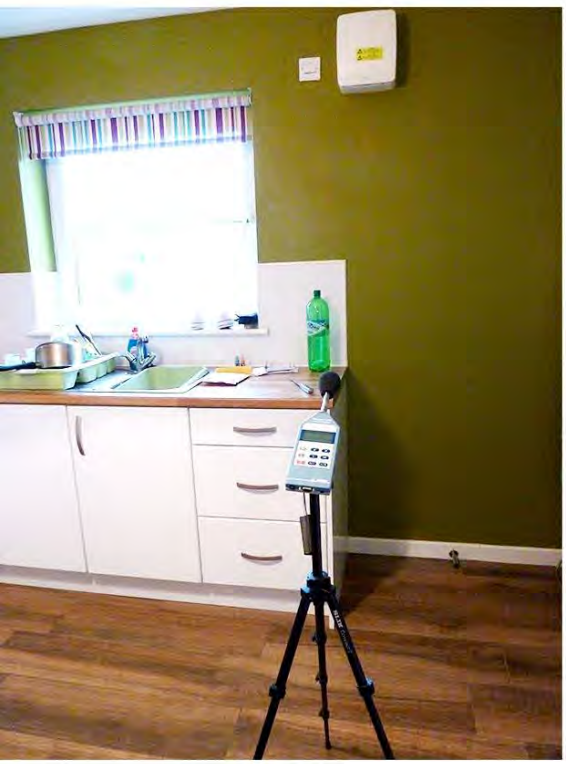

MACKINTOSH ENVIRONMENTAL ARCHITECTURE RESEARCH UNIT THE GLASGOW SCHOOL OF ART

Tender (27/09/2017):

'Ability of decentralised mechanical ventilation to act as 'whole-house' ventilation systems in new-build dwellings'

Principal contact: Prof Tim Sharpe, [redacted]

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Statement of purpose, objectives and scope

The Mackintosh Environmental Architecture Research Unit, in collaboration with Energy Systems Research Unit at Strathclyde University, HabLab at John Gilbert Architects and Anderson Bell Christie Architects is pleased to submit a tender for this work. It presents an opportunity to draw on significant practice and research experience of low energy building design and the implications of improved thermal efficiency on the quality of the internal environment. It brings together team members with specific understanding and experience of architectural design, construction, ventilation, indoor air quality, end-user interactions, building performance evaluation, modelling and simulation, environmental and low energy design, and health and wellbeing in buildings. It provides a unique opportunity to draw on knowledge being generated by a wide range of related projects that the team are conducting into environmental conditions in housing, including building performance evaluation of low energy homes and the influence of ventilation design on the indoor microbiome. It brings an industry perspective from practicing architects with significant experience of housing design.

The underlying context of this work is the potential implications of increasing standards of airtightness in construction resulting from mandatory requirements of the Technical Standards. These have been successfully adopted by designers and contractors alike. In 2011 the Building Standards Division (BSD) commissioned research to identify the effect that increasing air-tightness may have on air quality within dwellings[1]. This research concluded that the Domestic Technical Handbook guidance on natural ventilation was fit for purpose down to an air-tightness level of 5 $m^2/m^3.h$ @ 50 Pa. However, the research assumed that trickle ventilators and internal doors remain open, but did not consider when and why occupants interact with trickle ventilators and windows in dwellings.

This was the topic of discussion at a workshop on ventilation held at BSD in October 2013 (attended by team members Sharpe, Tuohy and McQuillan), which identified a number of research questions. These included how occupants use trickle ventilation, what effects this use may have on ventilation and indoor air quality (IAQ), and what measures may be undertaken to address this. As a result, the BSD commissioned a study to investigate occupier influence on IAQ in dwellings[2], which evidenced a lack of trickle vent use in contemporary housing and poor ventilation in practice. These findings were supported by similar work commissioned by DCLG[3] on IAQ in naturally-ventilated homes built to 2006 standards, which concluded that to compensate for the fact that homes are becoming more airtight, the size of the trickle vents provided in the most airtight homes (≤4 $m^3/hr/m^2$) should be increased.

[1] BRE, 2012, The effect that increasing air-tightness may have on air quality within buildings. http://www.scotland.gov.uk/Resource/0040/00402329.pdf
[2] Sharpe et al. 2014, Research project to investigate occupier influence on indoor air quality in dwellings, http://www.gov.scot/Resource/0046/00460968.pdf
[3] DCLG, 2010, Ventilation and indoor air quality in Part F homes, BD 2702

Following the outcomes of the trickle vent study, proposals were made for revisions to guidance supporting the standards, to increase occupant awareness of IAQ issues. In 2015, changes to the Domestic Technical Handbook introduced requirements for carbon dioxide (CO_2) sensors in principle bedrooms in dwellings constructed to an airtightness of less than 15 $m^3/hr/m^2$ @50Pa, to help raise awareness of elevated CO_2 levels (and therefore ventilation) in bedroom environments, which is currently lacking. Further changes in 2015 include the adoption of the European standard for sizing background ventilators using 'equivalent area', as opposed to free/geometric area. This was a subtle but important change that had significant implications on trickle ventilation requirements in homes. For example, where the norm was to provide 8000mm^2 ventilator (free area) in an inward opening window, designers are now finding that this is providing almost half what it did previously, which has contributed (in part) to the application of dMEV systems with reduced trickle ventilation provision to apartments.

At a workshop held at BSD in September 2014 to disseminate the findings of the study, concerns were raised regarding the ability of decentralised mechanical ventilation systems to act as 'whole house' ventilation systems in new-build housing with an air-tightness of between 3 and 5 $m^3/hr/m^2$ @ 50 Pa, coupled with reduced trickle ventilation (2500m^2) to habitable rooms, as approved by some verifiers. The concern that is emerging is that whilst this strategy can potentially achieve satisfactory results in factory conditions and in modelling, there are number of situations arising in real world situations which may compromise performance. These include the effects of internal layouts, size and placement of trickle vents and windows, building form and location, and occupant behaviour. Sub-optimal performance could result in inadequate ventilation and associated indoor air quality problems.

In 2015 MEARU were commissioned by Innovate UK to undertake a meta-study of homes within the IUK Building Performance Evaluation programme[4] that utilised Mechanical Ventilation with Heat Recovery (MVHR) and a dissemination event at BSD also raised the issue of reliance on constantly running mechanical systems and possible effects of other interaction such as window opening.

It is apparent that the use of dMEV is gaining in popularity in airtight homes due to its relatively simple requirements. The question arising is whether these systems are delivering sufficient ventilation rates, particularly in rooms that may be at risk of being bypassed and apartments with limited cross ventilation. The main aim of this research therefore is to establish if new-build dwellings fitted with dMEV in moisture producing rooms, coupled with a reduced area of trickle ventilation in habitable rooms of 2500m^2, can maintain satisfactory ventilation and IAQ in a real-life context.

