Technology Strategy Board
Driving Innovation

Retrofit for the Future

Project final report

Cover note

This report was prepared by the collaborative project team for this Retrofit for the Future project, to provide fuller context on their experiences and the particulars of their retrofit's specification, construction and occupation.

The authors were encouraged to include honest, transparent and constructive comment, garnered from multiple perspectives across their team. All views are taken to be an accurate account from the time.

There may have been further modifications to the property after this report was produced. It is therefore possible that a small minority of statements will no longer be valid.

Although minor modifications have been made to this report by the Technology Strategy Board, these were only to ensure the privacy of individuals, including the residents, and compliance with the Data Protection Act.

This report may contain links to other websites, such as for project partners or the retrofit project. The Technology Strategy Board is not responsible for the content of those websites.

This report has already proven to be a valuable source of information for the technical and cost analysis reports published by the Technology Strategy Board which are available at: www.retrofitanalysis.org

Retrofit for the Future Project Final Report

Project number: ZA577J
Property number: TSB057

Author: East Midlands Housing Association Limited
EMHA

The work reported here has been funded by the Technology Strategy Board under the Small Business Research Initiative (SBRI) under the Retrofit for the Future programme. This project is one of nearly 90 projects funded under the programme. Further information on the programme can be found at: www.innovateuk.org/retrofit

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Driving Innovation

SBRI Government challenges. Ideas from business. Innovative solutions.

Final Report

Project information

- **ZA reference number:** ZA577

- **Location of property:** LE5, Leicester

- **Lead participant details:**
  East Midlands Housing Association Limited
  Jubilee House
  Stenson Road
  Coalville
  Leicestershire
  LE67 4NA

- **Date report issued:** 1 June 2011

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1. Project details and directory

Role	Organisation	Contact Details
Project Executive	East Midlands Housing Association Limited	Jubilee House Stenson Road Whitwick Business Park Coalville, Leicestershire LE67 4NA www.emha.org
Housing Association	East Midlands Housing Association Limited	Jubilee House Stenson Road Whitwick Business Park Coalville, Leicestershire LE67 4NA www.emha.org
Architect/Engineer	Gordon White Hood Architects and Surveyors	Beresford House 1 Newtown Street Leicester LE1 6WH www.gwh.co.uk
Clients Representative	East Midlands Housing Association Limited	Jubilee House Stenson Road Whitwick Business Park Coalville, Leicestershire LE67 4NA www.emha.org
Project Management	Vanguard Homes Limited	17 Foxfield Way Oakham Rutland, LE15 6PR
Energy Advisors	Institute of Energy and Sustainable Development De Montfort University	The Gateway Leicester LE1 9BH www.dmu.ac.uk
Main contractor	Aqua Interiors Limited	Green Park House 2A Colliers Way Clayton West Huddersfield, W Yorkshire www.aqua-interiors.com
Supplier – Solar thermal	Ideal Heating	PO Box 103 National Avenue Hull HU5 4JN www.idealheating.com
Sub-contractor – electric		
Sub-contractor – heating		
Supplier - windows	Jeld Wen	Snow Hill

		Melton Mowbray Leicestershire LE13 1PD www.jeld-wen.co.uk
Supplier - MVHR	Itho UK Ltd	10 Faraday Court First Avenue Centrum 100 Burton on Trent Staffordshire DE14 2WX www.itho.co.uk
Supplier - Energy Management	Watt Box	The Technocentre Coventry University Technology Park Puma Way Coventry CV1 2TT www.wattbox.com
Supplier – voltage optimiser	V Phase	Third Floor Castlefield House Liverpool Road Castlefield Manchester M3 4SB www.vphase.co.uk
Supplier – Loft Pod	EnviroHomes Limited	Brayton Domain Aspatria Wigton, Cumbria. CA7 2BD www.envirohomes.co.uk
Supplier - Lighting	Illuma	Sills Road Willow Farm Business Park, Castle Donington Derbyshire DE74 2US www.illuma.co.uk

2. Introduction

The Institute of Energy and Sustainable Development (IESD) part of De Montfort University Leicester (DMU) answered the retrofit call, and were looking for an asset owning partner to participate in the project. This link was established as one of the East Midlands Housing Association Limited (EMHA) board members was in contact with the IESD.

DMU had previous links with other partners who were involved with the Carbon Challenge bid in Peterborough (Vanguard Homes, a MMC consultant with experience of closed panels and also Studio Urban Area of Newcastle, planning consultants who were already involved in a Retrofit for the Future bid with Newcastle City Council). This collaboration provided expertise in project management, design, building energy systems and monitoring, Offsite manufacturing and property refurbishment. The partnership had an extensive network of potential suppliers, upon which it could draw throughout the project.

EMHA selected two properties for submission, both Victorian mid terraces, of which EMHA has many ‘pepper potted’ across the East Midlands region. These were identified as typically hard to heat and insulate by nature of their design and layout. Other attributes included solid wall construction, back of pavement location, ‘flying’ first floor party walls etc.

In the original proposal EMHA had included both void and occupied properties, allowing for comparison of retrofit solutions. However we were successful in securing only one project for phase two, the void TSB057 property. This had recently become void at the time of our submission and was due for refurbishment under EMHA’s Decent Homes programme. We anticipated that the learning from the project would filter into future specification of East Midland’s refurbishment works and the incorporation of renewable solutions into their housing stock.

3. Occupants

New occupants moved into the property following the retrofit; it had been void prior to the works.

The retrofit project was publicised through EMHA newsletters and various media coverage (TV press and radio). Following this, some existing tenants made contact and expressed an interest in living in the property once complete. EMHA were keen to ensure that the new occupants were used to living in this sort of Victorian terraced property so they could make a direct comparison with previous experiences. They were expected to show an interest in the project and be willing to participate in the subsequent evaluation process. This meant that tenants were specifically selected, a process that was not consistent with EMHA's letting policy and procedure.

In the initial submission the property was intended to be used as a decant for multiple tenants for 6-8 weeks whilst their permanent homes were being refurbished. However, in response to TSB feedback this was changed in favour of permanent occupant.

The make-up of occupants before and after the retrofit:

Age band	Number before retrofit	Number after retrofit
Under 5 years	0	0
5-16 years	1	1
17-21 years	0	0
22-50 years	1	1
51-65 years	0	0
Over 65 years	0	0
Please state if (yes/no):	**Before retrofit**	**After retrofit**
Married couple / partners	No	No
Couple / partners with children	No	No
Any disabled persons	No	Yes
Single parent	Yes	Yes

4. Dates

Event	Date
Occupants moved out (state if they remained or property was empty)	Void property
Contract for work let / signed	Existing framework
Project Initiation Document published	19 February 2010
Project start date (when was the first proposal discussed or agreed)	25 January 2010
Planning application submitted	29 April 2010
Planning permission granted	23 June 2010
Building Regulations application submitted (Approved Inspector)	30 June 2010
Start on site	26 July 2010
Loft Pod install date	04 August 2010
EMHA First fix preliminary air tightness test	15 October 2010
Monitoring system commissioned and operating properly	19 November 2010
Building services and controls operating correctly	19 November 2010
Building defects corrected	26 November 2010
Completion of retrofit	26 November 2010
EMHA Post completion air tightness test	15 December 2010
Building Regulations Completion Certificate issued (Approved Inspector)	25 January 2011
EST Project Air Tightness Test and Thermal Imaging	28 February 2011
Occupants moved in	18 April 2011

5. Pre-retrofit property

TSB057 is a traditional back of pavement Victorian mid terraced property with solid 9'' brick walls, a floor area of 70m^2 and a shared side passage with an adjacent property. Prior to the retrofit the house had a traditional layout with two living rooms and a kitchen on the ground floor, two bedrooms and a bathroom on the first floor. The roof was a traditional cut with a slate covering and insulated loft space. The first floor was suspended timber and the solid ground floor had a quarry tile finish. There was gas fired central heating with a back boiler and hot water storage cylinder. Neither of the neighbouring properties are owned by EMHA and no pre works monitoring had been undertaken.

