives from the Canadian Well and enters the ventilation unit where the air is diffused inside the building. The ventilation system balances the flow of fresh air from the Canadian Well and the flow of stale air extracted from the building while at the same time optimising the heat exchange. This system can be controlled by a home automation system.

The system is supplied by a network of pipes laid around the home at 1.5m below ground. Fresh air is then drawn through the pipes via an air intake and the pipe acts as a high performing heat conductor allowing heat transfer between ground and air.

The ground temperature is colder than outdoor air in the summer season and warmer than outdoor air in the cold season. The earth tubes pre-temper outside air for ventilation using geothermal energy.

The ventilation air can be drawn through the underground pipes, which pre-cools the air in the summer and pre-heats it in winter by using the near constant temperature of the ground (8-12 °C)

On the hottest of summer days the system has the effect of pre-cooling the incoming air by up to 14°C and in the winter of pre-heating it by as much 9°C.

Figure 2.9 Image below 'Canadian Wells' system. Image extent of site area

Passive stack and MVAC

The quality of the air within the dwelling will be managed by employing both active and passive systems. A bespoke Mechanical Ventilation and Heat Recovery (MVHR) system will extract warm air from bathrooms, kitchens and other rooms through a duct system. This air will be passed through the MVHR unit to extract surplus moisture together with pollens, particulates, pollutants and pathogens. The air will be returned as fresh dehumidified air which is pushed through the ducts in the floors and walls by the ultra energy efficient fans. The system will be designed to move air from those rooms with surplus solar gain into those with a solar energy deficit.

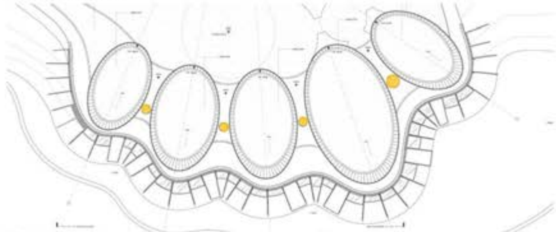
The MVHR will supplement and complement the passive Trombe wall and solar slab system.

The innovation is in incorporation of ducts connected with the solar slab / Trombe wall and the integration of active with passive air management systems.

Light wells

The design includes deep light wells within the main residence which will offer light into the deeper rooms of the dwelling.

This offers an opportunity to benefit from the a stack effect providing a driving force for vertical air movement. Air driven by stack and wind pressures will cause vertical air movement and benefit air quality within the dwelling.



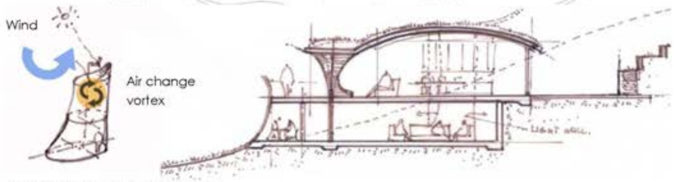


Figure 2.9.1 Location of light wells

Innovation Summary

The innovation demonstrated is the connection of the Trombe wall and solar slab with the hybrid solar PV-T, heat pump and earth energy bank intersessional storage.

The benefit of tying these elements together adds the thermal energy to the system, **minimizing potential overheating**, by removal of excess thermal gain from the solar slab, **adding that energy** to the thermal energy from the PV-T and **storing it** for when its needed most.

(i.e. in winter when there is potential for little solar gain and the ambient temperature is at its coldest.)

External Envelope

The specification of the external envelope and employed systems are to result in a high performing responsive envelope. Green roofs and living walls to float above concrete decks to create living architecture.

Biotecture-Green Roofs and living walls

Green roofs will provide a surface for vegetation to grow and reoccupying the land which the building is sited within the landscape. Green roofs offer a number of sustainable advantages, providing a useful habitat for birds and invertebrates, the ability to store water during a storm which will alleviate pressure on the rainwater harvesting system.

- Absorb heat from the sun / Temperature regulation
- Sound proofing
- Absorption of carbon dioxide

Living walls / Bio-wall

Self sufficient vertical garden living wall panel systems offer a living connection with the landscape while also

- Protects exterior walls from weather damage and corrosion
- Adds to biodiversity: attracts bees, butterflies, insects, bats and birds
- Keeps building cooler in summer as well as warmer in winter

3 HYDROLOGY

Hydrology

The proposals include:

- All rainwater falling on all roofs will be collected, filtered and reused for drinking for animals, flushing toilets, and cleaning etc
- The extent of the ground surfaces which are impermeable have been minimised to allow recharge of the aquifer by rainwater. etc
- All grey water will be processed through the Klagester etc
- All foul water will be processed through the Klagester etc

The significant water demands of most homes do not need to be met by water that meets drinking quality standards. Current average consumption in most homes is in excess of 160 litres per person per day. Flushing toilets, watering plants, washing clothes can all be undertaken using recycled rainwater, and appropriately abstracted and filtered water.

