Mackintosh Environmental Architecture Research Unit

The Glasgow School of Art

The Mackintosh Environmental Architecture Research Unit was established in Glasgow's Mackintosh School of Architecture in 1993 to carry out research and building performance evaluation that would lead to better quality public housing for all.

Its founder, Professor Colin Porteous OBE, is an architect and researcher who, in 1981, became active in the international solar community, leading a community technical aid centre and linking problems of fuel poverty to passive solar solutions. He became a full-time academic in 1986.

Since its founding, MEARU has established a track record of high-quality research into environmental architecture, raising awareness of poor-quality living conditions and sharing our findings widely. We remain firm in our mission to undertake work that will lead to improved indoor environments and health outcomes for occupants and users of all types of buildings.

Today MEARU continues to work on cutting edge research in housing quality and building performance evaluation, collaborating with academics and construction professionals in Scotland and across the globe.

This exhibition gives a snapshot of the breadth of our projects over the last 30 years.

(By the way, it's MEARU ('*mee-roo*') if you prefer less of a mouthful.)

1993

Easthall Solar Demonstration Project

Context

Easthall is a residential area in the east end of Glasgow, that was built in the 1950s. Being largely uninsulated, they were difficult and expensive to heat, had condensation and dampness and caused high levels of fuel poverty. The tenants complained to their landlord, Glasgow City Council, of mould on walls, furniture, carpeting and clothing and that living in these conditions had a major impact on their physical and mental health.

When these problems were blamed on their lifestyle – and not the poor quality of the houses – the tenants felt that their voice was unheard. To fix this they set up the Dampness Group, which campaigned for warm, dry homes. One of the Easthall residents, Cathy McCormack (1952 – 2022), became a driving force in the group, going on to become an anti-poverty campaigner on the global stage.

Project

In 1987 the HEATFEST Ideas Conference and Competition led to Easthall being the subject of the first tenant-led retrofit in Europe, titled the 'Passive Solar Retrofit of Thermally Sub-standard Housing'. The aim of the project was to demonstrate how heating costs could be reduced and condensation and dampness eliminated in 36 of the houses. It was the first major retrofit in Scotland to achieve this, and used a combination of passive and hybrid solar techniques including insulating the homes, creating glazed 'buffer spaces' and using solar heat exchangers to preheat hot water.

MEARU's role was to carry out a comparative assessment of the upgraded homes against a sample of the homes that had not been upgraded. The results demonstrated, beyond any doubt, that heating bills were reduced to a fraction of what they had been before.

All images: MEARU

Funding

Glasgow City Council and the Commission of European Communities

Impact

This project upgraded 36 homes for residents in the Easthall community to give then warm, dry places to live. Cathy McCormack, one of the campaigners, became involved in global health issues and Glasgow Women's Library holds an archive of Cathy's activism activities.

Scan this QR Code to view the short film 'War Without Bullets…' written and presented by Cathy McCormack

THE GLASGOW SCHOOL OF ART

1999

Building Health in Glasgow Exhibition

Project

Initiated by Professor James McEwen, head of the Department of Public Health at the University of Glasgow, and shown in Glasgow Royal Infirmary from August - November 1999, this exhibition was designed to help celebrate the Fourth Centenary of the Royal College of Physicians and Surgeons of Glasgow. It presented a visual story of the role buildings have played over two hundred years of public health improvements in Glasgow. MEARU conducted the research, curated and published an accompanying information booklet covering a time-line of epidemics, health issues and subsequent reforms aimed at improving population health.

Despite better sanitation in the mid-19th century, indoor air quality in homes remained very poor. The exhibition chronicled changes to housing design through the second half of the 19th century, including enlarged rooms, cross ventilation, high ceilings and large windows to let in sunlight – all of which helped to minimise infections in densely populated areas. With the Industrial Revolution leading to rapid increases in urban populations, the corresponding need for decent-quality mass housing saw the development of tenements that included all of these new design features.

Three-quarters of a century later, collective amnesia set in and these fundamental principles of good housing design for public health were largely discarded in favour of the 'modern' goals of cheapness, speed and mass production. With some notable exceptions, 1950s housing went back to having inadequate ventilation, dampness and poor occupant health. It is no small irony that much of the housing stock from this period is marked for replacement, while the tenements of the 19th century retain their strong attraction.

The exhibition ended on a positive note by indicating that in the 21st century, design and delivery of healthy buildings is not just possible, but a fundamental human right.

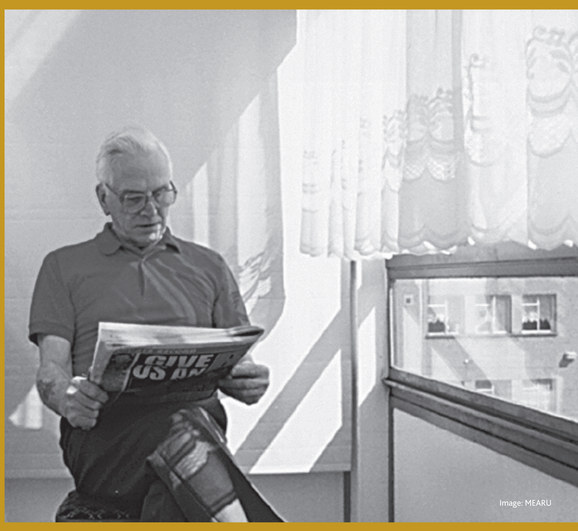

Image: MEARU


Image: Martyr's School by C.R. Mackintosh, reproduced from 'Building Health in Glasgow' 1999

Funding

Astra Zeneca; W.S. Atkins; Boots the Chemists; Glasgow 1999 Partnership Fund; Glasgow Royal Infirmary; Glaxo Wellcome; Laing Ltd; Macintosh School of Architecture – Glasgow School of Art; MacRoberts; Pfizer, Royal College of Physicians and Surgeons of Glasgow; Scottish Widows.