The property was failing the government's Decent Homes standard, was due for refurbishment during 2010 and coincidentally became void during this period. It was one of many properties of this type, owned by EMHA, within the area and offered the opportunity to demonstrate how retrofit solutions could be applied had the property been in a conservation area.

6. Design

There were no material changes to the original proposal.
The design of the project was based on PassivHaus principals although there was an acceptance that these could not be met in full. It focused on providing a highly thermal efficient and air tight envelope, using proven and readily available building products. We wished to minimise the reliance on expensive renewable technologies. The objective to consider the property as if it was in a conservation area meant that external fabric improvements needed to be carried out internally. This resulted in an overall loss of internal floor space which needed to be replaced. This was achieved by utilising the roof void to create a replacement bedroom.

Key technologies and suppliers:
Whole house MVHR was required to maintain air quality and circulation and maximise heat recovery as a result of the property having a much higher air tightness standard than is expected for this type of property.
V Phase was used to optimise incoming voltage and reduce electricity consumption by up to 10%.
Wattbox energy management system provided adaptive and interactive energy demand controls.
Enviro Homes provided an innovative offsite manufactured solution for the loft space in the form of a pod
Jeld Wen provided high efficiency timber windows with triple glazing, including vertical sliding sash windows.
Ideal Heating provided solar hot water and heating

The intention of the project was to cause minimal disruption to the structural integrity of the property.

Anticipated interventions:
Pad stones for spreading the loft pod load were set on the front elevation.
Renewal of water main into property to replace a section of lead main.
Strengthening of wall and insertion of lintels on the ground floor side passage wall where the chimneys were removed. Existing joists spliced.
Staircase design adapted to take into account adjustments to headroom and ceiling heights on the first floor.

Unforeseen interventions:
Timber lintels were replaced above windows and door openings on the first floor rear elevation by concrete lintels to act as pad stones.
Rear addition gable needed to be rebuilt.
Existing stairwell walls were removed on 1st floor for safety reasons.
Damp related issues to ground floor walls required tanking.
Underpinning of the ground floor partition was necessary between the kitchen and dining room.

7. Construction

Procurement
Existing framework contractor

Contract type
Framework partnering agreement backed with a JCT intermediate Contract

Contract structure
Main contractor with direct labour covering most trades plus some subcontractor work

Subcontractors
Staircase- manufacturer and installation – Norray Joinery, Leicester
Decorating – MA Russell, Leicester

Specialist installers
Wattbox – manufacture and installation – engaged by Client-EMHA
Loft Pod – manufacture and install – Enviro Homes – engaged by client – EMHA

Specialist equipment suppliers
None

Site supervision
EMHA Representative, covering all aspects of quality control and supervision, daily presence on site.

Role of architect/design team
The design team consisted of all project partners and was supported by the Architect in detailing and statutory submissions. An Approved Inspector was used to sign off building regulation.

Project successes
Loft module
Measured and manufactured to a very high standard. Risks of access and installation identified and mitigated (investigating load restriction, road closures, leaflet drops, pre install and delivery survey). On the day of installation all went to plan.

Site operative learning
Operatives adapting to and accepting the use of different methods and materials for retrofit (air tightness and insulation, techniques and products i.e. membranes, tapes and installation details) and being able to adapt to non-standard problems, such as installation of MVHR and ducting runs.

Future proofing
Installation of integrated TV/satellite/telephone system, to minimise inadvertent third party envelope breaching.

Project issues
Although certain issues were encountered they often were the result of a skills gap which was noticeably bridged through experiences within the project. This needs to be considered alongside the following:

Timescales
Although airtightness work went well it required significantly higher labour involvement than originally intended. In future we would consider alternative air tightness methods such as plastering and propriety paints.

Property
In order to achieve the high standards originally envisaged for retrofit (e.g. air tightness), additional problems not generally encountered through decent homes work were exacerbated by the age of the property.

Detailing
Some construction details were too intricate to detail, or could not be anticipated at the planning stage. As a result, bespoke solutions had to be identified and implemented on site, resulting in delays (e.g. pod air tightness interface with existing structure).

Loft Pod Module
Even though the pod was manufactured to a very tight tolerance, especially considering the weight (approximately 4 tons), some integral airtightness details could have been improved with more time.

8. Commissioning and occupancy

Prior to closing over, intermediate air tightness tests were carried out to highlight problem areas and respond accordingly.

MVHR ducting runs were tested for leaks and adjusted for flow and extraction rates to ensure manufacturer's recommendations were achieved.

Gas, electrical and solar hot water and heating were commissioned as normal with no issues identified. The Wattbox energy management system was commissioned and is working efficiently.

The tenant has only recently moved in (April); they were provided with a detailed induction explaining the controls and the technologies employed within the property. Further to this, a user manual is being finalised.

It is intended to undertake a set of post occupancy interviews with the tenant over next two years. These will provide a greater understanding of any user issues arising as a result of the retrofit works.

9. Costs

Item	Design Stage		Post - Construction		Comments
	Materals	Labour	Materals	Labour	
Management and Administration	-	£43,200.00		£32,067.74	
Design		EMHA Contribution		£12,974.08	([redacted])
Construction Overall	-	-	-	-	
Prelims		inc		£23,074.35	% add on to total costs [redacted]
Building Fabric	-	-	-	-	
Windows and Ex Doors	£10,500.00	£1,546.00	£7,100.88	£1,065.02	
Works External Walls	£5,803.00	£3,091.00	£5,867.03	£11,158.92	Air Tightness, Insulation, Structural Alterations
Ground Floor Slab	£1,680.00	£1,030.00	£2,464.62	£3,009.47	Dig out, DPM, Insulate, concrete
Timber 1st floor	£0.00	£0.00	£508.76	£419.66	Joist replacement and alterations
Ceilings	£0.00	£0.00	£217.76	£1,667.78	Ceiling renewals
Loft Pod Construction	£5,750.00	Inc	£8,621.52	£8,663.71	Manufacture costs
Loft Pod Installation	Inc	£1,200.00	£1,670.00	£1,288.00	Crane hire, banksman, labour, supervision, haulage
Roof	£5,050.00	Inc	£3,193.58	£5,890.24	Roof Strip, Prep for Pod, rafter eves extensions from pod, roof covering, guttering, flashings
Demolition	£2,009.00	£2,061.00	£664.77	£4,826.44	Property strip out
Ground works	£210.00	£515.00	£290.80	£1,223.64	Drainage, slabbing
Solar Collectors	£1,000.00	£500.00	foc	£90.64	Panel installation only (Plumbing costs elsewhere)
Wattbox	£6,200.00	Inc	£7,700.00	Inc	Includes equipment, monitoring, commissioning
MVRH	£2,200.00	£1,288.00	£1,865.76	£600.00	Heat recovery system
Low energy lighting	£6,000.00	£515.00	£5,061.90	£1,350.00	Illuma
Heating	£0.00	£0.00	£1,816.00	£700.00	Boiler, rads, distribution system
Electrics Other + Vphase	£1,258.00	£1,000.00	£2,450.00	£750.00	Inc Vphase
TV Aerial	£0.00	£0.00	£150.00	£600.00	Aerial, dish, coax through out property
2nd Fix Joinery	£1,960.00	£1,030.00	£1,168.30	£3,246.91	floorboards. Skirting, doors
Kitchen	£1,680.00	Inc	£1,278.53	£938.12	Units, splash tiles
Bathrooms	£1,400.00	£515.00	£1,249.09	£1,239.28	Shower, WC's
Decoration	£1,400.00	£2,318.00	£1,800.00	£2,200.00	Dec through out
Flooring	£1,540.00	£515.00	£994.00	Inc	Kitchen, Shower, Laundry, WC
Sundries	£2,400.00	£0.00	£915.00	£117.00	Skips,
Services	£517.00	£0.00	£1,373.65	-	Utilities, Council tax
Meetings, Travel etc.	£0.00	£4,500.00	-		
EMHA DHS contribution	£0.00	-£15,000.00	-	-£15,000.00	
VAT(17.5%)		£21,592.00	Inc above	Inc above	
Contingency		£14,497.00	Inc above	Inc above	
Totals	**£144,470.00**		**£162,582.95**		