Water that is not only 'grey water' but effectively contaminated is taken and filtered by the house and reused to meet a significant proportion of the water demands of the home.

Additional measures, such as wastewater heat recovery and low flow showers and taps, will go further in reducing the overall thermal and water requirement and demands.

Surface Drainage

The NPPF indicates that "Surface water arising from a developed site should as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development, while reducing the flood risk to the site itself and elsewhere, taking climate change into account".

Foul Drainage

The most sustainable option for a residential property in this location is for a septic tank or package sewage treatment plant with effluent discharged via a properly designed and sized infiltration system into the ground or to a local water course. This option will be designed in conjunction with a manufacturer and the Environment Agency.

For the main residence, the proposals include a Klargester waste water sewage treatment, employing biological trickling filter process where a natural breakdown of sewage can occur.

The sewage treatment plant supports a biologically active film or biomass onto which aerobic micro-organisms, naturally found in sewage, become established. Natural breakdown of sewage can then occur. The Klargester is proposed to be positioned to the east of the site feeding outflow into biofilters located within the garden with the overflow into the pond.

Figure 3.0 Example Klargester waste water sewage system.

Reed Bed, Natural Filtration

A reed bed is proposed to be positioned 'downflow' of the unit and will provide additional filtration to further enhance the quality of the effluent. Once 'cleaned and filtered it will be allowed into the adjacent pond, field or surrounding watercourses.

Reed beds are an environmentally sustainable method for the treatment of contaminated water. As well as being beneficial for wildlife, they are often significantly cheaper than the equivalent mechanical systems and are easier to operate and maintain. Reed beds are very efficient at treating effluents including sewage.

The site for the reed bed will be to provide good sunlight for reed growth and be located down slope of the primary treatment unit to allow for gravity flow through the treatment system.

Indigenous deciduous shrubs and tree will be planted around the border of the reed beds. Shrubs will be thinned and lower branches removed to allow for air movement across the ground surface, aiding in evaporation.

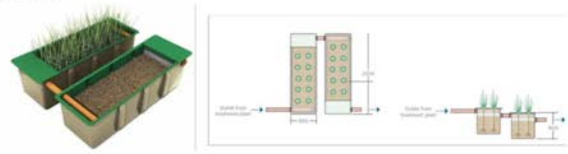
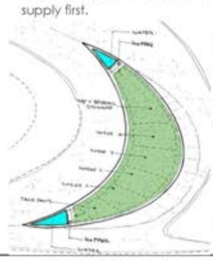


Figure 3.1 Example Reed Bed System

Rainwater Harvesting

A rainwater harvesting system will collect rain from roof guttering, filtering out leaves and debris and storing water in an underground tank.

The water will then be pumped into the house to be used for non-potable applications for example the filtered rainwater can be used for various appliances, WC flushing, washing machines, vehicle washing and garden watering. If the tank runs empty, the system automatically switches to the borehole supply to ensure a continuity of service. The system will always draw from the rainwater supply first.



Both the barn and stables have open water collectors which can serve the horses on site and for site activities.

There is also the potential for the rainwater harvesting to provide irrigation for the on site orchard.

Figure 3.2 Location of water collectors shown on stable roof plan

BUILDING PERFORMANCE

4

Introduction

The Government has recently introduced a new system which comprises of optional Building Regulations on water, access and a new national space standard, referred to as the new national technical standards.

This includes regulations for the energy used to provide space heating and cooling, hot water and fixed lighting, as outlined in Part L1A of the Building Regulations. The design has been discussed with BRE and will contribute to the emerging body of research into the deliverability of zero carbon homes.

Although emissions resulting from cooking and 'plug-in' appliances such as computers and televisions are not addressed as part of any zero-carbon commitment this ambitious paragraph 79 house will be zero carbon with respect to these emissions. In this way, the home will exceed the planned future zero carbon standards for the UK.