Impact

The exhibition successfully pulled together a rich resource of information that raised awareness about epidemics and the resulting public health reforms that impacted building design in Glasgow over a 200 year period.

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2007

Wyndford Housing Estate Upgrade

Context

The 1960s Wyndford Estate includes approximately 1,500 homes arranged in a mix of high-rise (lift access) with low-rise (walk-up access) blocks with flatted and maisonette house types. It is owned by Cube Housing Association and located in the heart of Maryhill, on the north side of Glasgow city centre.

Project

MEARU carried out an options appraisal study to examine the energy performance of a range of homes in the estate and found that they were poorly insulated (or not insulated at all) and difficult and expensive to heat. This was partially due to the all-electric heating based primarily on storage heaters, which occupants found difficult to control and often augmented with direct electric heaters on a much more expensive tariff.

As a result, a large proportion of tenants were in fuel poverty and debt. Like our findings at Easthall in 1993, high levels of dampness, condensation and mould growth could be found in homes, all of which negatively affected tenants' health.

MEARU helped to develop a series of design options to improve the energy efficiency of the homes, reduce fuel poverty and improve indoor environmental conditions. These upgrades were expected to save an average of almost 50% in energy consumption, reducing the cost of heating.

All images: MEARU

Funding

Cube Housing Association

Impact

MEARU's options appraisal resulted in improvements to the energy efficiency of the buildings through the installation of insulation and affordable heating. In turn, this reduced heating costs for the tenants, helping to alleviate fuel poverty.

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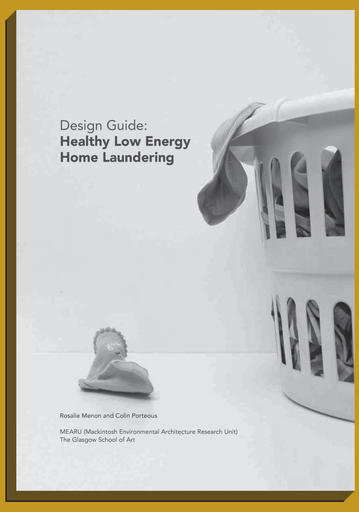
2008

Healthy Home Laundry



Context

Following our work in other projects, including Easthall and Wyndford, researchers at MEARU identified that high numbers of tenants did not have outdoor drying greens or communal drying spaces, so they were forced to dry laundry indoors.

Over three years, MEARU studied domestic laundry drying in 100 homes in Glasgow to inform a new design guide for domestic laundry. During the research, residents told the researchers about the problems of drying laundry indoors, including the amount of space it took up, staining on walls and a damp smell.

Project

MEARU's research found increased indoor moisture levels when washing was being dried indoors, increased mould spores and dust mites and a potential link between laundry fragrance and ill health. Research has shown how these can negatively affect the health of occupants, particularly those who have asthma or other respiratory health complaints.

A key finding was that 30% of moisture in the homes studied was attributable to clothes drying, leading to our principal message to households to ventilate when drying clothing indoors to minimise adverse outcomes on the indoor air quality.

The design guide sets out the energy, environmental and social context of drying washing indoors and includes practical design steps for housing providers and their architects to consider during the design phase of housing.

All images: MEARU

Funding

Engineering and Physical Sciences Research Council (EPSRC)

Impact

View our impact area in the exhibition for more information about this project.

THE GLASGOW SCHOOL OF ART

Scan this QR Code to download a copy of the Laundry Guide

2010

Quick Start Home-user Guide

Project

During MEARU's research on different housing projects, we often saw that those moving into new homes would be given a set of information – usually an 'Operation and Maintenance Manual' – and occasionally a brief demonstration on how to operate different systems, including extract fans and heating. Despite this, tenants would still have problems operating these effectively. This project explored why those problems occurred, how they could be resolved and identified two main issues.

Firstly, tenants often suffered from information overload, trying to understand potentially complex demonstrations of the different systems at the same time as organising a house move, dealing with utilities and arranging multiple other related tasks. Secondly, many tenants found that moving into a new home in spring or summer – when heating was not needed – meant they had forgotten how to operate the system efficiently when winter arrived.

MEARU learnt that manuals were too technical and did not exactly match what had been installed, making it difficult to correctly set controls. As a result, manuals frequently ended up unread and tenants managed their systems through trial and error or by asking a friend. Such misunderstandings can potentially increase energy costs and cause poor indoor air quality, establishing the need for a non-technical and engaging approach to communicating this information.

Building on previous research work with the Scottish Government on occupant guides, MEARU worked with the Home Log Book Company to create a template for a 'quick start' guide – simple, bespoke instructions for tenants and homeowners on how to efficiently operate their new house.

Re-named the 'Home Starter Guide' the document is now a mandatory requirement of the Scottish Domestic Building Regulations for all new homes in Scotland.

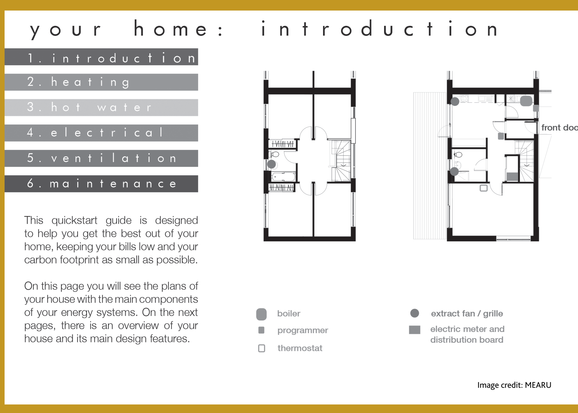


Image credit: MEARU

Image credit: MEARU

Funding

CIC Start on-line

Impact

Before 2010, Scottish Building Regulations for new homes only required written information for occupiers on heating and hot water systems. MEARU's work made comprehensive, non-technical Quick Start Guides mandatory for all new homes.

Scan this QR Code to download a copy of MEARU's template for the Quick Start Guides

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2012

Building Performance Evaluation

Project

Until the early 2010s, very little research had been conducted to assess the effectiveness of improved energy efficiency targets in Scottish Building Regulations, as well as any unintended consequences.