10. Wash-up meeting

A Project Closure meeting was held on 5th November 2010 with attendees from East Midlands Housing Association, Vanguard Homes and De Montfort University. The purpose was to discuss post completion works such as tenancy occupation and TSB requirements but was primarily focussed on project analysis. This covered three key areas: Project Approach, Implementation and Project Learning. The following are points not covered elsewhere in this report.

Project Approach

- During phase one, emphasis was placed more on CO2 reduction rather than technical details and design development. Consequently, when phase two commenced there was some time lost completing the technical designs.
- A significant part of the project was the challenge of completing a loft conversion with an Offsite manufactured loft module; more emphasis could have been placed on the potential procurement during phase one. The ability and enthusiasm of the Offsite industry to supply a bespoke loft module was over estimated and the process of finding a suitable supplier led to delays.
- The performance of key suppliers was discussed.
    - Enviro Homes manufactured and installed the loft module. They performed very well particularly considering the pressure for delivering in a tight timescale – caused by procurement difficulties. The end product was good and had exceptional tolerances.
    - Jeld Wen supplied the windows & external doors. Commitments were met but it was felt that the project was too small for a company of that size.
    - Itho supplied the MVHR system. The product is very good and the company provided good customer interaction and support. There were some installation problems on site that can be attributed to the teams' inexperience with MVHR.
    - V Phase supplied a voltage optimisation device. As this was supply only there was not much interaction required. The installation was very easy but the product performance will be proven during the monitoring period.
    - Illuma provided lighting design and supply. It was felt that the lighting scheme was over designed, but there were no major problems.
    - WattBox supplied and installed the control and monitoring system. Their customer interaction and support was very good particularly during 1st fix installation. Again, the product will be proven during the monitoring period.
    - Ideal supplied the boiler and solar hot water system. This supply only deal was exceptional. The complete system was designed and all components supplied FOC.

Implementation

- Budget.
  The project over spend came from three particular areas;
    1. Pod supply. The difficulties in procurement resulted in a need to design, manufacture and install in a very short timescale.
    2. Additional labour. Unforeseen problems with the building integrity resulted in additional unplanned work.
    3. Expanding the scope of works. This was a deliberate, controlled action to ensure a better finish standard was achieved.

On site learning was considerable and contributed to the project overrun.

- Quality.
  Considerable effort went into the installing of the air tight membrane with results indicating that PassivHaus air tightness standards could have been achieved had more time been available for dealing with offsite manufactured components (e.g. loft pod and sash windows).

11. Doing it again

Would definitely do again

- Use an offsite solution.
  The site installation proved its benefits for accuracy, quality and programme but with more time available the design could have been refined and manufacturing costs reduced.
- Less reliance on renewable technology as a solution.
  Reducing energy consumption through high levels of insulation and air tightness rather than relying on renewable technology to generate a supply creates a simpler solution that is easier to install and less reliant on specialist installation contractors. However, there are lessons concerning the air tight solution.

Would definitely not do again

- Rely on air tight membrane to provide total air tightness.
  Installing the membrane, folding round multiple corners and round difficult areas such as joist ends was very time consuming and ultimately didn't result in the best reading. Would still use for window junctions and roof.
- Dig out existing solid floor. Look for alternative solutions, such as over insulation.
- Mix client and contractor roles
- Not tag the project on to existing contractual agreements and have a stand alone project/contract.

Reduction of costs

- Ensure retrofit knowledge is embedded within contractors and EMHA
- Review lighting design
- Increased Design & Development time for the loft module and no over time for manufacturing would significantly reduce costs.
- Dig out solid floor
- Reduced use of air tight membrane – other methods, such as wet plaster which could be spray applied, would be quicker and cheaper to fit and may give better results.
- Less process orientated meeting and more emphasis on technical and design problem solving meetings
- Explore in greater detail prefabricated wall panelling

Improvement of the design process

- Having the Architect more actively involved during phase one would have ensured details were developed sooner and issues were tackled at design stage rather than when on site.
- Also, phase one involvement for the module manufacturer. When the contract was awarded they would have been able to start detail design straight away, enabling more time for design and development

Improvement of the construction process

- Removing labour intensive solutions such as application of airtight membranes
- Better integration between on and off site solutions.
- Better works programming
- Have a permanent site foreman

Improvement of the commissioning and occupancy process
The whole commissioning process did not interfere or slow down site progress. Earlier air tests were to mitigate potential time consuming and costly alterations further down the programme. Also, the lack of renewable systems meant less of an impact for commissioning and those used were of a simpler installation.

Retrofit at scale
In a larger programme of retrofits, e.g. 50 homes of similar age and design in a similar neighbourhood

- An offsite solution would be a more viable. The economies of scale would considerably reduce manufacturing costs and based on the installation time for this project. The manufacturing and site costs for the loft pod module could be reduced considerably by manufacturing repeat modules and installing five modules a day.
- With a constant level of multiple trade skills working across a number of properties this would the momentum of a site programme based many properties.
- Retrofitting the same type of property using identical solutions, would allow for the skills and knowledge to be imbedded in the workforce.
- Greater purchasing and negotiation power with manufacturers and suppliers, on a large scale project

Making replication at scale successful
The project would need to be a whole street scheme or properties within a close catchment area. Explore the issues of mass customisation of similar components (INET project currently being explored for the laser measurement of similar properties).

12. Business benefits

Lessons learned

- A diverse interaction and collaboration of professionals such as EMHA, DMU, GWH and other project partners, that would not have happened under normal circumstances.
- The personal learning and development of project team members has been very high, with the new learning being filtered down to the respective organisations
- The capability and potential for Offsite solutions for the loft pod module and other aspects of the retrofit.
- The realisation that you don't necessarily need to invest in expensive technology to gain ecological benefits.
- this project has exposed EMHA to new learning and now a greater emphasis is being placed on looking at renewable solutions and is now high on the agenda for the organisation

Business leads

- Potential for Knowledge Transfer Programme between DMU and EMHA.
- Additional collaboration for future development projects.
- Potential for offsite solutions in EMHA new build projects.
- Potential offsite project collaboration for Vanguard Homes.
- INET project currently being explored for the laser measurement of similar properties
- EnviroHomes partnership with the Kingfisher Group and the Green Deal

It is not currently possible to quantify the value of retrofit business expected as a result of this project, however it is anticipated that future developments may take place.