The research objectives include the following:

- To identify a sample of new-build (post 2015) housing developments in Scotland with an airtightness of between 3 and 5 $m^3/hr/m^2$ @50Pa that are ventilated using dMEV systems, with a reduced trickle ventilation provision of 2500m^2 in habitable rooms

[4] Sharpe et al. Characteristics and performance of MVHR systems: A meta study of MVHR systems used in the Innovate UK BPE programme, http://radar.gsa.ac.uk/4073/1/MVHR%20Meta%20Study%20Report%20March%202016%20FINAL%20PUBLISHED.pdf

- To understand the overall ventilation system design specifications, the as-designed individual ventilation component specifications, the as-implemented and as-operated ventilation systems and associated user guidance
- To investigate how occupants interact with dMEV systems, trickle ventilators and other components such as doors, door undercuts and windows in their home, their awareness of these systems and controls, their perception of IAQ, and their willingness to participate in the monitoring study, through a household survey
- To establish ventilation levels in selected homes with dMEV systems and reduced trickle ventilation of 2500mm^2 during winter based on measured CO_2 levels in habitable rooms while gathering relevant contextual information
- To calculate ventilation rates and relate these to a range of standard occupancy patterns
- To establish hygrothermal conditions in these homes based on measured temperature and humidity together with relevant contextual information
- To examine in detail the airflows including potential for short-circuiting of fresh air from trickle ventilator(s) by the dMEV unit, through a review of the design, as-implemented and as-used systems coupled with analysis of airflow pathways using smoke testing and simulation tools
- To draw together data from the household survey, monitoring study, detailed measurements and modelling to examine and fully comprehend the nature of ventilation provision and use
- To compare ventilation rates and dwelling characteristics to identify patterns or explain variations
- To assess the implications for future design, legislation and advice, and identify any issues concerning current regulatory standards and/or practices and options for improvement

This tender sets out the approaches that the project team believe would provide the most effective and robust approach.

Team

Prof Tim Sharpe, Director of the Mackintosh Environmental Architecture Research Unit, Glasgow School of Art, [redacted]

Dr Gráinne McGill, Researcher at the Mackintosh Environmental Architecture Research Unit, Glasgow School of Art [redacted]

Dr Paul Tuohy, Lecturer, Energy Systems Research Unit, University of Strathclyde, [redacted]

Chris Morgan, Director and Architect, John Gilbert Architects, [redacted]

Barbara Lantschner, Building Performance Specialist, Hab-Lab, John Gilbert Architects, [redacted]

Jonathan McQuillan, Associate, Anderson Bell & Christie, [redacted]

OVERVIEW

The project team will be formed by collaboration between the Mackintosh Environmental Architecture Research Unit (MEARU) of Glasgow School of Art (as lead partner), researchers from the Energy Systems Research Unit (ESRU) at University of Strathclyde, Building Performance Evaluation specialists at HabLab (John Gilbert Architects) and Architects at Anderson Bell & Christie Architects.

The project lead will be Prof Tim Sharpe (MEARU), assisted by Dr Gráinne McGill (MEARU) and Dr Paul Tuohy (University of Strathclyde). Project partners include Chris Morgan (Director at John Gilbert Architects), Barbara Lantschner, (Building Performance specialist at HabLab, John Gilbert Architects) and Jonathan McQuillan, Director at Anderson Bell & Christie Architects. The team will also seek contributions from a wider group of industry based organisations with whom we are collaborating on several projects. These include architects, housing associations, contractors, manufacturers, local government agencies and public bodies. Prof Sharpe sits on the NHBC Technical committee and chairs the NHBC Scottish Technical committee. The team has had good experience of working together on similar projects.

MEARU have undertaken a number of projects that have examined issues of ventilation in housing. These include: the Research Project 'To Investigate Occupier Influence On Indoor Air Quality In Dwellings' for BSD; a range of projects undertaken for Innovate UK that undertook Building Performance Evaluation of new homes in Scotland; a meta-study of houses with MVHR systems; two Knowledge Transfer Partnerships that have examined the real world energy and environmental performance of buildings; and have established a research network to examine the health effects of modern airtight construction.

Other relevant projects include a 3-year EPSRC funded 'Investigation into the Energy and Environmental Effects of Domestic Laundering' (£520,759, EP/ G00028X/1) led by MEARU in collaboration with Strathclyde and Glasgow Caledonian Universities; and 'Comparison of ventilation methodologies of energy efficient dwellings relative to internal air quality and energy performance', undertaken by MEARU in collaboration with ABC Architects. MEARU is currently conducting a Knowledge Transfer Partnership with John Gilbert Architects examining the effects of retrofit strategies on energy use and indoor environments, and this includes a project looking specifically at demand controlled ventilation and is also working with ABC architects on two projects investigating energy and ventilation issues.

MEARU

The Mackintosh Environmental Architecture Research Unit (MEARU) has been in operation for over 20 years and has an established track record of high quality research in environmental architecture. It operates at a unique interface between architectural design, scientific based research and human factors. The unit is built on established expertise and track record in passive solar energy and participatory design. It was founded by Colin Porteous and Tim Sharpe, who previously worked in architectural practice at the Technical Services Agency, a tenant managed Community Technical Aid Centre, where they worked closely with tenants groups on a variety of housing and other design and rehabilitation projects.

MEARU has a long history of working with user groups in relation to housing, but its remit now includes all aspects of construction, low energy design, sustainability and post occupancy evaluation. The unit also has detailed knowledge of building construction and typologies, particularly in relation to housing.

Recent work has led to the significant expansion of MEARU, widening its portfolio of expertise to include: health and wellbeing in buildings; energy efficient refurbishment; low and zero carbon new-build, including mass customisation; control systems in space planning and energy efficiency; and building integrated renewables. The unit undertakes both research and consultancy, with corporate and commercial clients well as commercial and public organisations such as the national and local authorities, housing associations and architects.

The unit had undertaken over £4m funded research in the past 6 years, including funding grants from research councils (EPSRC £770k, AHRC £300k), Industry bodies (TSB, £470k, KTP £720k, EU/ ERDF £140k, and HA's and local councils £350k). The unit is represented on several national and international agencies including the International Energy Agency. Prof. Sharpe is chair of the Ventilation sub group of the UK Centre for Moisture in Buildings, and is also a topic expert on the newly form NICE committee for standards for Indoor Air Quality and chairs the NHBC Scotland Technical Committee.

MEARU was a member of the steering group of the European funded CICStart Online Knowledge Transfer project and subsequent Mainstreaming Innovation and Sharpe is an academic lead on the newly formed Construction Scotland Innovation Centre and participant in the Energy Technology Partnership. The unit is also well networked with similar European partners, is represented on several national and international committees including the International Energy Agency, Innovate UK Building Performance Evaluation, EAAE Research committee, the UK Indoor Environments Group, and

attends regularly at the Eurosun, Northsun, PLEA, Healthy Buildings, Indoor Air and WREC conference circuits.