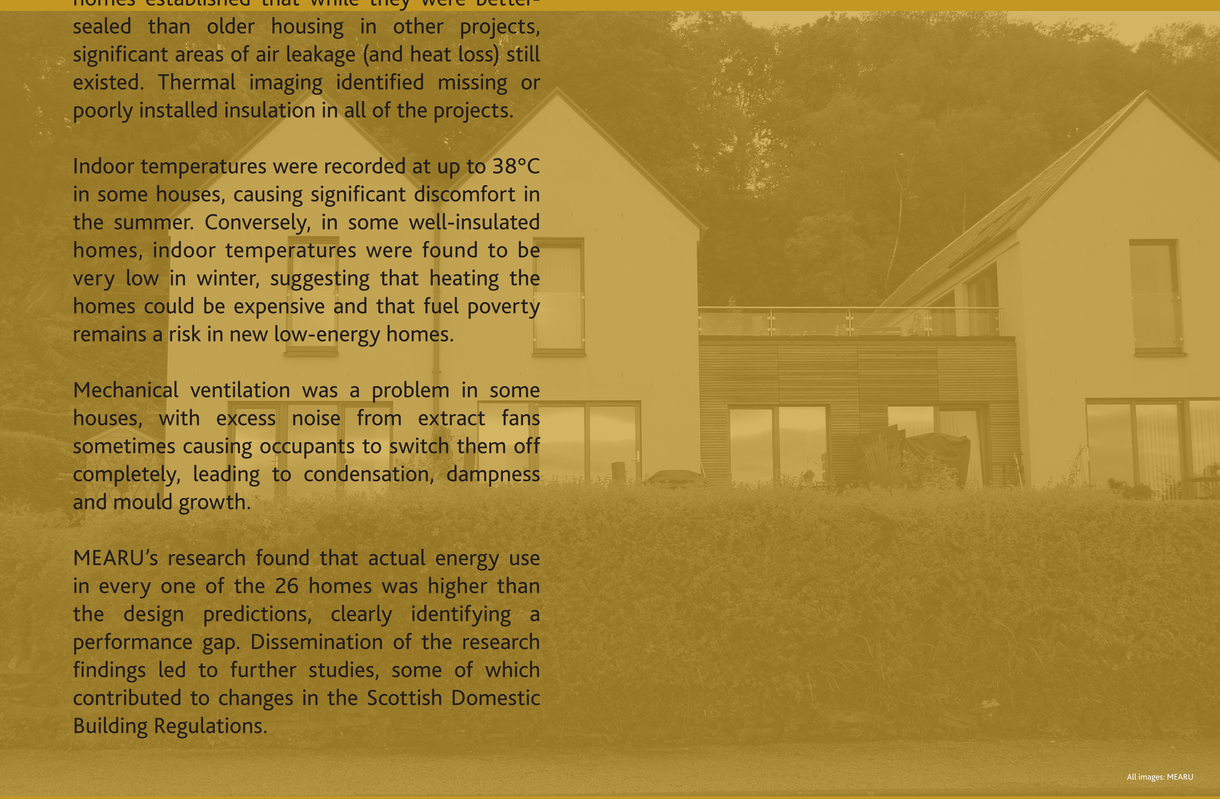
Undertaken as part of a UK-wide Building Performance Evaluation (BPE) Programme, MEARU assessed the energy consumption, indoor environmental quality and building fabric performance of 26 homes in six new housing developments in Scotland over a two-year period. This study differed from MEARU's previous work in that it compared *intended* design performance against the *actual* performance of recently constructed 'low-carbon' homes.

Airtightness testing and tracing of draughts in the homes established that while they were better-sealed than older housing in other projects, significant areas of air leakage (and heat loss) still existed. Thermal imaging identified missing or poorly installed insulation in all of the projects.

Indoor temperatures were recorded at up to 38°C in some houses, causing significant discomfort in the summer. Conversely, in some well-insulated homes, indoor temperatures were found to be very low in winter, suggesting that heating the homes could be expensive and that fuel poverty remains a risk in new low-energy homes.

Mechanical ventilation was a problem in some houses, with excess noise from extract fans sometimes causing occupants to switch them off completely, leading to condensation, dampness and mould growth.

MEARU's research found that actual energy use in every one of the 26 homes was higher than the design predictions, clearly identifying a performance gap. Dissemination of the research findings led to further studies, some of which contributed to changes in the Scottish Domestic Building Regulations.



All images: MEARU

Funding

Innovate UK (formerly Technology Strategy Board)

Impact

MEARU's work demonstrated a clear performance gap between design intent and the actual performance of new homes - both in energy use and indoor air quality. This contributed to further research on overheating, indoor air quality and ventilation in new and existing homes.

2015

Knowledge Transfer Partnership

Context

A Knowledge Transfer Partnership is a collaboration between a university and a business that would like to innovate to develop market opportunities that make an economic impact or to gain a competitive advantage with the services they offer. On this project, John Gilbert Architects, based in Glasgow, identified an opportunity to develop in-house building performance evaluation expertise and collaborated with MEARU to develop benchmarking and evaluation techniques for existing and new dwellings.

The two partners worked together for around 29 months to explore how to improve energy efficiency and ventilation provision in existing uninsulated properties in the social housing sector.

Project

The work aimed to establish the extent to which the retrofitted dwellings had improved thermal comfort and affordable heating costs for tenants. It was achieved by adopting a short-term building performance evaluation approach where a number of flats in different locations were examined before retrofit. The approach led to a detailed understanding of the heat loss through walls, airtightness levels, the extent of thermal bridging and assessment of indoor environmental conditions and ventilation.

In turn, this data was used to create benchmarks against which retrofit improvements could be accurately compared. While unintended consequences of the initial retrofit approach were found, recommendations were given for future external wall retrofit plans. Overall this partnership resulted in the formation of Hab-Lab, a successful and integral part of John Gilbert Architects.