Appendices

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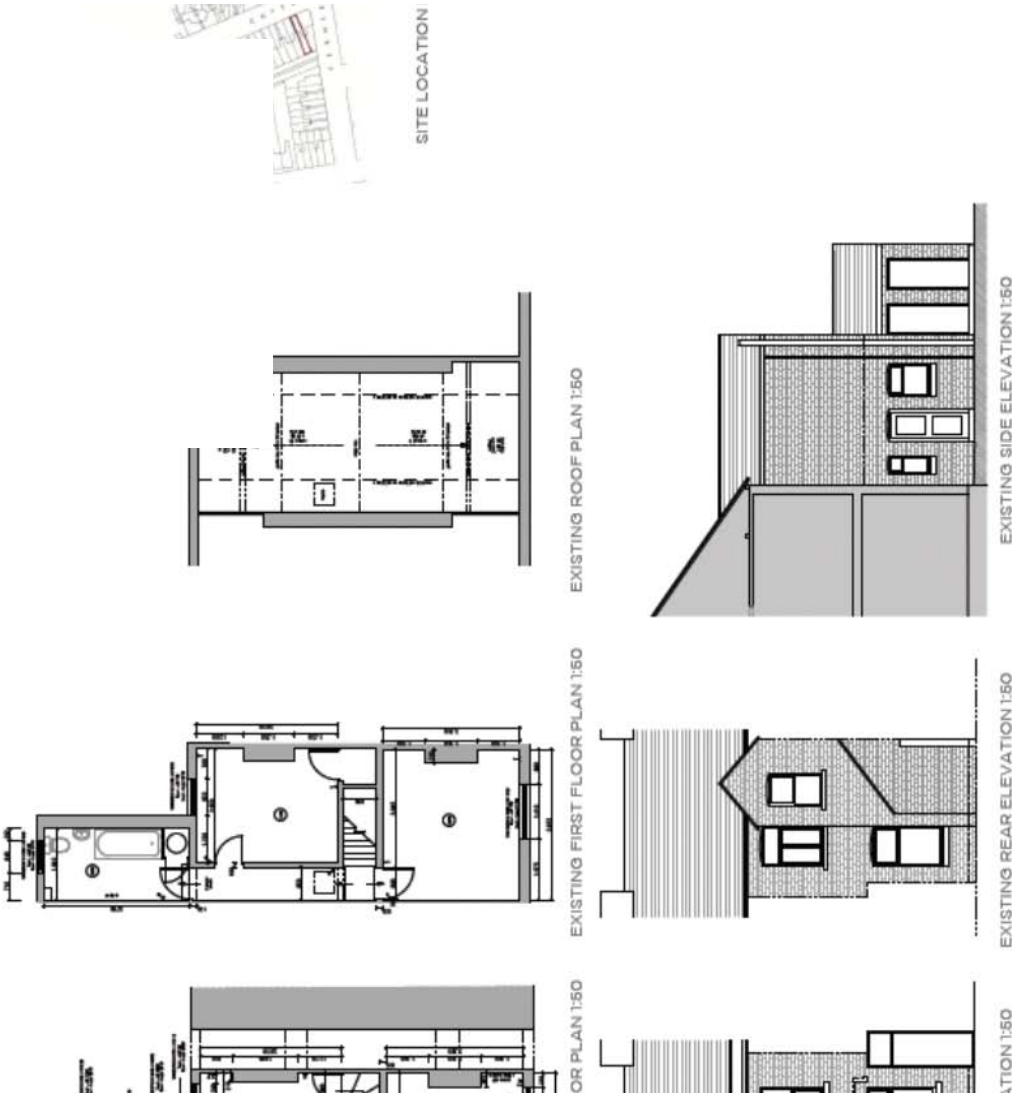
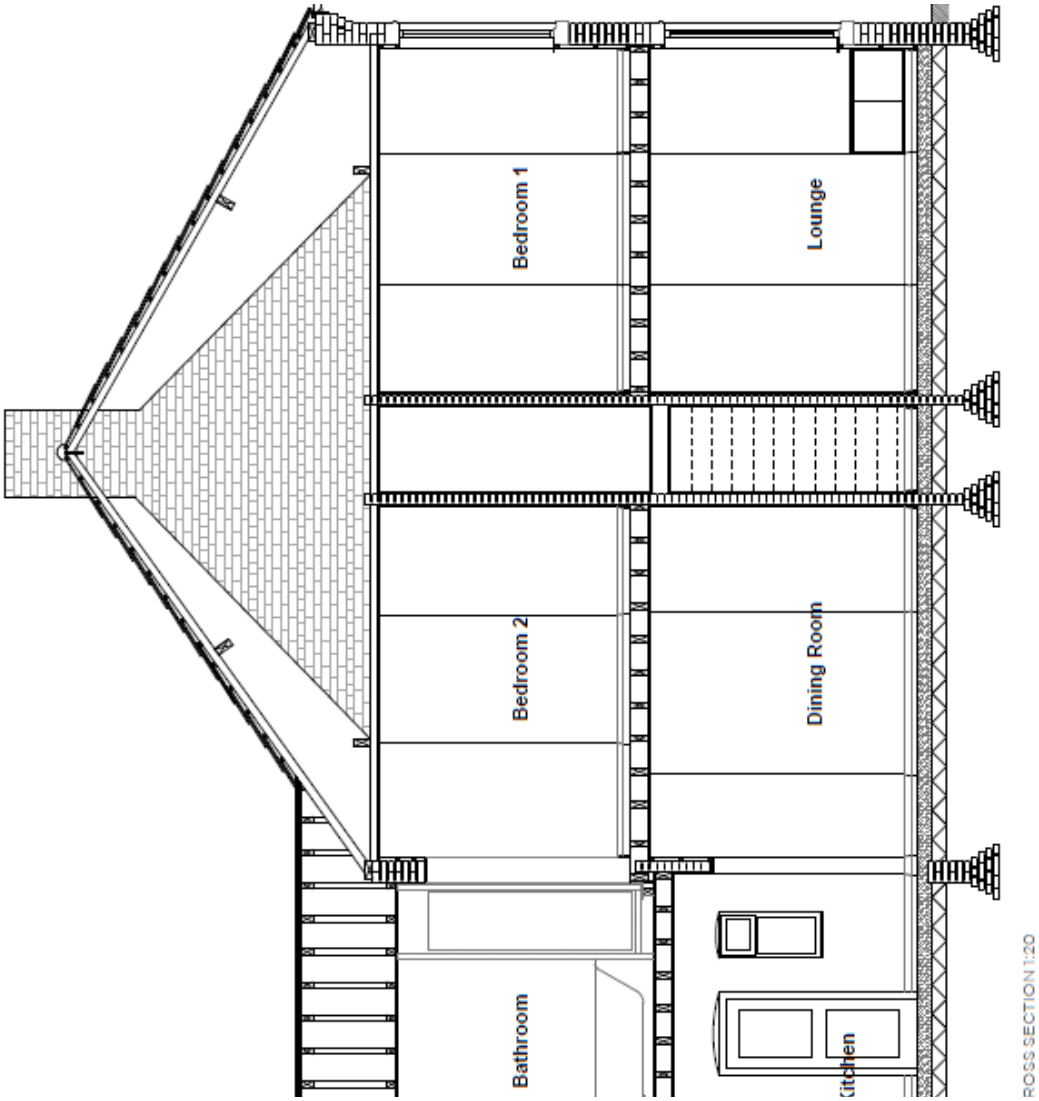
Please note all drawings, plans and photographs are available in dwg, pdf, jpeg etc., on request.