Zero Carbon Solution

The innovative paragraph 79 house will deliver on the core requirements for the development to aim to qualify as zero carbon:

- The fabric performance will as a minimum comply with the Fabric Energy Efficiency Standard (FEES) – Target is 52 kWh/m²/yr.
- All the CO_2 emissions that remain after consideration of heating, cooling, fixed lighting and ventilation, will be less than the Carbon Compliance limit - Target is 10kg.CO_2/m²/yr.
- The FEE is not influenced by building services; heating system, fixed lighting or ventilation strategy. As a performance standard, it will employ different combinations of fabric specification to achieve the targets. This has allowed flexibility in the selection of innovative structural, fabric and finishing materials and thermal specifications. The Fabric Energy Efficiency (FEE) modelling has taken into account the emissions arising from both the space heating and cooling demand from the house.

The FEE target performance will be achieved by;

- Building fabric U-values;
- Thermal bridging; attention to detail in engineering the structure and fixing to the external building envelope
- Air permeability; attention to detail in the design of service entries
- Thermal mass; - including slow release massing
- Solar orientation – maximising the available gains through alignment of the house and all the ancillary buildings
- Daylighting - maximising this from fenestration design
- Energy recovery – using MVHR
- Passive heat gains from occupants

Thermal Efficiency

The house and the ancillary buildings realise the benefits of the solar orientation and thermal mass building techniques. This will reduce the demand for artificial heating and cooling systems in the house.

The thermal massing has been designed to balance the internal space heating demand and the solar gains. This recognises that comfort and performance increases with increases of thermal mass and acknowledges that there is no upper limit for the amount of well-designed thermal mass. The architecture reflects a managed tension between the desired aesthetics of design and the required performance from building physics.

Wherever possible as much thermal mass has been located in direct sunlight (heated by radiation) – longer term heat storage is provided by the mass that is located out of the direct sunlight (heated by air convection and geothermal radiance).

The high thermal mass materials will conduct a significant proportion of the incoming thermal energy deep into the structure of the home. This means that instead of the first couple of millimetres of a walls heating up 5–10 degrees, the entire wall will heat up only 1–2 degrees. The material then re-radiates heat at a lower temperature, but re-radiates it for a longer period of time.

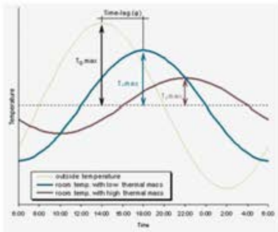


Figure 4.0 Thermal mass model

This will help occupants stay more comfortable, longer and support the underfloor heating. When the internal temperature of the space falls at night, there is more energy still stored within the walls to be re-radiated back out.

The underfloor heating efficiency will be improved by more than 50% as a consequence of the innovative massing of the building.

5

CONSTRUCTION

Responsible Sourcing of Materials

The materials to be employed in the construction of the home will be selected according to the extent which they; contribute to health and well being of occupants, include content from renewable and recycled sources, and are of local provenance.

The procurement of construction materials will generally be in accordance with the BRE guide for green building materials.[1] The innovation in the house will be the priority being given to embedding the economic benefits of the construction in the local economy. The bespoke building components will be sourced from local artisans, There will be an emphasis on supporting local SME's. The project aspires to source, Corten steel , Grass roof and timber as locally as possible.

An audit of the on-site geology has confirmed that all soils and stone which will be excavated for the foundations, service trenches, roads and heat collectors can be reused within the construction.

In particular the gravels, subsoils, top soils, and organic materials will be reused and employed in both the building and the grounds. For example, the high levels of organic materials can be used in the establishment of green roofs.

A cut and fill balance can be achieved and this will ensure that the need for new materials to be imported to site is minimised. This will also avoid any materials being taken off site.

This level of commitment to reducing the need to importing new materials will lead to a substantial reduction on the carbon footprint of the construction.

There are significant areas of sustainably managed woodland within 20 miles of the site. There are local carpentry and joinery fabrication facilities. As such it is expected that close to 100% of the Building Elements can be locally /responsibly sourced including: window frames, joists, beams, roof trusses, external cladding, internal walls (including separating walls), Foundation/substructure, Stairs and all timber windows, External & internal doors, Skirting, Panelling, Furniture, Fascia and timber used during construction, including formwork, site hoardings and other temporary site timber used for the purpose of facilitating construction will be sustainably managed sources and independently certified.