All images: MEARU / John Gilbert Architects

Funding

Glasgow School of Art, Innovate UK and John Gilbert Architects

Impact

This partnership created Hab-Lab, a successful addition to John Gilbert Architects' services, and improved indoor environments for tenants living in the retrofitted housing association homes.

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Scan this QR Code to find out more about Hab-Lab and its work to close the performance gap

2015

Sunshine, Health & Wellbeing

Context

In recent years a growing body of evidence has developed from hospital and workplace environments that supports the theory that rooms receiving sunlight are better for occupant health than those that do not. Despite this being suspected since the late 1800s, there is still little empirical evidence of how these benefits relate to housing. As a result, this study evaluated how sunlight admittance influenced the psychological health of residents living in a social housing project in Glasgow.

All images: MEARU

Project

The study was based on data collected for living rooms and kitchens in 40 homes in four tower blocks in the Shawlands area of Glasgow. Data included details about occupiers' activity levels, sleep quality, diet, curtain or blind usage, ventilation and indoor environment quality.

To enhance this information, a computer simulation was used to assess the sunlight opportunity in living rooms and kitchens of the homes, including determining an assessment of how far sunlight penetrated into the rooms.

The research found that access to sunlight in the home was likely to positively influence the psychological health of the residents, particularly for individuals who spent much of their time at home. This paper was developed from previous sunshine accessibility research and was presented at the Daylight Symposium, in September 2015 in London.

Funding

Self-funded by MEARU and the Glasgow School of Art

Impact

MEARU's research for this project supported previous theories to help demonstrate that the amount of sunshine received in the home can impact the mental health of occupiers.

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2016

Build Tight, Ventilate Right

Project

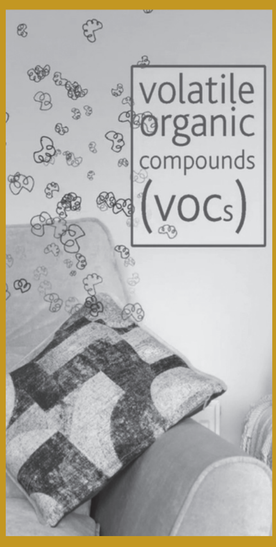
Indoor air can be up to five times more polluted than outside air, which makes it essential to ventilate homes effectively. Pollution types in homes are wide and varied and include body odour, cleaning products, toiletries, cosmetics, fire retardants, particulates from cooking and burning candles, moisture from breathing and sweating, and steam generated in the kitchen and bathroom. These pollutants are not easily seen and a lack of adequate ventilation allows them to build up, often to dangerous levels.

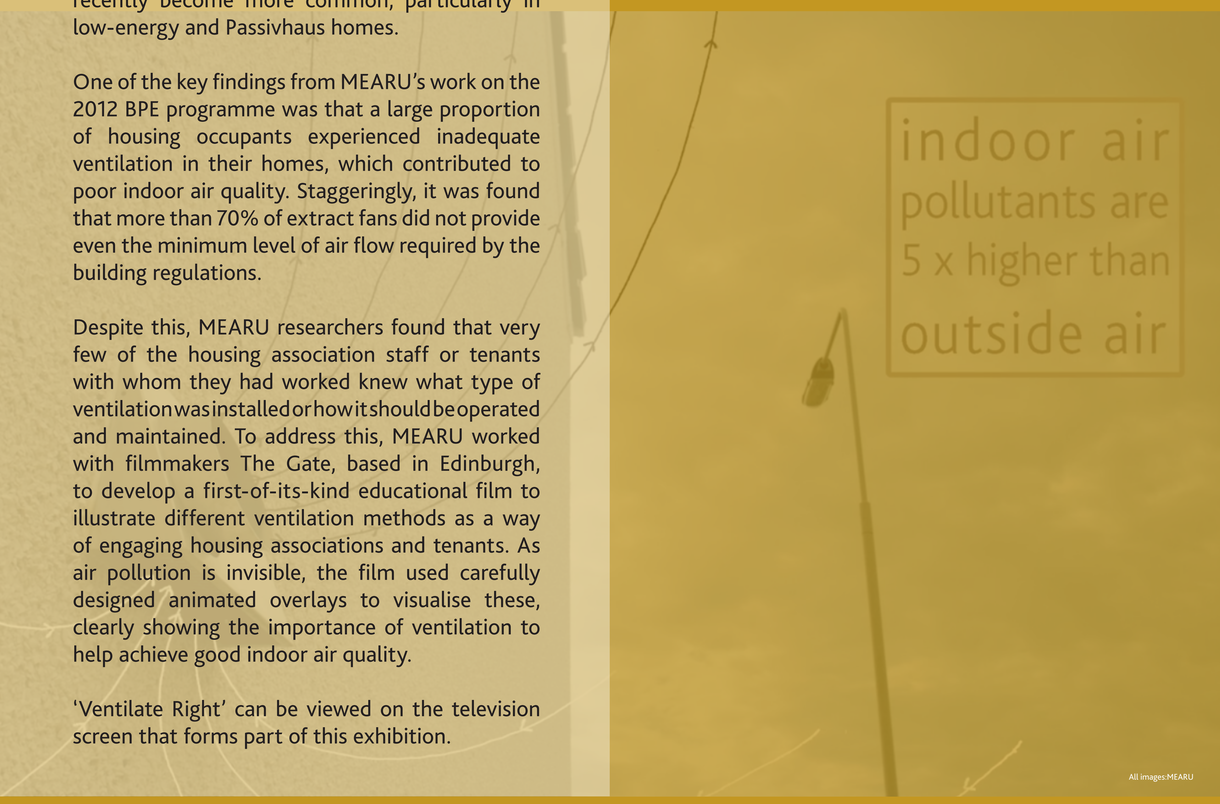
Since the 1970s, mechanical extract fans have been commonly used in kitchens and bathrooms to complement opening windows in other rooms as a way of ventilating homes. To reduce the uncontrolled heat loss that this approach causes, whole-house heat recovery ventilation has recently become more common, particularly in low-energy and Passivhaus homes.