The Unit has undertaken a wide range of research and publishes extensively in both academic and professional fields. This activity contributes greatly to the learning and teaching culture of The Mackintosh School of Architecture and has also established MEARU as a significant global research player in scientific and architectural circles. The Unit has particular research interests in building users and their interactions with their environments, and conducted work previously for Scottish Building Standards on 'Guidance for Living in a Low Carbon Home' and 'Research Project to Investigate Occupier Influence on Indoor Air Quality'.

John Gilbert Architects / HAB LAB

John Gilbert Architects has developed over 25 years' experience and expertise in innovative, sustainable new build housing across Scotland. The practice has grappled with a range of relevant issues such as airtightness, Passivhaus levels of insulation, a variety of ventilation techniques, usable control systems and an abiding interest in good air quality delivered through low-toxin materials and effective ventilation. We have delivered many hundreds of houses successfully and operate an ongoing policy of acquiring feedback and post-occupancy evaluation where possible.

We have now formalised the process of building performance evaluation (BPE) through the initiation of 'Hab-Lab'. Hab-Lab is unique within the architectural profession, having been developed with MEARU initially as a KTP project but now operational as an integral part of the business. Hab-Lab undertakes on-site building performance evaluation and monitoring to provide an evidence base that can be used to improve the energy efficiency and durability of buildings as well as the health and comfort of residents. Learning from Hab-Lab is fed back into our own practice as well as our Clients.

Director Chris Morgan and Building Performance Specialist Barbara Lantschner have both worked at MEARU and will be responsible for much of the physical monitoring work on the project. Between them, they have many years of experience in building performance evaluation, along with a perspective on how this is undertaken in different countries. They are currently working with a number of Housing Associations and Council Housing departments and will be able to access these contacts in order to help identify the requisite number of properties to test.

Chris Morgan has a track record of interest in ventilation stretching back to the early 1990's when he worked on an 'Eco-village' in Sweden which employed a number of innovative techniques to control comfort and air quality. He has contributed to a number of conferences on the subject, often in combination with wider efficiency and health concerns and is currently a committee member of the HEMAC network. A small selection of projects involving Chris Morgan and Barbara Lantschner are shown in their respective CVs.

ESRU, University of Strathclyde

ESRU was established in 1987 as a cross-discipline research group concerned with new approaches to built environment energy utilisation and the introduction of sustainable means of energy supply at various scales. The work of the group is divided between research, consultancy, knowledge exchange and software development. Research activities cover a range of topics from national/local energy

systems performance to indoor/outdoor health & comfort. Consultancy services include the laboratory testing of new products, the performance appraisal of proposed new designs or retrofits, and the field monitoring of energy systems in use. ESRU is located within the Department of Mechanical and Aerospace Engineering. and operates the BRE Centre for Energy Utilisation.

Our consultancy services to industry include modelling studies in support of design decision-making, laboratory tests to characterise the behaviour of new products, and field monitoring to determine the performance of buildings and new/renewable energy plant in use. Issues that may be studied include natural ventilation approaches and heat recovery, indoor and outdoor air movement and emissions, thermal, visual and acoustic assessments, indoor air quality and condensation studies.

ESRU has extensive experience in air quality monitoring and modelling, undertaking both consultancy and research in the area. ESRU have their own modelling software – ESP-r. In addition to its primary role as an energy analysis tool, ESP-r can be used in the analysis of indoor air quality and contaminant transport in naturally ventilated and mechanically ventilated buildings.

The group have undertaken a large number of studies of naturally ventilated buildings for industrial clients, with the buildings analysed ranging from individual homes to large office buildings. A combination of thermal simulation software (ESP-r) and computational fluid dynamics software was used in these studies. Projects have included: analysis of natural ventilation in Edinburgh Schools for WSP Ltd, energy and ventilation assessment of Shanghai airport, energy performance evaluation in naturally ventilated rooms for the University of Firenze, and analysis of CO concentrations in underground car parks.

The group has also been involved in numerous research projects in the field of indoor air quality including work for Scottish Homes developing a tool to assess the impact of mould on indoor air quality; and modelling the effects of window opening on energy performance and air quality.

Anderson Bell & Christie

Anderson Bell Christie are award-winning architects with a track record of integrated sustainable design. We have been at the forefront of working with communities for more than 20 years and we pride ourselves in being able to provide the design, technical and project management skills that deliver successful built projects for our clients. We have been involved in design review and policy for Government, best practice briefing, pilot projects and advocacy of best practice in housing design with Local Authorities, Scottish Government and Contractors. We were amongst the first to advocate partnership working, comprehensive resident participation in design, the use of modern methods of construction and physical master planning. It encourages staff to maintain academic links, and we have recently worked with MEARU, Robert Gordon and Napier Universities on various projects. We provide a full range of architectural and design services, from large-scale masterplanning through to individual building projects. Our clients include charities, local authorities, housing associations, development trusts, health boards, community and voluntary groups, as well as individuals and developers.

Experience

The following pages outline our experience relevant to this project. We have the following skills:

• A thorough understanding of design and construction of domestic buildings, demonstrated though our track record in practice, technical aid, advice and consultancy to a wide range of tenant groups, housing associations, local authorities and architects.

• Both architectural practice and research based knowledge of the challenges of creating and maintaining internal comfort conditions in homes, as evidenced through a range of monitoring and evaluation projects; work with housing associations and local authorities leading to expert advice and improving living conditions; and current projects developing zero carbon housing.

•A track record of research into internal air quality, energy use in domestic buildings, including ground breaking work into passive solar design and integrated energy, evidenced by publication through books, journal papers, conferences and seminars.

•Recently completed research and building performance evaluation analysing the use of MVHR systems and occupant effected ventilation regimes.

•A large portfolio of on-going monitoring and building performance evaluation projects – Prof Sharpe was an expert Evaluator on the Innovate UK Building Performance Evaluation program and MEARU was appointed expert contractor for 7 out of 7 TSB BPE Domestic projects in Scotland.

•A holistic understanding of the inter-relationship of installed technology, internal air quality and occupant behaviour.

•A thorough knowledge and understanding of the Building Regulation system supported by previous work undertaken with both English and Scottish Building Standards.

•Expert knowledge of the health effects of indoor air quality in housing, developed through practice and research, evidenced by publication through books, journal papers, conferences and seminars and advanced through management of the Health Effects of Modern Airtight Construction (HEMAC) multidisciplinary network

•Widespread knowledge of the design of domestic buildings, application of Building Standards, and working with users and occupant groups.

•Extensive knowledge and experience of architectural practice, with specific knowledge of housing design, including use and application of Building Standards.

•Clear and concise report writing in plain English and graphic communication, including producing effective communications for dissemination to audiences of varied technical abilities.