Sustainability of Materials

The construction is based on lean methods utilising materials from renewable sources which are available or produced as close to the site as possible. Wherever possible materials that incorporate a proportion of post-consumer recycled content will be used. This will allow the construction to stimulate the production of new construction materials and to minimise the carbon footprint of the construction. The procurement framework for the construction will be guided by the BRE Green Guide to Specification. This will allow the impact of the home to be understood when comparted to the Green Guide 12 criteria[2]

1 BES6001:2008 Issue 1 Framework Standard for the Responsible Sourcing of Construction Products, BRE Global, 2008.

2 1.Climate Change 2. Water Extraction 3. Mineral Resource Extraction 4. Stratospheric Ozone Depletion 5. Human Toxicity 6. Ecotoxicity to Freshwater and Land 7. Nuclear Waste 8. Waste Disposal 9. Fossil Fuel Depletion 10. Eutrophication 11. Photochemical Ozone Creation 12. Acidification

This will allow the impact of the home to be understood when reviewed with the Green Guide Calculator. Materials resource efficiency The diagram opposite shows how this can be approached and the white boxes highlight the areas where designers can have a significant impact.

Figure 5.0 Example of materials resource efficiency as part of sustainable construction

Waste Minimisation

One of the most innovative aspects of the paragraph 79 home is the plan for end use and deconstruction so that, when future modifications or decommissioning occurs this can be undertaken with ease and minimal waste. Spaces are flexible (to allow for changes in usage) and future-proofed against advances in technology and trends.

Materials have been selected that reduce waste and that have recycled content based on durability and reuse and recycling options. These materials are consistent with the expected life of the home.

Prefabricated and pre-cut components will been specified where ever possible, recognising that off-site fabrication will reduce waste, facilitate separation of waste streams and improve recovery rates.

The final design will take into account efficient distribution routes for building services.

The internal layout incorporates adequate space for segregation and storage of recyclables and organic materials. Composting, reuse, and self-sufficiency is at the heart of the design philosophy.

The excavated material during the build will be utilised on site for landscaping, base for drainage and the mound feature of the swimming pool. Top soil will be retained and treated on site with compost (or other remediation) for the use on the green roof and for soft landscaping.

The detailed design stage will incorporate structural design optimisation to include, optimisation of size of structural members and positioning of load bearing elements to allow for future flexibility.

At construction stage the contractors are to identify and implement the best opportunities on a project.

Airtightness

The design and the quality of the construction of the home will have a major effect on the amount of air leakage. Moving from an air tightness of $3m^3/m^2/h$ @ 50Pa, to $1m^3/m^2/h$ @ 50Pa, results in a 50% decrease in the annual energy required to meet the thermal demands of a space (currently to meet building regulations an air permeability of building must be below $10m^3/m^2/h$ @ 50Pa is required.

By eliminating the need for heat in the first place, and having control of the air changes, it is possible to accurately predict the amount of energy needed to heat the building envelope, making a highly efficient low temperature heating system much more viable.

The design has taken into account the potential impact arising from wind against the elevations and the buoyancy effect (warm air rises and creates a drawing effect, pulling air in through gaps in the ground floor and walls). Cold outside air may be drawn into the home through gaps in the walls, ground floor and ceiling (infiltration), resulting in cold draughts. In some cases, infiltration can cool the surfaces of elements in the structure, leading to condensation.

The principles of a Fabric First approach will be applied in detailing of the low energy dwelling which will deliver less cold bridging and greater airtightness.

Warm air leaking out through gaps in the home envelope (exfiltration) could be a major cause of heat loss and, consequently, wasted energy. The design and the quality of its construction will have a major effect on the amount of air leakage.

The windows and doors will have a level of thermal performance that will far exceed Building Regulation Standards. While the main focus is the achievement of an airtight home, ventilation is necessary for a comfortable and healthy environment as it removes or dilutes pollutants that accumulate inside. The airtightness strategy has taken into account the potential sources of pollution within the internal environment including:

- Moisture
- Volatile organic compounds (VOCs)
- House dust mites
- Oxides of nitrogen
- Carbon monoxide (CO)
- Carbon dioxide (CO2)
- Tobacco smoke /Food smells/Body odours

Our approach to airtightness for the home is based on the managing the most significant pollution risk which is moisture. The high volumes generated by common activities such as cooking, showering, bathing and laundry have a significant potential to cause deterioration of the building finishes and fabric and prejudice human health. Moisture from these activities can result in condensation and, in extreme cases, mould growth.

In order to deliver the airtightness targets the construction will be sequenced so that each part of the air barrier is completed before following trades cover the work. The 'out of sight – out of mind' approach will not achieve airtightness: a subsequent pressure test will show up any inadequacies. The sequencing recognises that the test simply shows the overall airtightness.

Subsequent air leakage audits will be needed to identify significant leakage paths. This will ensure that leakage is identified before the air barrier has been concealed.