One of the key findings from MEARU's work on the 2012 BPE programme was that a large proportion of housing occupants experienced inadequate ventilation in their homes, which contributed to poor indoor air quality. Staggeringly, it was found that more than 70% of extract fans did not provide even the minimum level of air flow required by the building regulations.

Despite this, MEARU researchers found that very few of the housing association staff or tenants with whom they had worked knew what type of ventilation was installed or how it should be operated and maintained. To address this, MEARU worked with filmmakers The Gate, based in Edinburgh, to develop a first-of-its-kind educational film to illustrate different ventilation methods as a way of engaging housing associations and tenants. As air pollution is invisible, the film used carefully designed animated overlays to visualise these, clearly showing the importance of ventilation to help achieve good indoor air quality.

'Ventilate Right' can be viewed on the television screen that forms part of this exhibition.





All images:MEARU

Funding

Glasgow School of Art;
Zero Carbon Hub, Innovate UK;
Historic Environment Scotland.

Impact

It can be difficult to appreciate the value of good ventilation in buildings. This film provided easy to understand information to a wide audience and remains freely available for use. The film can be viewed on the GSA's Vimeo channel.

Scan this QR Code to watch a BBC News report about the research behind the film

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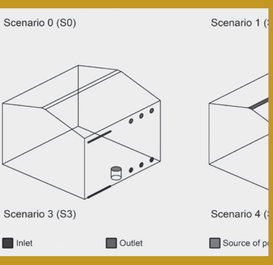
2022

Improving Informal Dwellings in Nairobi, Kenya



Context

'Particulate matter' is the term used to describe solid molecules of pollution in the air. Particulate matter with a diameter of 2.5 micrometres or less ('PM2.5') poses a greater risk to human health than any other air pollutant. Its most common source is the burning of fossil fuels, including wood, oil, coal and gas, as well as petrochemical derivatives such as plastics.

The research team for this project, which was made up of MEARU, the University of Nairobi and the African Population & Health Research Center, hypothesised that the high levels of PM2.5 found in low-resourced settlements in Nairobi could be reduced through a combination of air quality policies, distributive justice and occupant participation.

Project

The project aim was to investigate and clearly identify PM2.5 (in)justice in a representative settlement in Nairobi and use this evidence to develop policy actions and occupant participation towards better air quality. A detailed understanding was developed of the key sources of indoor PM2.5 and the occupant activities in the home.

Burning fuels for cooking was found to be the main source of PM2.5 in these homes. Different passive ventilation options were assessed through computer simulation, leading to three options being retrofitted to sample homes. This included nets to stop mosquitos from entering the home through the retrofitted ventilation openings. The overall goal was to reduce particulate exposure indoors and protect respiratory health. Overall the approaches reduced the build-up of PM2.5 in the homes and improved the indoor air quality.

All images: MEARU, the University of Nairobi and the African Population & Health Research Center

Funding

British Academy

Impact

MEARU's collaboration with other institutions and the homeowners involved led to the design and installation of low-cost ventilation solutions for the homes in this study. This resulted in improved indoor conditions and directly benefited the health of the families living in the homes.

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MEARU Projects
1993 - 2003

General SAP social housing survey involving low-level monitoring program to validate theoretical SAP calculations against performance data. Funded by Communities Scotland.

SAP+ The development of the Standard Assessment Procedure energy model.

Design of glazed roof preheat spaces in new housing construction by Dunbritton Housing Association, Dumbarton. Funded by Energy Action Scotland.

An evaluation of CAD as a method for enabling user participation in housing design. Funded by Scottish Homes.

A project to develop a spreadsheet version of the BREDEM and SAP methodology in collaboration with the Building Research Establishment (BRE). Funded by Right to Warmth.

T84 Feasibility Study and EU Thermie submission for solar thermal upgrading of T84 housing blocks in Glasgow. Funded by Glasgow City Council.

Consultancy advice on energy efficient improvements and participatory development of proposals in new-build housing in Priesthill. Glasgow City Council Property Services.

Building Health in Glasgow exhibition commissioned by The Department of Public Health, Glasgow University. Graphic work on exhibition boards by Mary Patrick, Graphics Co., Edinburgh.

Window-Integrated Solar Air Collectors (WISACs), and solar-boosted dynamic insulation for solar preheated air in conjunction with Paul Baker, BRE.

Easthall Solar retrofit project in Easterhouse Glasgow to eliminate condensation dampness in thermally substandard local authority houses by passive and hybrid solar techniques. Commission of European Communities Fund.

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MEARU Projects
2003 - 2013

Dormont Park Passivhaus Building Performance Evaluation for Dormont Estate funded by the Technology Strategy Board.

Dormont Estate Passivhaus Zero Carbon Assessment. SFC Innovation Voucher.

Murray Place Performance Evaluation for Hanover Scotland Housing Association funded by the Technology Strategy Board.

Knowledge Transfer Partnership (3-year associate), Cartwright Pickard Architects, Building Performance Evaluation.

Scotland's Housing Expo Phase 2 Building Performance Evaluation, in collaboration with Architecture and Design Scotland. Funded by Technology Strategy Board.

The Glasgow House Phase 1 Building Performance Evaluation, in collaboration with Glasgow Housing Association. Funded by Technology Strategy Board.

Bloom Court Building Performance Evaluation, in collaboration with Energy Conscious Design. Funded by Technology Strategy Board.

Tigh Na Cladach Building Performance Evaluation in collaboration with Fyne Initiatives. Funded by Technology Strategy Board.

Evaluation of Sunshine, Health and Wellbeing in Housing in collaboration with Stirling University. AHRC/SFC Knowledge Exchange Programme titled healthier Scotland.

PassivTen: Developing options for refurbishment of tenement properties in Glasgow's East End to Passivhaus standard.

Feasibility study for PVT solar thermal system in collaboration with engineers TUV-SUD on retrofit of Stow College Building. The Glasgow School of Art.
'Quick Start Guide' to develop guidance for occupiers on how to live in a low carbon home. Scottish Government Building Standard Directorate.