•Access and ownership of in house testing and monitoring equipment for environmental conditions, including temp/RH sensors, CO_2 monitors, testing of tVOCs, NO_2, HCHO, PM2.5/10, thermography, U-Value testing

•Experience of conducting interviews with building occupants and questionnaire development for building use studies.

•Experience of how to engage with building occupants in order to gain meaningful data and insights.

Relevant Research: MEARU

- Influence of ventilation design on the prevalence of anti-microbial bacteria in homes, (Oct 17 – Mar 19), AHRC, [redacted]
- KTP project with John Gilbert Architects (Mar 15 - Aug 17) [redacted] A project to develop BPE processes for on domestic retrofit projects to examine effects of retrofit measures on energy and environmental performance.
- Meta Study of MVHR systems in the IUK BPE programme. Study funded by IUK examining the performance of MVHR system in the BPE programme. [redacted]
- Health Effects of Modern Airtight Construction (HEMAC) Multi-disciplinary Network (May 16 – May 17), AHRC [redacted] (www.hemacnetwork.com)
- KTP project with Cartwright Pickard Architects, London. (Oct 2013 - Jan 2015). A project to develop BPE methodology on RSL properties in London. [redacted]
- Housing Fair Performance Evaluation - TSB funded, undertaken with A+DS. Building performance evaluation of exemplar social housing designed and constructed for the Scottish Housing Expo. [redacted]
- Comparison of Domestic Ventilation Methodologies in Energy Efficient Housing - ERDF/SEEKIT funded, undertaken with Anderson Bell + Christie Architects. Comparing internal air quality of similar dwellings with known infiltration rates and differing ventilation strategies [redacted]
- Dormont Park Building Performance Evaluation - TSB funded, in conjunction with Dormont Estates. A research project analysing the performance of 4 Passivhaus standard houses in Lockerbie. [redacted]
- Murray Place Performance Evaluation - TSB funded, in conjunction with Hanover Scotland Housing Association. A research project analysing the performance of 3 houses in a development for older people. [redacted]
- Glasgow House Building Performance Evaluation – TSB funded, in conjunction with Glasgow Housing Association. A research project analysing the performance of 2 exemplar, energy efficient dwellings through monitoring of 6 focussed occupancy scenarios. [redacted]
- Sunshine Health and Wellbeing - SFC funded, undertaken in partnership with Stirling and Glasgow Caledonian Universities. A study assessing the impact of lighting and internal environment quality on the physical and mental health of residents [redacted]
- Passivhaus Performance Evaluation - ERDF/SEEKIT and TSB funded, in partnership with Fyne Initiatives. Performance analysis of Scotland's first certified Passivhaus with a particular focus on monitoring and analysis of internal air quality. [redacted]
- Bloom Court - sub-contractor for evaluation of low energy sheltered housing in Livingston, by ECD architects.

- Environmental Assessment of Domestic Laundering. (Sept 08 - Nov 2011). [redacted] This research aimed to investigate the energy and environmental impacts attributable to domestic laundering and develop recommendations to address them. This three year project funded by the Engineering and Physical Sciences Research Council involved the monitoring and evaluation of 100 homes in Scotland to examine internal environments, occupancy, and effects of domestic laundry practices.
- KTP project Zero-Carbon Housing Design (May 09 – April 12) [redacted] A project to develop air-tight energy-efficient industrialised building system as well as design guidelines that can be applied to the delivery of affordable, replicable and marketable zero-carbon mass-customisable housing, which meets requirements to achieve the Code for Sustainable Homes Level 6.
- Post Occupancy Evaluation Carbon, Cost and Comfort in Housing, ERDF/SEEKIT. A feasibility study undertaking comparative Post Occupancy Evaluation on low energy housing to scope out the potential of a KTP project to develop a methodology for understanding issues of performance and occupancy in housing. John Gilbert Associates
- Low Energy Housing Refurbishment Post Occupancy Evaluation for Dumfries and Galloway Housing Association. ERDF/SEEKIT. Post Occupancy Evaluation of Passivhaus standard refurbishment of social housing.
- Control system for reduction of heating in unoccupied spaces. A project investigation innovative TRV controls for wet central heating systems, funded by the Technology Strategy Board, Energy Efficient Whitehall.
- Assessing the energy impact of different strategies of integrating PV/Thermal Heat Recovery systems in Scottish homes. Scottish Funding Council Voucher Scheme, Robert Ryan Homes
- IEA Joint SHC Task 40/ECBCS Annex 52 Towards Net Zero Energy Solar Buildings, EU.
- A Hybrid Solar Thermal Mass System Development for the Application to Tenants First Housing Co-operative's Zero-carbon Affordable Homes. ERDF/SEEKIT. A feasibility conducting research on a hybrid solar thermal mass (HSTM) system in which rooftop solar water heating pipes are physically connected to concrete thermal wall/floor mass
- QXHA - Westercommon CESP Report ERDF/SEEKIT. Investigation of energy performance upgrades of Tracoba Towers and 4 storey maisonettes at Westercommon, for Queens Cross Housing Association
- Robert Ryan Homes, Offsite Fabricated Cottages. Scottish Funding Council Innovation Scheme. A project to build zero carbon homes undertaking a series of research actions to gain a high level of technical knowledge relating to passive design techniques that help reduce the energy demand as well as active renewable energy technologies that supplement the remainder with local power generation.

Approach

WP1 Project management and development

[22 lines redacted exempt.]

WP2 Household survey (up to 200 homes)

[14 lines redacted exempt.]

[19 lines redacted exempt.]

WP3 Monitoring study (up to 50 homes)

[21 lines redacted exempt.]

[13 lines redacted exempt.]

WP4 Analysis of ventilation effectiveness

[11 lines redacted exempt.]

WP5 Detailed monitoring study (4-6 dwellings)

[9 lines redacted exempt.]

[7 lines redacted exempt.]