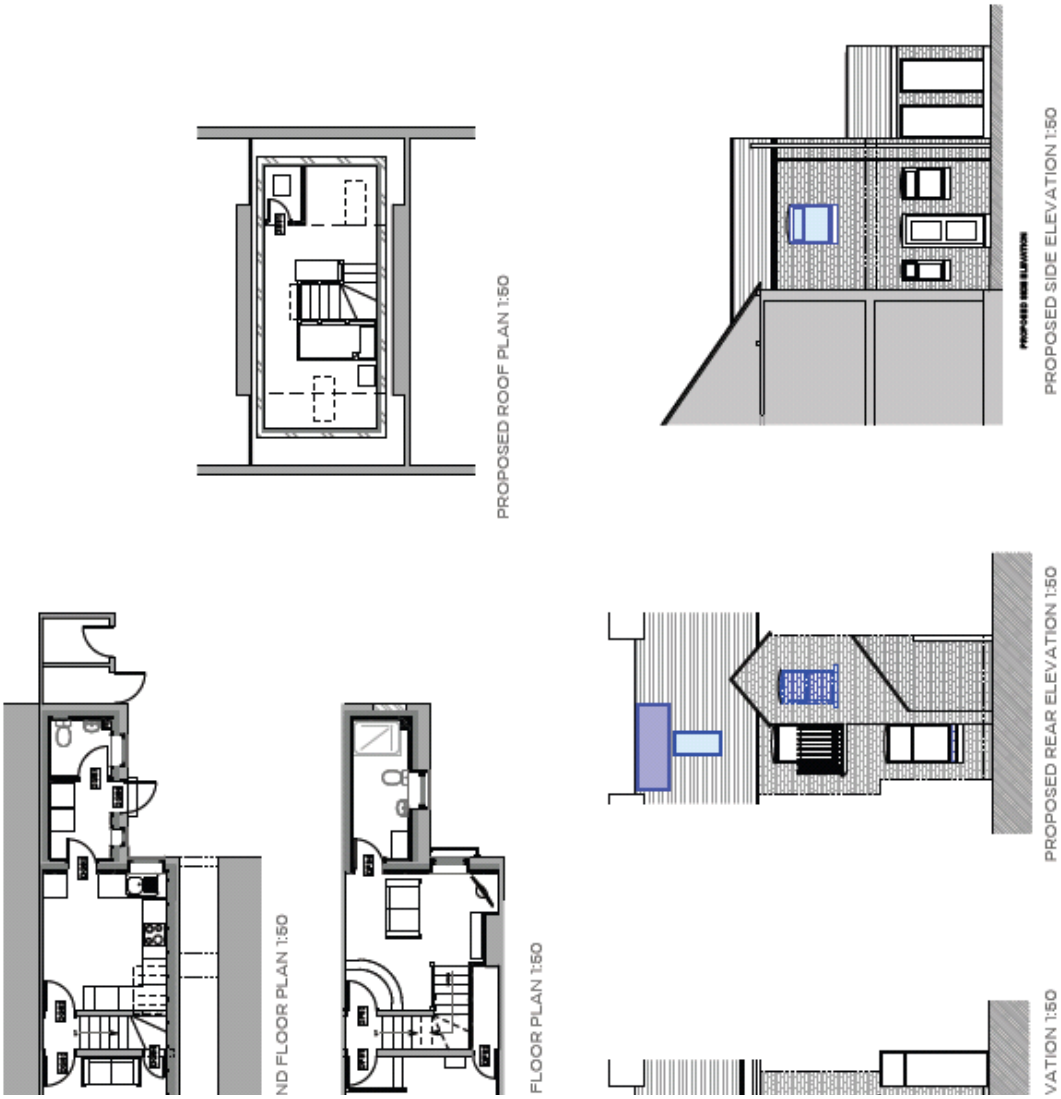
Appendix A Existing floor plans pre retrofit works



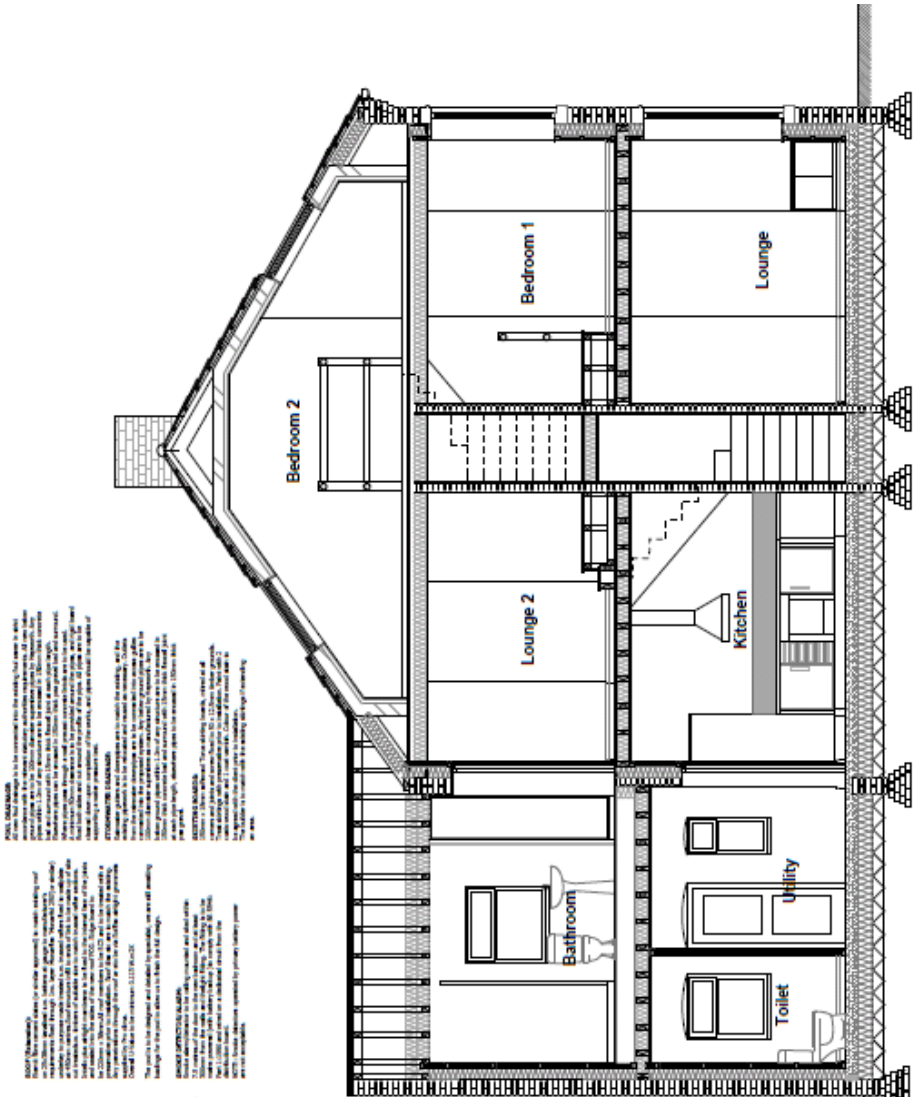
Appendix B Existing cross section pre retrofit works