The prototypical 'Glasgow House' Post Occupancy Evaluation – POE and analysis of low energy public housing.

Gilmour's Close, Edinburgh - comparing theoretical performance of a suite of sustainable installations in the building against actual performance. CICStart feasibility study.

Collaboration with Glasgow Housing Association (GHA) to provide design advice on the prototype low energy Glasgow House.

Development of Post Occupancy Evaluation for evaluation of innovative low carbon social housing projects. CICStart feasibility study.

Prototypical energy-efficient, affordable home evaluation with Enkelt Simple Living Ltd. CICStart feasibility study.

Environmental assessment of domestic laundering in collaboration with Strathclyde University and Glasgow Caledonian University. EP/G00028X/1 EPSRC funded project

CROSSFLEX Building Integrated Wind Turbine concept development, in conjunction with Proven Engineering Ltd. Funded by SMART, Scottish Executive.

Wyndford Energy Efficiency Project. Feasibility Study into energy efficient upgrading of 1,800 dwellings on the Wyndford Estate. CUBE Housing Association.

Feasibility study into the use of roof-mounted wind turbines on multi-storey housing blocks in Whiteinch, Glasgow for the Dumbarton Road Environment Corridor Trust. KTTBE funding award.

Bowmore Distillery Building Performance Evaluation study. Funded by Technology Strategy Board.

Lochgelly Business Centre, Building Performance Evaluation. Funded by Technology Strategy Board.

CONSERVE Energy Efficient study for Whitehall, Westminster, London. Innovate UK

Dundasvale Court Environmental Assessment, Examination of constructional problems for high-rise flats for Glasgow Housing Association.

Newberry Tower Wind Turbine. Project to install and monitor wind turbine on GSA campus building. Funded by Scottish Power Green Energy Trust, Glasgow City Council.

Knowledge Transfer Partnership (3-year associate), with Tenants First Housing Association, Aberdeen to design low energy housing.

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MEARU Projects
2013 - 2023

Pre-refurbishment Building Performance Evaluation (BPE) of Mid-Century Peter Womersley Building with CSY architects, Galashiels. SFC Innovation Voucher.

Particulate Pollution Justice, review of policy and practice in collaboration with the African Population and Health Centre, University of Nairobi, Global Challenges Research Fund, British Academy.

Acoustic Impact on Ventilation and Indoor Air Quality in Post 2010 Housing, Charing Cross Housing Association. SFC Innovation Voucher.

Health Effects of Modern Airtight Construction (HEMAC Network): Follow-on funding AHRC AH/N006607/1

Gannochy Trust for BPE project investigating building performance of new-build housing scheme for the Gannochy Trust in Perth. The Gannochy Trust.

Anti-Microbial Simulator Project (AMRsim), collaboration with GSA SimVis. Funded by EPSRC.

Pre and post-refurbishment building performance monitoring of high-density housing, Muirhouse Estate, Edinburgh. City of Edinburgh Council.

5-Year durational pre and post-refurbishment monitoring of Robert Burns Monument, Alloway for National Trust for Scotland. Historic Environment Scotland.

Fraserburgh low energy house indoor environmental monitoring and particulate monitoring in collaboration with Gokay Deveci architect and Robert Gordon University.

Building Performance Evaluation of newly constructed social housing development for Kingdom Housing Association, Inverkeithing. Kingdom Housing Ltd.

Production of a public information film titled ‘Ventilate Right’. In collaboration with Scotland’s Housing Network, Thermal Image UK, Gate film and artist Rachel Duckhouse. Funded by Historic Environment Scotland, Zero Waste Scotland, GSA and Innovate UK.

Feasibility of decentralised mechanical ventilation to act as ‘whole-house’ ventilation systems in new-build dwellings for the Building Standards Directorate. Scottish Government.

Environmental analysis of retrofitted high-rise Cedar Flats, Glasgow, in collaboration with Collective Architects. SFC Innovation Voucher.

Margaret McDonald Students Halls of Residence, Durational indoor air quality monitoring and energy consumption analysis. GSA Sustainability. Reid Building GSA,

Indoor environmental quality assessments and monitoring. GSA Estates, GSA Sustainability and GSA H&S.

Development of a Quick Start Guide for The Glasgow School of Art, Reid Building. GSA Sustainability

Modern Methods of Construction – Comparative study of construction typologies, Eildon Housing Association. Construction Scotland Innovation Centre.

Influence of ventilation design on the prevalence of anti-microbial bacteria in homes. AHRC AH/R00207X/1.

Knowledge Transfer Partnership, Cartwright Pickard Architects, to develop innovative tools for applying building information modelling (BIM) and building performance evaluation (BPE) for application within the build to rent market.

Gannochy Trust for BPE project investigating health and ventilation design in a new-build housing scheme for the Gannochy Trust in Perth. Gannochy Trust and Construction Scotland Innovation Centre.

Advanced natural ventilation strategy for high density flats, Greendykes, Edinburgh. Anderson Bell Christie Architects and Construction Scotland Innovation Centre.

Establishment of an international multidisciplinary research network into the health effects of modern airtight construction (HEMAC Network) AHRC AH/N006607/1

Fabric Integrated Thermal Storage in Low Carbon Dwellings (FITS-LCD). EP/N021479/1, EPSRC

Knowledge Transfer Partnership, John Gilbert Architects, Building Performance Evaluation of existing dwellings.

Designing and monitoring energy performance in innovative house designs, Dualchas Architects. SFC Innovation voucher.

Building Performance Evaluation of pre and post-refurbishment of traditional rural community building, in collaboration with Sam Foster Architects. SFC Innovation Voucher and Zero Waste Scotland.

Occupier influence on indoor air quality in dwellings, Building Standards Directorate. Scottish Government.

Building Performance Evaluation study of GHA’s prototype ‘Glasgow House’ follow-on projects. Wheatley Group.