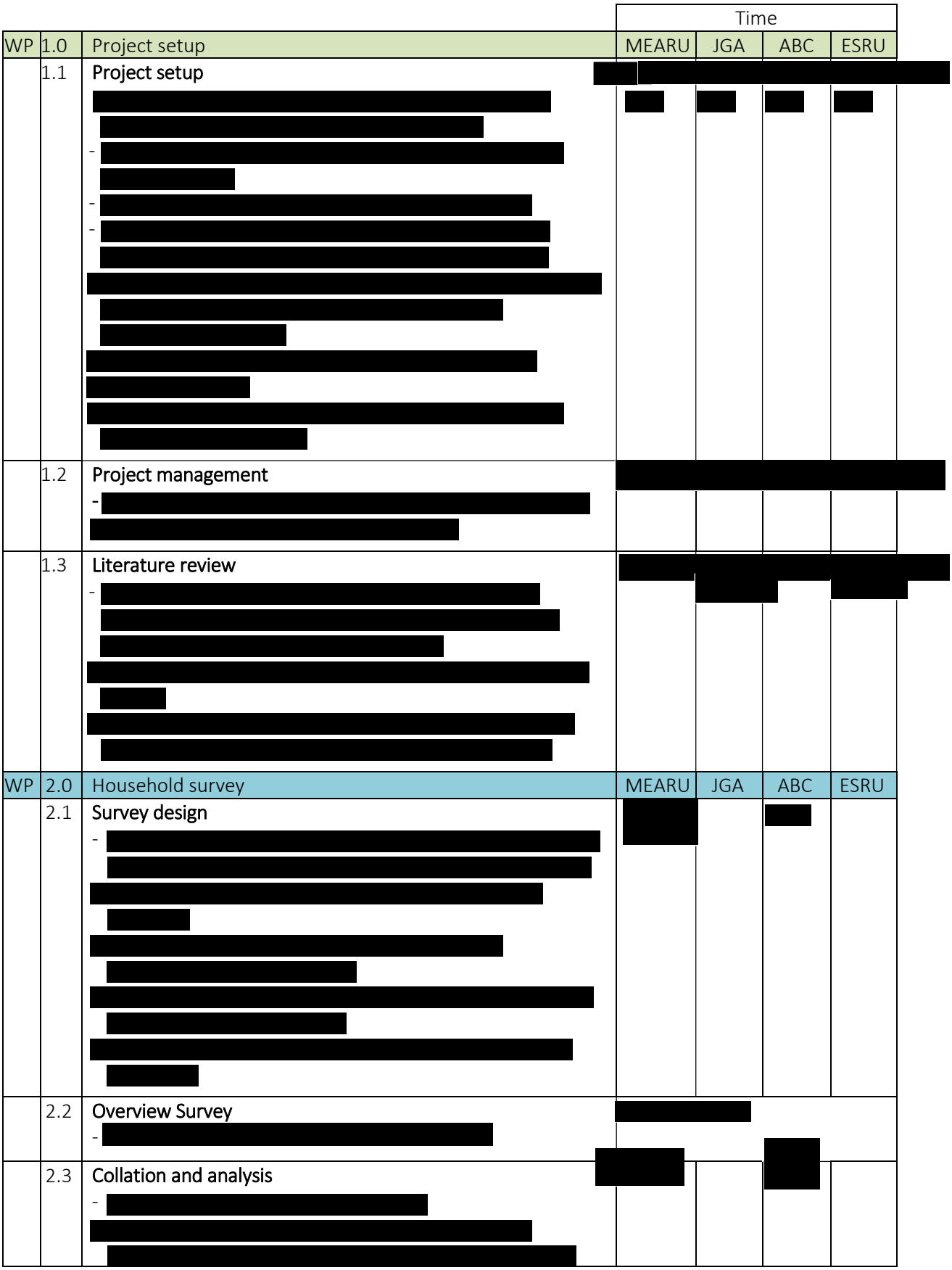
[8 lines redacted exempt.]

WP6 Analysis and dissemination

[7 lines redacted exempt.]

[10] Samuel, A.A.A.; Strachan, P.A. 2006, Contaminant modelling, In: HVAC and R Research, Vol. 12, No. 3a, 07.2006, p. 599-619.

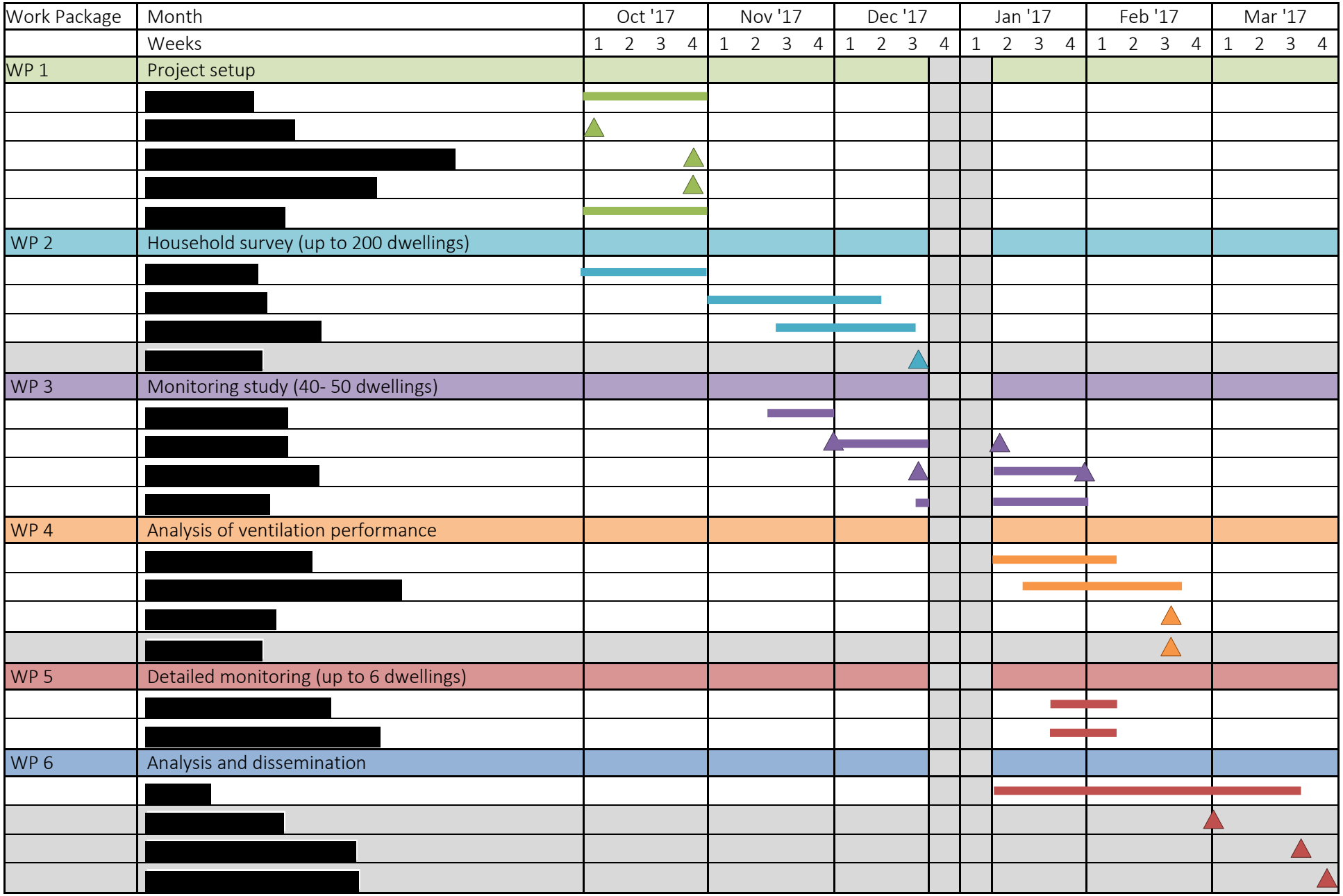
Methodology



		- [redacted]				
		Interim report - [redacted]				
WP	3.0	Monitoring study	MEARU	JGA	ABC	ESRU
	3.1	Monitoring setup - [redacted]				
	3.2	Equipment install (40- 50 dwellings) - [redacted]				
	3.3	Equipment collection - [redacted]				
	3.4	Data download - [redacted]				
WP	4.0	Analysis of ventilation performance	MEARU	JGA	ABC	ESRU
	4.1	Analysis of CO2 data - [redacted]				
	4.2	Identify patterns and variations [redacted]				
	4.3	Reporting - [redacted]				
WP	5.0	Detailed monitoring (up to 6 apartments)	MEARU	JGA	ABC	ESRU
	5.1	Airflow measurements - [redacted]				
	5.2	Investigation of air pathways [redacted]				
WP	6.0	Analysis and dissemination	MEARU	JGA	ABC	ESRU
	6.1	Analysis - [redacted]				