Appendix C Proposed floor plans



Appendix D Proposed cross section



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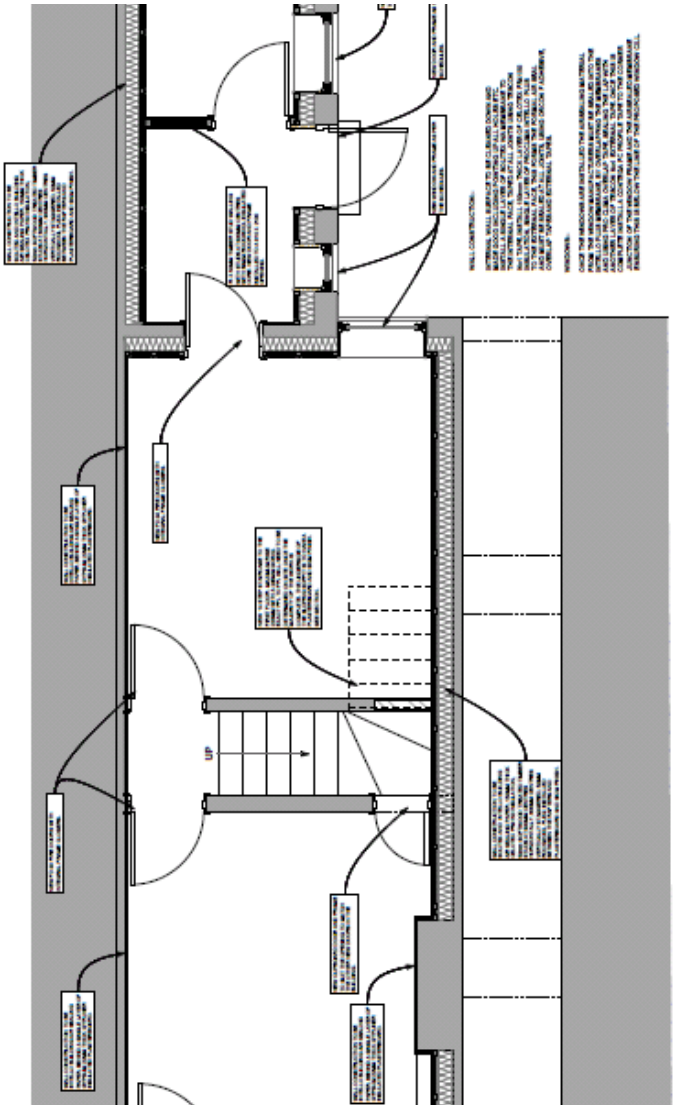
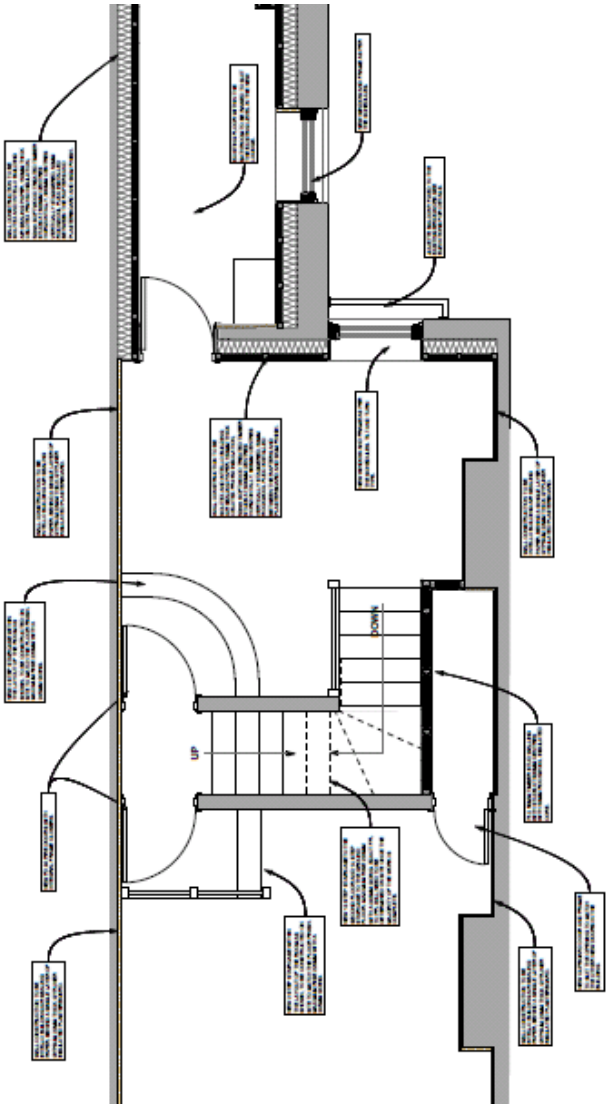
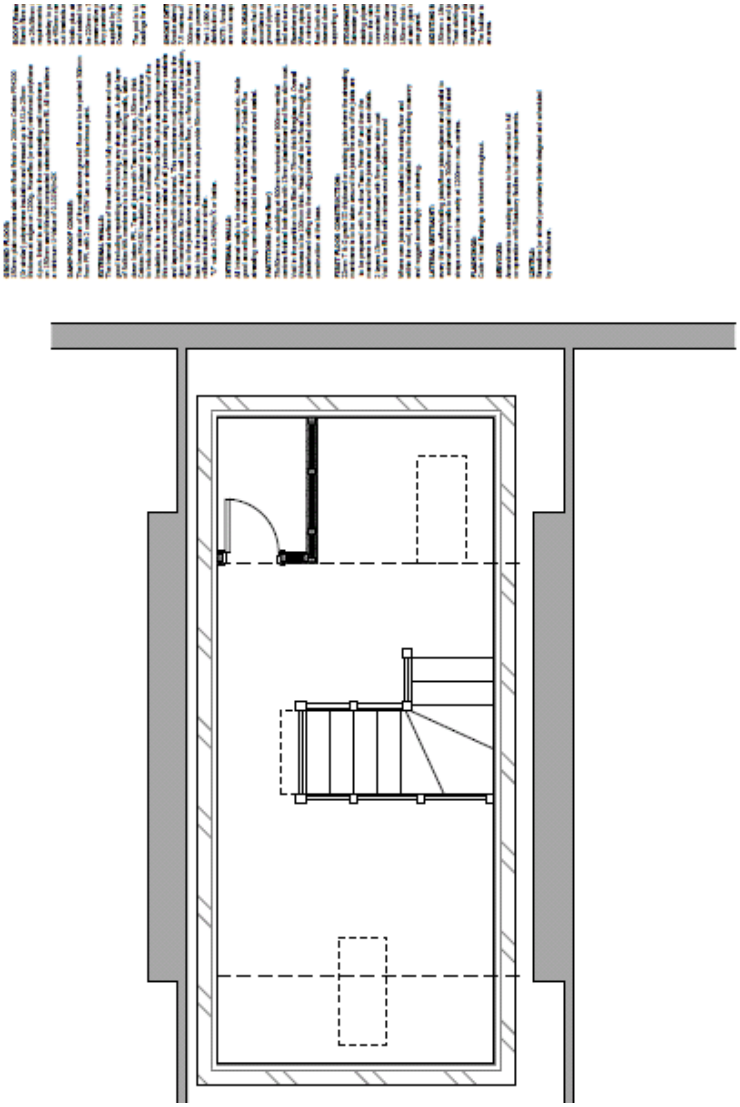
Appendix E Proposed ground floor works