Meta-study of Mechanical Ventilation with Heat Recovery systems in new housing. Technology Strategy Board.

THE GLASGOW SCHOOL OF ART

VENTILATE RIGHT

2016: Ventilate Right film (4m 39s)

Indoor air can be up to five times more polluted than outdoor air.

During MEARU's work in social rented, affordable and private dwellings in Scotland we often found that homes were not ventilated properly, leading to poor indoor air quality and affecting occupant health.

Inspired by a dissemination event hosted by Scotland's Housing Network, a unique short film was produced by MEARU and The Gate to help housing association staff and their tenants understand different ventilation methods.

Air pollution molecules are microscopic so the film employed animation to 'see' how these move around homes and can be removed by ventilation.

The film launched at the Glasgow Film Theatre on 22nd April 2016 and was followed by a panel discussion with ventilation experts.

30 years of Building Performance Research

MEARU's research

MEARU has been researching housing quality and undertaking building performance evaluation since 1993 and sharing its findings with a broad audience, leading to positive impacts in design and construction.

Our researchers aim to make a positive difference in the world for the benefit of society. The research that we undertake includes assessing energy efficiency and indoor environmental quality in buildings to find out how well they provide comfortable and healthy places for people to inhabit.

Our research is informed by conducting interviews with occupants and taking a variety of physical measurements using specialist equipment. This includes measuring heat loss through external walls, using airtightness testing and thermographic cameras to detect cold spots in the building fabric, assessing the effectiveness of ventilation systems, and measuring pollutant levels, indoor air temperature and moisture levels. The data we collect are examined against design targets and the occupant activities and experiences. This enables us to determine where the building design works well and where it does not, and – most importantly – establish why that is.

MEARU deposits its research outputs online on Glasgow School of Art's RADAR (Repository of Art, Design & Architecture Research).

What is 'impact'?

Impact Case Studies are produced for evaluation by the UK's national Research Excellence Framework (REF), which defines research as "*a process of investigation leading to new insights, effectively shared…*" that should have "*an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia*."

Once every seven years, academic institutions demonstrate the impact of their research through the submission of Impact Case Studies. These report on the evidenced benefits that the research has made in the real world.

Scan this QR code to view the searchable RADAR database.

THE GLASGOW SCHOOL OF ART

30 years of Research Impact

Impact Case Study – Home Laundry

MEARU's Design Guide for Healthy Low Energy Home Laundering, published in 2012, was based on measured data collected from 100 homes across Scotland. Our research for the project demonstrated that drying laundry indoors can impact indoor air quality and energy consumption. High indoor moisture levels from wet laundry can increase dust mite populations and mould spores (which are linked with asthma). Our research also found that drying laundry indoors can increase the amount of heating people use, potentially exacerbating fuel poverty – particularly in homes that are already hard to heat.

The original findings of this research were presented to the Scottish Government's Building Standards Division with the aim of changing standards for housing design and construction, improving indoor air quality and reducing energy consumption.

Through the research MEARU identified that best practice guidance was needed for landlords and developers in both public and private sector housing to help them understand the research findings and to make the changes needed to improve health in housing.

The official launch of the design guide generated a large amount of media interest, with reports appearing on television, radio and newspapers, regionally, nationally and internationally. Public engagement raised awareness of the impacts on health and energy consumption associated with laundry drying practices in the home.

2014

REF

Scan this QR code to view BBC News footage about the research

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30 years of Research Impact

Impact Case Study – Retrofit

2014

REF

In 2008 MEARU collaborated with Cube Housing Association to develop retrofit strategies to comply with the Scottish Housing Quality Standard (SHQS) and eliminate fuel poverty for Cube HA's tenants.

Strategies explored included improving the buildings' thermal efficiency by applying external wall insulation and installing a combined heat and power (CHP) district heating system. At the time, this was one of the largest CHP projects in the UK and provides low-cost hot water and heat to more than 1,500 homes. Retrofitting of the CHP system involved fitting responsive `wet' radiators, all with thermostatic valves enabling fine-tuning in each room. This replaced electric heaters, which were difficult to control and expensive to run. As well as making a tangible impact on Cube Housing Association and the public health of its tenants, the work has also contributed to Scotland's carbon dioxide emission reduction targets.

Today we are used to seeing high-rise towers being demolished, which is an expensive route to achieving the number of affordable, energy-efficient homes that Scotland needs. Retrofit is essential, and the transition from electric heating to responsive systems provided by CHP can have a major impact.

The other key impact of the CHP from the landlord's perspective is that the electricity it generates offsets the power demand for lifts and communal lighting. More than 1500 Cube Housing Association tenants and around 200 owner-occupiers benefitted from cheaper fuel bills and improved indoor air quality conditions as a result of the retrofit works.

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30 years of Research Impact

Impact Case Study – Ventilation

2021

REF

This impact case study was shaped by a number of separate MEARU projects focusing on building performance evaluation research on indoor air quality in social housing. These projects included:

a) measuring carbon dioxide concentrations in occupied bedrooms;
b) a meta-study of the performance of mechanical ventilation with heat recovery in homes, and;
c) a MEARU-led project in collaboration with the University of Strathclyde to gather data about occupant interaction with natural ventilation and its relation to indoor air quality.

The last of these assessed how often occupants open and closed trickle ventilators (the small vents commonly found in window frames) in the normal course of their day, and explored the reasons for doing so. Our findings revealed that trickle vents were rarely used and occupants typically lacked knowledge on the benefits of ventilation. This work provided an evidence base indicating inadequate ventilation practices in homes, which have the potential for negative long-term health and socio-economic impacts on occupants.

The research assessing bedroom ventilation led to an update of the domestic Building Regulations (2015) so that the installation of carbon dioxide monitors became mandatory in master bedrooms in all new housing. By January 2020, an estimated 86,450 new homes in Scotland had been positively affected by this change.

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30 years of Multidisciplinary Teamwork

Each of the individuals listed below has contributed to MEARU's work since its inception in 1993.