		- [redacted]				
	6.2	Reporting - [redacted]	[redacted]			

Timescale


Work Package
Month
Weeks
Oct '17
Nov '17
Dec '17
Jan '17
Feb '17
Mar '17
1 2 3 4
WP 1
Project setup
WP 2
Household survey (up to 200 dwellings)
WP 3
Monitoring study (40- 50 dwellings)
WP 4
Analysis of ventilation performance
WP 5
Detailed monitoring (up to 6 dwellings)
WP 6
Analysis and dissemination

Time input (project partners)

WP	1.0	Project setup	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	1.1	[redacted]	[redacted]					
	1.2	[redacted]						
	1.3	[redacted]						
		TOTAL						
WP	2.0	Household survey	MEARU (TS)	MEARU	JGA	JGA	ABC (JM)	ESRU
	2.1	[redacted]		[redacted]				
	2.2	[redacted]	[redacted]					
	2.3	[redacted]	[redacted]				[redacted]	
	2.4	[redacted]						
		TOTAL						
WP	3.0	Monitoring study	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	3.1	[redacted]				[redacted]		
	3.2	[redacted])	[redacted]					
	3.3	[redacted]						
	3.4	[redacted]						
		TOTAL	[redacted]					
WP	4.0	Analysis of ventilation performance	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	4.1	[redacted]						[redacted]
	4.2	[redacted]				[redacted]		
	4.3	[redacted]	[redacted]	[redacted]				
		TOTAL	[redacted]					
WP	5.0	Detailed monitoring (up to 6 apartments)	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	5.1	[redacted]				[redacted]		
	5.2							[redacted]
		TOTAL	[redacted]					
WP	6.0	Analysis and dissemination	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	6.1	[redacted]	[redacted]					
	6.2	[redacted]						
		TOTAL	[redacted]					

Risks

Issue	Likelihood of risk	Mitigating action(s)	Recovery plan
Difficulty obtaining information on equivalent area of trickle vents installed in the properties	[redacted]	[redacted]	[redacted]
Selected dwellings subsequently found to have trickle vents larger than 2500mm^2	[redacted]	[redacted]	[redacted]
Difficulty obtaining survey locations	[redacted]	[redacted]	[redacted]
Insufficient occupant participants	[redacted]	[redacted]	[redacted]
Dwellings are subsequently found to be not as airtight as certified	[redacted]	[redacted]	[redacted]
Insufficient occupant participants for monitoring study	[redacted]	[redacted]	[redacted]
Occupant withdrawal	[redacted]	[redacted]	[redacted]
Failure of monitoring equipment	[redacted]	[redacted]	[redacted]

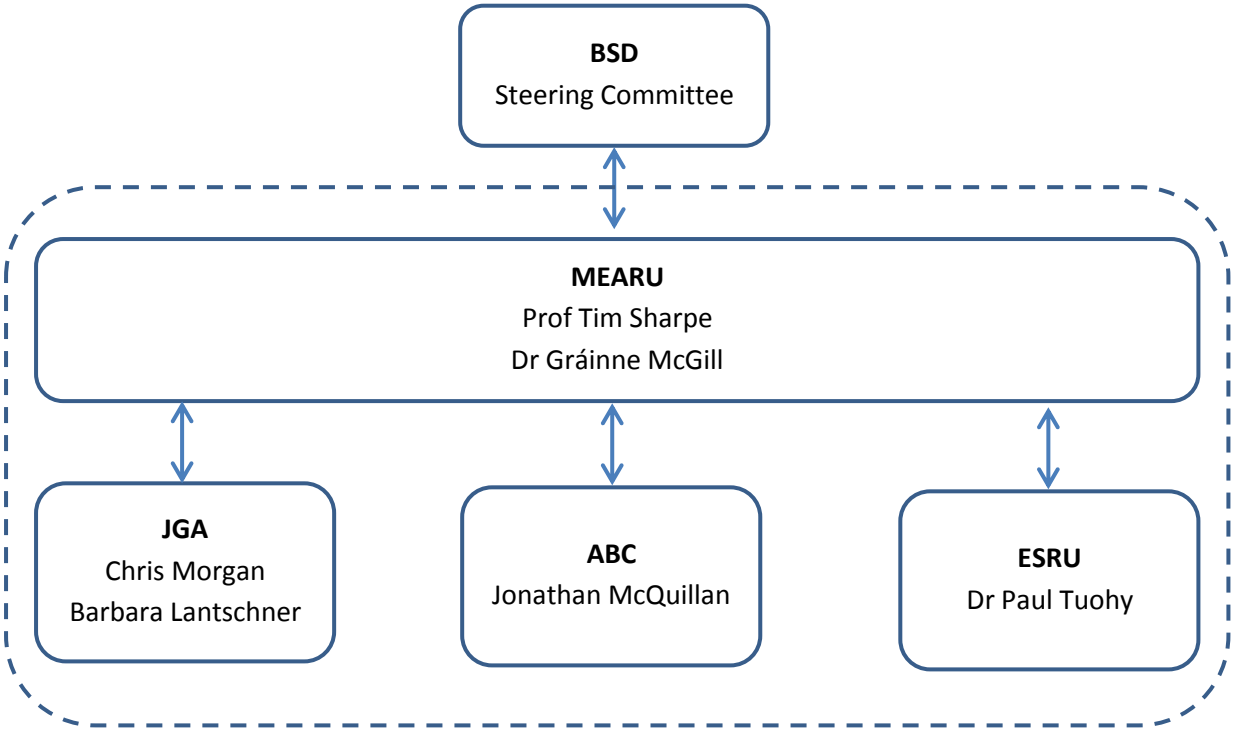
Adverse weather affecting site work	[redacted]	[redacted]	[redacted]
Fire/flood	[redacted]	[redacted]	[redacted]
Illness / absence of key person	[redacted]	[redacted]	[redacted]

Project management and quality assurance

The project will be undertaken within the remit of MEARU and will be subject to reporting at monthly project review meetings. More frequent meetings will be held by the project team. Identification of timescales and tasks will be reviewed at each of these meetings, suitable resources allocated to those tasks and details of reporting back to the project lead will be agreed. The project lead and principle investigators will meet on a weekly basis to check on review progress.