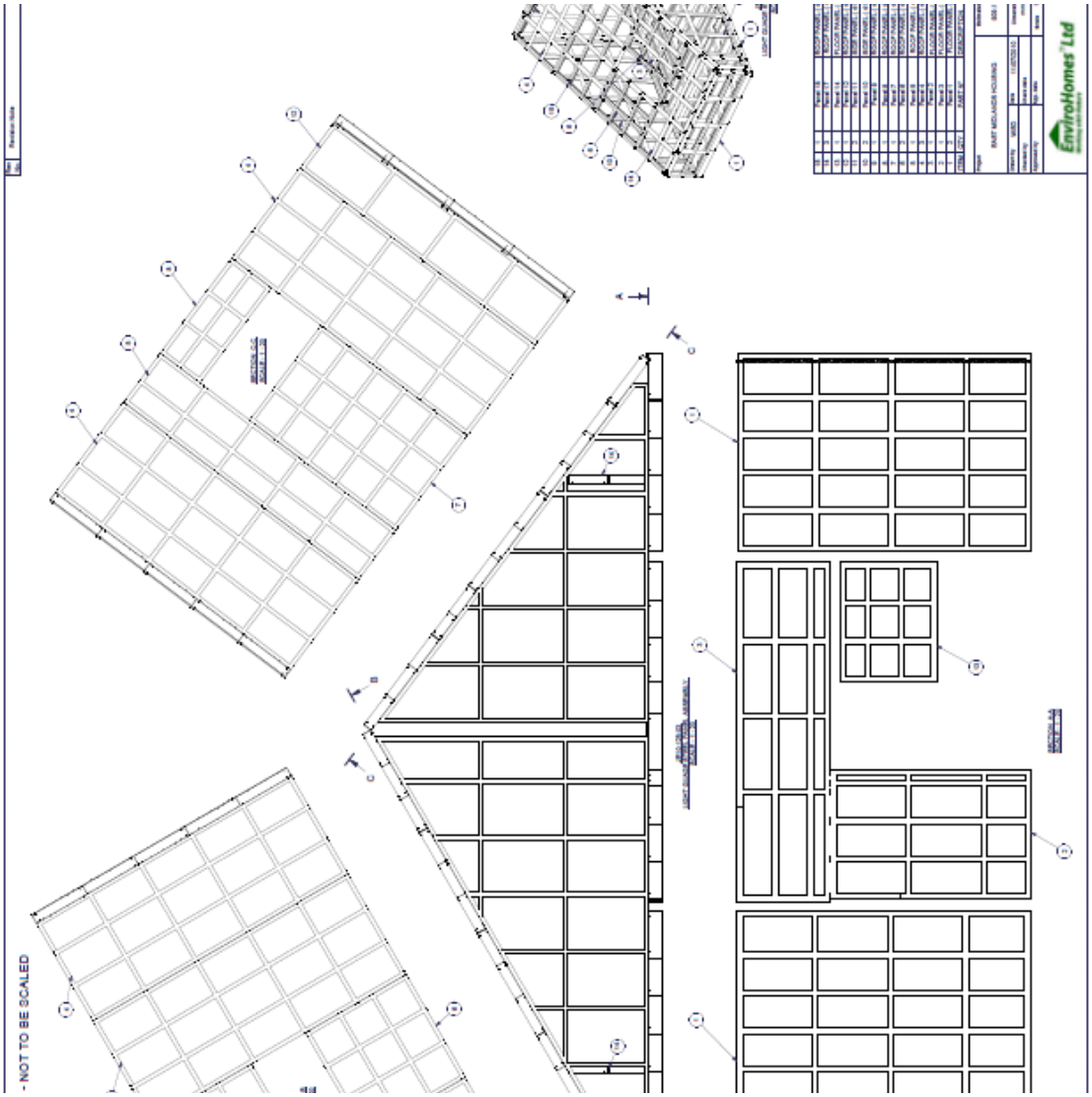
Appendix F Proposed first floor works



Appendix G Proposed roof works



Appendix H Loft pod module assembly drawings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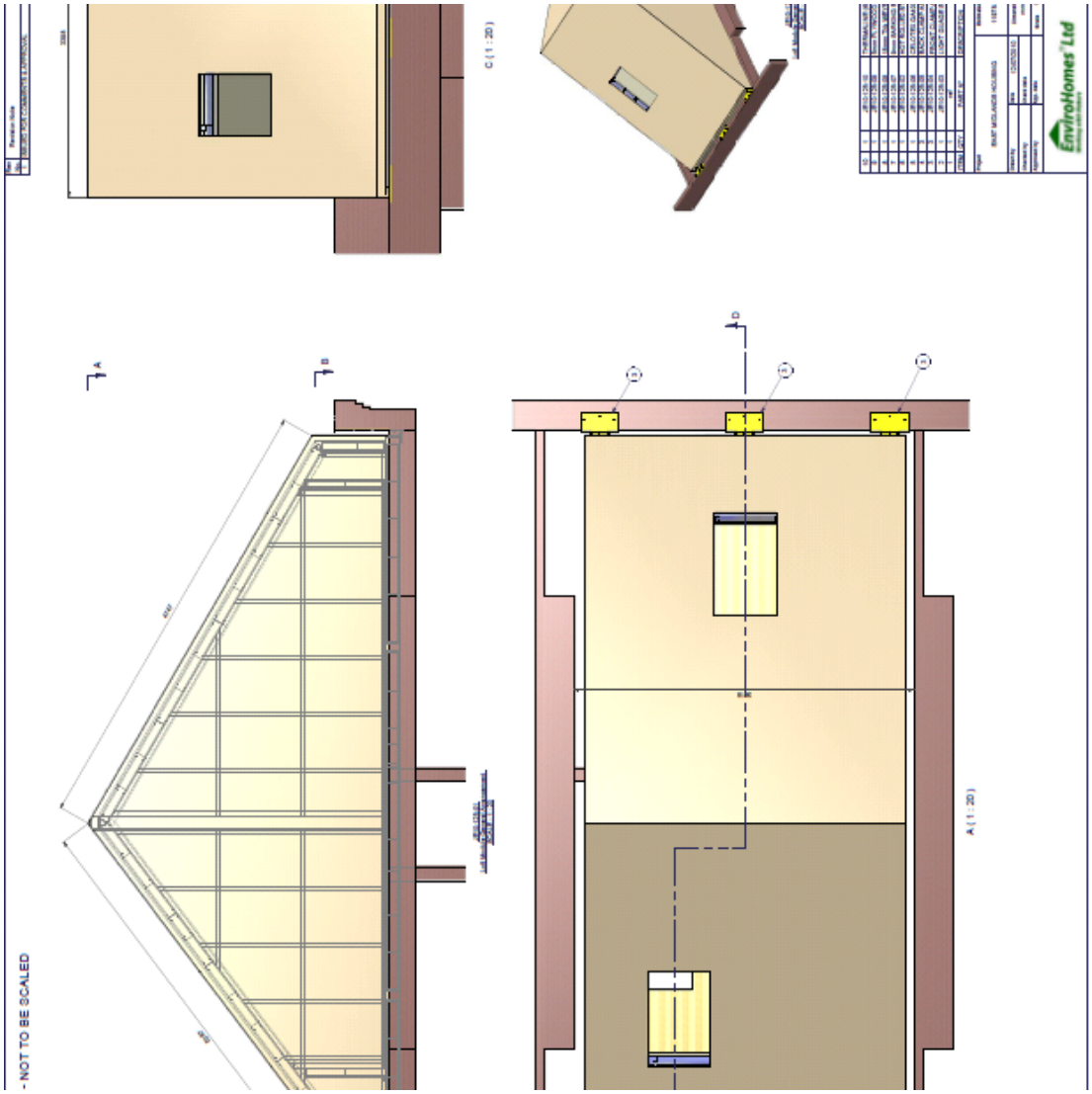
EnviroHomes Ltd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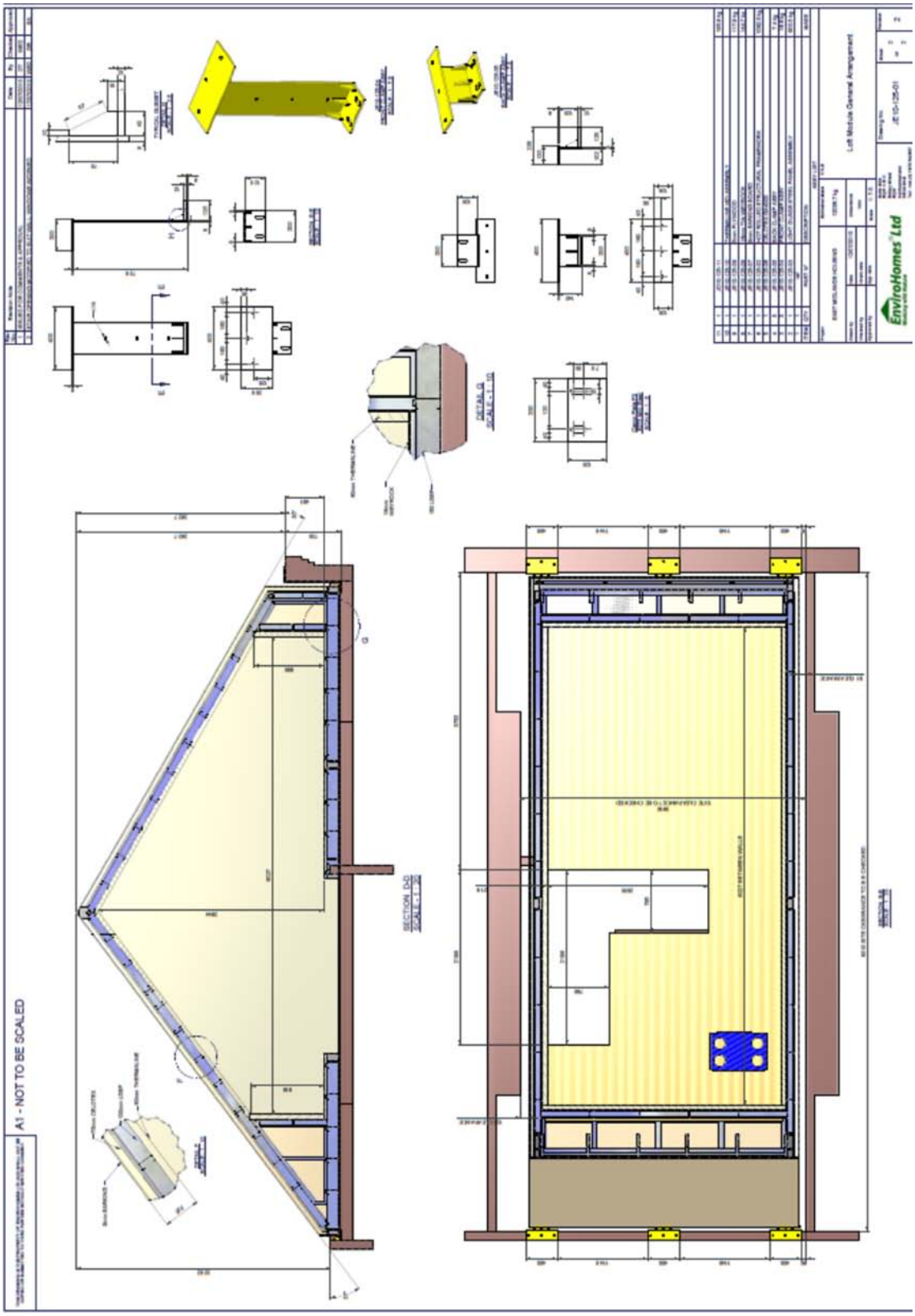
A (1 : 20)
EnviroHomes Ltd