Our team consists of practising architects, building services engineer, academic researchers, and knowledge transfer partnership research associates, all of whom have a particular passion for low-energy buildings and healthy indoor environments. In addition to their research work at MEARU, the staff contribute to undergraduate and postgraduate teaching at the Mackintosh School of Architecture. The staff list also includes the administrators, without whom MEARU would be lost!

Professor Colin Porteous OBE

Professor Tim Sharpe

Louise Kilmartin

Dr Ming Ho

Sarah Jane Stewart

Masa Noguchi

Widya Sujana

Nick Anderson

Irena Kondratenko

Rosalie Menon

Dr Haruna Musa Moda

Dr Filbert Musau

Kate Stewart

Jo Tomlinson

Matt Bridgestock

Donald Shearer

Tom McNeil

Janice Foster

Chris Morgan

Anna Poston

Fiona Jones

Dr Lynette Robertson

Barbara Lantschner

Dr Gráinne McGill

Dr Maria Manuela Marinho de Castro

Mariangela Zanni

Dr Alejandro Moreno-Rangel

Eileen McGee

Laura Barnfield

Virginia Rammou

Claire Coquet

Dr Leonidas Tsichritzis

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30 years of Research & Teaching

Research knowledge is exchanged between MEARU and the whole of The Glasgow School of Art, with MEARU staff teaching across the Mackintosh School of Architecture.

Undergraduate

During the three-year undergraduate BArch degree, students are taught Principles of Building, Environmental Design and Structural Design. MEARU supports students in developing their knowledge, skills and competencies necessary to deliver a zero-carbon built environment. MEARU's knowledge of building physics and research helps students understand the theories of environmental design and how to apply them in practice.

MEARU staff input directly into the teaching and assessment of undergraduate courses, and work collaboratively with studio tutors to ensure environmental knowledge is embedded in studio work.

Postgraduate

Postgraduate Diploma in Architecture
Stages 4 and 5 of the PGDip course integrate architectural technology teaching. MEARU provides teaching input at key stages to evaluate designs relative to impacts of climate change, ecological construction, building performance and healthy indoor environments. MEARU also contributes to supervision of stage 4 students who are writing their research projects.

Master of Architectural Studies (MArch)
The Pathways of Energy and Environmental Studies and Zero-Energy Mass Customised Housing of the MArch course are led by MEARU staff to prepare graduates for the challenges associated within the context of zero carbon construction. Students are encouraged to participate in live MEARU research projects where possible.

Masters in Environmental Architecture (MSc)
This course was run from 2017-2020 by the Mackintosh School of Architecture within The Glasgow School of Art. It provided students with specialist knowledge and insight into the relationships between low energy architectural design, energy, environmental performance and building occupant comfort and health. The programme was based on MEARU's research strengths, while active research projects informed the teaching content.

Elective: Energy Comfort & Health
MEARU staff have delivered this postgraduate elective module since 2013. Students explore the latest developments in environmental design theory and practice and gain a better understanding of the complex relationship between energy and health in buildings.

PhD Supervision
Applied knowledge and expertise through research undertaken in MEARU provide an opportunity for PhD supervision. PhD students enrich the research culture within MEARU with previous students specialising in areas including building performance, indoor environmental conditions relative to low energy homes and building occupant behaviours.

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30 years of Research Dissemination

MEARU is highly-connected with similar European partners and is represented on the International Energy Agency and ISES (International Solar Energy Society) Europe. We publish regularly at Eurosun, PLEA (Passive Low Energy Architecture), Healthy Buildings and WREC (World Renewable Energy Congress) conference circuits. This activity contributes greatly to the learning and teaching culture of The Glasgow School of Art and has also established MEARU as a significant global research player in scientific and architectural circles.

MEARU's research is disseminated at local, national and international level. The research outputs are not only in the form of academic publications, but include books, films, design toolkits and exhibitions.

Knowledge Transfer Partnerships

MEARU's longstanding connections with industry have been enhanced through a series of Innovate UK funded three-year Knowledge Transfer Partnerships, delivered through the appointment of KTP associates based at The Glasgow School of Art.

MEARU has undertaken four such projects, helping housing associations and architects to innovate for growth. One particular success was the close relationship MEARU established with research-led Scottish architects practice John Gilbert Architects, the partnership facilitating the creation of 'spin off' company Hab-Lab, which has responded to the growing need for building performance evaluation services across the UK. MEARU's role included training the KTP associate in the operation of the monitoring equipment and the required methodology to undertake successful Post Occupancy Evaluation studies.

Other KTPs include:

Tenants First Housing Co-operative, Aberdeen

This KTP with an Aberdeen-based housing association developed a prototype for a low carbon home with micro renewable technology, offsite manufacturing and airtight construction. This enabled the housing association to improve energy efficiency of existing and new housing for the future.

Cartwright Pickard Architects, London - KTP 1

KTP with MEARU to establish a methodology to compare the predicted and 'as-built' performance of a variety of public sector housing in the South of England. This project helped Cartwright Pickard to develop an understanding of the energy and environmental performance of buildings to deliver cost-effective housing design for the future.

Cartwright Pickard Architects, London – KTP 2

KTP with MEARU to create prototype software that integrates whole life cost estimation with Building Information Modelling, assisting designers' decision-making based on accurate data of a building's performance. This project helped CPA to accurately predict whole life cost and carbon dioxide impacts, allowing them to understand the long-term viability of design options.

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Exhibition Acknowledgements

MEARU would like to thank everyone who helped with the preparations for this exhibition, particularly: Professor Colin Porteous OBE; Dr. Filbert Musau; Jenny Brownrigg; John Farrell; Stella Hook and the GSA Archives team; GSA Marketing and the GSA Research Office.

We also thank you, our visitors, and invite your feedback. This can be completed on a paper survey available in this exhibition hall or by scanning the QR code below for an online feedback form. The survey should take around two minutes to complete.

The Exhibition was curated by MEARU staff members Janice Foster and Rosalie Menon and funded by GSA Exhibitions and the GSA Research Office.

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