The research will follow RCUK Policy and Guidelines and GSA procedures including ethical approval and monitoring and reporting arrangements to ensure best practice in research management and quality assurance.

The management and reporting structure for this project will be as follows:



Ethical issues

All research conducted at GSA is subject to its ethical policy. The School is publicly accountable for research undertaken under its auspices, and all researchers have a responsibility to maintain the reputation of GSA and its excellent research standards. The GSA research ethics policy identifies the key research ethics issues and sets out the process for ethical review of research. It is available for scrutiny at: www.gsa.ac.uk/researchandpostgraduate

Glasgow School of Art has an equal opportunities policy, monitored by the Board of Governors. Our policies state that we provide equal opportunities to all, irrespective of their gender, race, ethnic origin, disability, age, nationality, national origin, sexuality, religion, marital status and social class. We oppose all forms of unlawful and unfair discrimination.

Our commitments include:

- Every employee is entitled to a working environment which promotes dignity and respect to all. No form of intimidation, bullying or harassment will be tolerated.
- The commitment to equal opportunities in the workplace is good management practice and makes sound business sense.
- Breaches of our equal opportunity policy will be regarded as misconduct and could lead to disciplinary proceedings.
- This policy is fully supported by senior management
- The policy will be monitored and reviewed annually.

Our policies will be implemented within the framework of the relevant legislation, which includes:

- Equal Pay Act 1970 (Equal Value Amendment 1984).
- Rehabilitation of Offenders Act 1974.
- Sex Discrimination Act 1975 (Gender Reassignment Regulations 1999).
- Race Relations Act 1976.
- Disability Discrimination Act 1995.
- The Protection from Harassment Act 1997.

References

Contract Description: [redacted]

Value: [redacted]

Duration: [redacted]

Name: [redacted]

Address: [redacted]

Contact Name & Tel No: [redacted]

Contract Description: [redacted]

Value: [redacted]

Duration: [redacted]

Name: [redacted]

Address: [redacted]

Contact Name & Tel No: [redacted]

Curricula Vitae

Name: Timothy Richard Sharpe
Work Telephone: [redacted]
Mobile: [redacted]
E-mail: [redacted]

[3 pages redacted exempt.]

Dr Gráinne McGill
Researcher, Mackintosh Environmental Architecture Research Unit, Glasgow School of Art

[3 pages redacted exempt.]

Dr Paul Gerard Tuohy
Energy Systems Research Unit (ESRU)
Mechanical And Aerospace Engineering
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[40 lines redacted exempt.]

[19 lines redacted exempt.]

Jonathan McQuillan
christie
Chartered Architect ARB RIAS
Position: Associate

anderson bell +

[33 lines redacted exempt.]

[14 lines redacted exempt.]

Chris Morgan BA BArch ARB RIAS CEPH

Director and Architect, John Gilbert Architects
Certified European Passivhaus Designer
RIAS accreditation for sustainable design (advanced)
PROFILE






[44 lines redacted exempt.]

Barbara Lantschner BA MSc

Building Performance Specialist, John Gilbert Architects
Certified European Passivhaus Designer/ Consultant

PROFILE

EDUCATION

[48 lines redacted exempt.]

Costs breakdown

WP	1.0	Project setup	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	1.1	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
	1.2	[redacted]	[redacted]					
	1.3	[redacted]	[redacted]					
		Total days	[redacted]					
		Daily rate						
		Total cost						
WP	2.0	Household survey	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	2.1	[redacted]		[redacted]			[redacted]	
	2.2	[redacted]	Lump sum					
	2.3	[redacted]	[redacted]	[redacted]			[redacted]	
	2.4	[redacted]	[redacted]	[redacted]			[redacted]	
		Total days	[redacted]	[redacted]			[redacted]	
		Daily rate	[redacted]	[redacted]			[redacted]	
		Total cost	[redacted]	[redacted]			[redacted]	
WP	3.0	Monitoring study	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	3.1	[redacted]				[redacted]		
	3.2	[redacted]				[redacted]		
	3.3	[redacted]				[redacted]		
	3.4	[redacted]				[redacted]		
		Total days	[redacted]	[redacted]		[redacted]		
		Daily rate	[redacted]	[redacted]		[redacted]		
		Total cost	[redacted]	[redacted]		[redacted]		
WP	4.0	Analysis of ventilation performance	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	4.1	[redacted]						[redacted]
	4.2	[redacted]				[redacted]		[redacted]
	4.3	[redacted]	[redacted]	[redacted]				[redacted]
		Total days	[redacted]	[redacted]		[redacted]		[redacted]
		Daily rate	[redacted]	[redacted]		[redacted]		[redacted]
		Total cost	[redacted]	[redacted]		[redacted]		[redacted]
WP	5.0	Detailed monitoring (up to 6 apartments)	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	5.1	[redacted]				[redacted]		
	5.2	[redacted]						[redacted]
		Total days				[redacted]		[redacted]
		Daily rate				[redacted]		[redacted]
		Total cost				[redacted]		[redacted]
WP	6.0	Analysis and dissemination	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
	6.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	6.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Total days	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Daily rate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Total cost	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Costs breakdown

Project partner	MEARU (TS)	MEARU (GM)	JGA (CM)	JGA (BL)	ABC (JM)	ESRU (PT)
Cost per day	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total number of days	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Additional costs

Description	Breakdown	Total
Household incentives [redacted]	[redacted]	[redacted]
Travel costs [redacted]	[redacted]	[redacted]
Household Survey [redacted]	[redacted]	[redacted]

Total: [redacted] (excluding VAT)

	Excluding VAT	**VAT**
Total staff costs	[redacted]	[redacted]
Total travel costs	[redacted]	[redacted]
Household survey	[redacted]	[redacted]

Total VAT : [redacted]

Total including VAT: [redacted]

Schedule 1

INSTRUCTIONS FOR TENDERERS

1. It is the responsibility of the tenderer to obtain for themselves at their own expense any additional information necessary for the preparation of their tender.

2. All information supplied by the Scottish Ministers in connection with the Invitation to Tender shall be treated as confidential by tenderers except that such information may be disclosed for the purpose of obtaining sureties and quotations necessary for the preparation and submission of the tender.

3. The issue of an Invitation to Tender (ITT) is not a commitment by the Scottish Ministers to place a contract as a result of the Tendering exercise or at a later stage.

4. All information requested should be provided on the Tender Schedules enclosed (additional sheets may be used if required, but all information should be provided in the order and format of the Schedules). **Tenderers should also note that their Pricing Schedule (Commercial Offer) must be submitted as a separate document.**

5. Tenderers may submit a tender using their own text creation facilities. However, the content and layout must be identical to the Scottish Government version of the relevant sections of the tender.