A1 - NOT TO BE SCALED
SECTION D-D
SCALE 1:100
DETAIL D
SCALE 1:10
EnviroHomes Ltd
Lift Module General Arrangement

Appendix I Loft pod install photographs

EnviroHomes Ltd

EnviroHomes Ltd
Working with Nature
retrofitting
the future

Appendix J Loft pod roof finish photographs

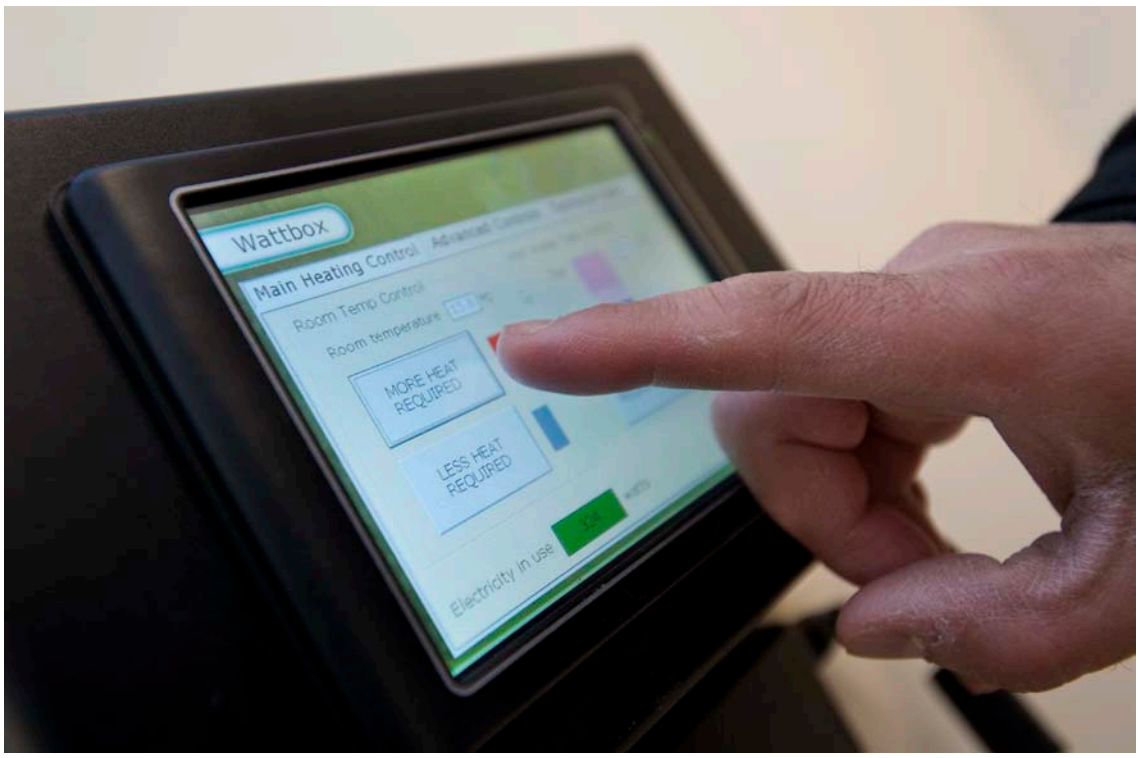
Appendix K Window airtightness detail

Appendix L Joist end sealing and airtightness continuity

Appendix M MVHR unit and ducting

Appendix N Solar thermal and twin coil cylinder

Appendix O Photographs of completed property


Wattbox
Main Heating Control
Room Temp Control
Room temperature
MORE HEAT REQUIRED
LESS HEAT REQUIRED
Electricity in use