The site supervision of the 'following on' trades will ensure that works will not compromise the air barrier by accidentally damaging it, or even deliberately penetrating it in order to complete their work. it will ensure that if additional service penetrations are needed after the air barrier has been completed, the damage caused to the barrier will be repaired. These repairs will be made before the air barrier is concealed. The strategy for ensuring airtightness is achieved will be:

- Appoint an independent airtightness adviser.
- Appoint an air barrier manager.
- Identify the line of the air barrier at an early stage of design.
- Inform the project teams of the importance of the air barrier.
- Refer to airtightness in all contracts which impact on the air barrier.
- Specify and/or select airtight components.
- Check interfaces between components and work packages to ensure the continuity of the air barrier.
- Inform the site management team of the location and importance of the air barrier.
- Explain to site operatives the critical importance of airtightness.
- Check air barrier completeness before it becomes impossible to access.
- Schedule an airtightness test by a competent body well in advance.
- Pre-test visit to site by the testing body.
- Ensure all airtightness works are complete.
- Contractor to have responsibility for sealing vents and open flues, closing trickle vents, external doors and windows, in preparation for airtightness test.
- Airtightness test carried out and results issued.
- Results submitted to Building Control/client by contractor.

The desire to ensure that buildings are airtight is not in itself innovative, the level of rigour and focus on this issue is highly unusual on a residential project and therefore displays innovation in application.

HEALTH AND WELLBEING

6

Air Quality and Humidity

The paragraph 79 home is designed to counter the risk of relative humidity levels exceeding 70 per cent for prolonged periods. In these situations, there is a high probability that the condensation occurring on cold surfaces will lead to mould growth.[3] A ventilation rate of between 0.5 and 1.5 air changes per hour (ach) for the whole dwelling will usually be sufficient to control condensation[4] but this is rarely achieved in modern homes.

These levels of ventilation are generally sufficient to control many other indoor pollutants e.g. combustion products generated by gas cooking, VOCs from building and consumer products, body odours. The paragraph 79 home will employ smart whole house mechanical ventilation (MVHR) system with supply and extract ventilation with atmospheric control system.

This will incorporate a heat exchanger for energy recovery. The system will extract warm moist air from 'wet' rooms via a system of ducting and is passed through a heat exchanger before being exhausted to outside. Fresh incoming air is preheated via the exchanger and ducted to the living room and other habitable rooms.

The system will contribute between 10 and 25% of the heating load of the house and in so doing will complement the provision of space heating from the underfloor heating. The system will be dual speed, providing low-speed continuous 'trickle' ventilation, and high-speed 'boost' extract flow.

The system will provide a ventilation system almost independently of the weather conditions. The energy saving and air quality benefits are proportionate to the airtightness with greater that proportionate benefits for <3m3/hr/m2 at 50Pa.

The amount of ventilation needed in each room will be influenced by the pollution level in that room (and, in some cases, whether anyone is present). Automatic controls will be provided with humidity sensor, occupancy/usage sensor, and detection of moisture/pollutant release. This will reduce the level of ventilation if the source of pollution and/or the pollution level is low, and thus save energy.

The ducting will be installed to minimise flow resistance (e.g. cutting the duct to length and minimising kinks, etc.) and balanced to equalise the supply and extract air that flows through the system and between rooms. The specifications will ensure a fan power of 1W/l/s or less when running at each of its settings and a heat recovery efficiency of at least 85 per cent.

Overheating

The design of the home takes account of the fact that the demand for thermally efficient glazing can often compromise overheating. Low-e glazing solar+ has tinted glazing and includes heat-reflective systems to reduce solar gains in the summer and this will be used to ensure no overheating Solar shading and orientation have been employed to ensure that there is no risk of overheating.

External Lighting

Illuminance levels for lighting in all external areas are designed to protect the night sky, to avoid any impact on foraging/commuting bats and to avoid light pollution.
All external lights will be PIR/sensor controlled and will be specified in accordance with BS 5489-1:2013.

Internal Lighting

The health benefits of natural light have guided the design and orientation of the paragraph 79 home. This has reduced the need for artificial lighting and has improved the health benefits of the home for users.

Average daylight factors are designed to be in excess of 2% for all rooms. The potential for disabling glare has been 'designed out' through orientation and design. The glare control strategy has been developed in tandem with the lighting strategy to ensure that glare is minimised whilst avoiding potential conflict with the lighting control systems, therefore avoiding higher than expected energy consumption. Luminance (lux) levels in all areas of the home are specified in accordance with the SLL Code for Lighting 2012 .

3 Surface condensation and mould growth in traditionally-built dwellings. BRE Digest 297.

4 British Standards Institution. BS5250. Control of condensation in buildings, BSI, London, 2012

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