6. Tenderers **must** submit their completed tenders via the Public Contracts Scotland (PCS) Portal for this opportunity. Please note that large electronic files take time to download and tenderers should ensure that sufficient time is allowed for this to be done. The speed with which submissions are made are dependent on the size of the document and inclusion of graphics, logos, photographs etc. should be omitted wherever possible.

7. Nothing in this ITT shall preclude Scottish Ministers from making public, under the Freedom of Information (Scotland) Act 2002 ("FOISA") and/or the Environmental Information (Scotland) Regulations 2004 ("EIRS") or otherwise, details of all matters relating to this ITT, And responses thereto unless such details fall within an exemption under FOISA and/or EIRS as may be applicable at the discretion of Scottish Ministers. Scottish Ministers (at its sole discretion) where they consider that such exemption shall apply, and (in respect of commercially sensitive information only) where a Tenderer has advised Scottish Ministers in writing that disclosure of specified information would or would be likely to substantially prejudice the commercial interests of any person (including but not limited to the Tenderer or Scottish Ministers).

8. Tenderers should also note that the receipt of any material or document marked "confidential" or equivalent by Scottish Ministers should not be taken to mean that Scottish Ministers accepts any duty of confidence by virtue of that marking.

9. The Tenderer should be aware that should any of its responses be found to be deliberately misleading or falsified, the bidding organisation may be disqualified from the tender process.

10. Scottish Ministers reserve the right to withdraw the requirement at any stage prior to the award of the contract and the right to amend the ITT documents at any time prior to the deadline for receipt of tenders. Any such amendment will be numbered and dated. Where amendments are significant, the Scottish Ministers may, at their discretion, extend the deadline for receipt of tenders.

11. Scottish Ministers reserve the right to reject or exclude from the procurement process a Tender, where the Tenderer has submit a response which is not in compliance with the requirements of the ITT; the ITT response is submitted late, is completed incorrectly or is incomplete. Where the Tenderer fails to respond in satisfactory terms to a request by Scottish Ministers for supplementary or to provide clarity in relation to the Tenderer's response to the ITT; or the Tenderer or any of its sub-contractors or consortium members is/are guilty of serious misrepresentation in relation to its response to the ITT and/or the procurement process; or where there is a change in identity, control, financial standing or other factor affecting the tenderer.

12. The date for tender return is **9am on Thursday 28 September 2017** Scottish Ministers will not enter into detailed discussions with Tenderers in relation to its requirements. All questions regarding the content of this ITT should be directed through the dedicated PCS messaging area by **Thursday 7 September 2017**. No other form of communication will be accepted. All technical queries should be directed to PCS on telephone number 0800 222 9003.

13. Direct or indirect canvassing of any elected official, public sector employee or agent by any Tenderer concerning this requirement, or any attempt to procure information from any elected official, public sector employee or agent concerning this ITT may result in the disqualification of the Tenderer from consideration for this requirement.

14. The successful tenderer will be selected on the basis of the most economically advantageous bid, throughout the tender process as a whole, having regard to the price and quality of the proposals against defined evaluation criteria. A Best Price Quality Ratio will be used in the tender evaluation. The Technical Proposal will form the basis of the quality evaluation and the Pricing Schedule will form the basis of the commercial evaluation.

15. The ITT is issued on the basis that nothing contained in it will constitute an inducement or incentive nor will have in any other way persuaded a tenderer to submit a Tender or enter into any contractual agreement.

16. Tenders shall remain valid and open for acceptance for 3 months after the tender return date. In exceptional circumstances, Scottish Ministers may request that the tenderer extend the validity period for a specified additional period.

17. Please provide the following information

17.1	Name of Contact for this Tender	[redacted]
17.2	Position	[redacted]
17.3	Address	[redacted]
17.4	Tel No	[redacted]
17.5	Email	[redacted]

Any tender that does not accord with all the requirements herein and in the covering letter may not be considered.

Schedule: 2

FORM OF TENDER TO THE SCOTTISH GOVERNMENT

(*DELETE AS APPROPRIATE)

*We the undersigned do hereby contract and agree on the acceptance of the Tender by the Scottish Ministers, to provide the goods and/or services in the Specification in accordance with the Schedules, at the prices entered in the Pricing Schedule and in accordance with the Scottish Government Standard Conditions of Contract for the Purchase of Services (SGTC2) which appear in this set of documents.

*We the undersigned undertake to submit a tender in accordance with the following documents:

Instructions for Tenderers (Schedule 1)

The Form of Tender (Schedule 2)

Price Proposals (Schedule 3)

Reference Schedule (Schedule 4), and

Invitation to Tender: Ability of decentralised mechanical ventilation to act as ‘whole-house’ ventilation systems in new-build dwellings

*We agree to abide by this tender from 9am on Thursday 28 September 2017 the date fixed for receiving tenders, until the Award of Contract.

*We understand that the Scottish Ministers are not bound to accept the lowest or any tender and shall not be bound to use the contractor as a sole supplier.

Signature	[redacted]	
Name	[redacted]	**(BLOCK CAPITALS)**
Designation	[redacted]	

Duly authorised to sign Tenders for and on behalf of:

Name of Tenderer	[redacted]	
Nature of Firm	[redacted]	
Address	[redacted]	
Telephone No	[redacted]	**INCLUDE AREA CODE**
Date	[redacted]	

It must be clearly shown whether the Tenderer is a limited liability company, statutory corporation, partnership, or single individual trading under his own name.

Schedule 3

PRICE SCHEDULE

Point of Delivery	Description of Services	Quantity	Price Per Unit Exc VAT	Total Price Exc VAT
WP 1	Project setup (researcher time)			[redacted]
WP 2	Household survey (researcher time) [redacted]			[redacted]
WP 3	Monitoring study (researcher time) [redacted]			[redacted]
WP 4	Analysis of ventilation performance (researcher time)			[redacted]
WP 5	Detailed monitoring (researcher time)			[redacted]
WP 6	Analysis and dissemination [redacted]			[redacted]

			Total Excluding VAT	[redacted]

VALUE ADDED TAX

1. Registration Number GB 790 7507 06

2. Total amount of VAT payable on this tender [redacted]

3. VAT rate (20%)

Schedule 4

RESTRICTED – COMMERCIAL

REFERENCES SCHEDULE

1. Tenderers must provide details of two references of past Clients whom comparable services have been provided. These Clients may be contacted for references.

Contract Description: [redacted]

Value: [redacted]

Duration: [redacted]

Name: [redacted]

Address: [redacted]

Contact Name & Tel No: [redacted]

Contract Description: [redacted]

Value: [redacted]

Duration: [redacted]

Name: [redacted]

Address: [redacted]

Contact Name & Tel No: [redacted]