

Institution: Robert Gordon University		
Unit of Assessment: 13 Architecture, Built Environment and Planning		
Title of case study: Innovation in Housing		
Period when the underpinning research was undertaken: January 2000-December 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Gokay Deveci	Professor	2000- present
Amar Bennadji	Senior Lecturer	2002- present
Period when the claimed impact occurred: 2014 to 2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words)		
<p>Highly innovative research at RGU, centred around low-energy buildings, has led to significant impacts relating to both new buildings and retro-fitting of older properties. These have resulted in positive outcomes such as the opening of new markets, improvements in turnover and reduction in energy consumption.</p> <p>The research has also enabled the mass-market housing industry to re-evaluate its technologies and processes and adopt PassivHaus standards (PH) – a low-energy building standard. This has resulted in the achievement of significant reductions in greenhouse gas emissions, improvement in skills, knowledge and building processes, lower energy consumption and futureproofing of housing stock.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>The underpinning research led by Professor Deveci and Dr Bennadji has involved work undertaken through collaboration with external partners, including housing developers (Dandara), property owners and providers of specialist technical processes and methods (Kishorn, Icynene) to improve environmental performance and expert advice (CSIC).</p> <p>Key underpinning research undertaken has included:</p> <ul style="list-style-type: none"> • Demonstrating ‘Passivhaus’ standards for the Scottish volume housing market (2017-19), Construction Scotland Innovation Centre with Dandara Ltd. (£147,259 including £54,305 grant to RGU) • The Truss House (Integra)- Affordable Housing Typologies (2017-18) Construction Scotland Innovation Centre with Sylvan Stuart Ltd (£98,582 including £49,833 grant to RGU) • Internal wall insulation (2019) Energy Technology Partnership with Novus Elements Ltd • Testing a method to insulate buildings with lathe / plaster inner wall of external double wall (2011) Construction Scotland Innovation Centre with Kishorn Insulations • Design optimisation and prototyping for affordable rural housing: digitisation, automation and robotics options for the Integra House (2020) Transforming Construction EPSRC Transforming Network Plus (Grant to RGU £53,869) 		

The underpinning research was mainly undertaken using applied and practice-led methods and utilised innovative design processes and retrofitting solutions that would have significant impact on climate mitigation and economic growth. The research provided insights and original findings regarding 'Passivhaus' standards (PH) in the context of mass market housing, the adoption of low carbon standards in volume housing development and the challenges of adapting historic buildings to meet climate change targets.

Research tested the hypothesis that the PH can be applied to provide high-quality housing in the mass market, at a competitive cost while still utilising the local Scottish supply chain. The research team worked with Dandara to remodel two existing house types: one to German PH standards while the other used Scottish supply chains where possible. Both house types were successfully completed to PH standards, clearly demonstrating that design and construction skills are available in Scotland, and that this project could act as a model for other volume housebuilders.

Underpinning research within the theme also involved study of the impact of retrofitting older buildings to improve energy performance, where many of these were not originally designed and constructed to accommodate modern insulation materials. This research included studies which concentrate on the development of new materials, processes that support their incorporation, and the effects on lifecycle and performance.

The applied research tested the barriers to, and challenges for, the adoption of Low/Zero-carbon construction standards within the volume house building industry, including capital cost, valuation, skill shortages, supply chain issues and changing the behaviours of building occupiers.

An important area of focus addressed reasons for resistance, or barriers to change, among volume house builders, as they are collectively responsible for construction of 90% of the UK's new houses. The research examined potential consequences of incomplete knowledge and a perception among housing developers that 'it is too much change'. It also concerned the perception within the industry that the additional capital costs involved could not be easily passed on to purchasers as the accumulated value of this style of housing is poorly understood and communicated.

3. References to the research (indicative maximum of six references)

Deveci, G. (2019) *Integra House*. Completed practice-based research, undertaken with private client, constructed by Sylvan Stuart Ltd.

Quality indicator: built towards meeting the passivhaus energy standard, with support from the Construction Scotland Innovation Centre. The work carried clear research questions, pertaining to buildability and economic impact, and to the potential for market uptake.

<https://rgu-repository.worktribe.com/output/1254489/integra-house>

Deveci, G. (2017) *Heritage Way, Fraserburgh*. Completed practice-based research, undertaken with Aberdeenshire Council, supported by the Scottish Government "Greener Homes Innovation Scheme".

Quality indicator: The research has been cited and highlighted by Architecture and Design Scotland, as an exemplar of cutting-edge offsite construction. (impact citation [2])

<https://rgu-repository.worktribe.com/output/1254884/heritage-way>

Seddiki, M., Anouche, K. and Bennadji, A. (2018), "Integrated FAHP-FPROMETHEE for thermal insulation of masonry buildings", *Facilities*, Vol. 36 No. 3/4, pp. 195-211

Quality indicator: *Facilities* is a **key Q1 journal** (Architecture), and all papers undergo a rigorous process of peer review.

Mohammed Seddiki, Amar Bennadji (2019) Multi-criteria evaluation of renewable energy alternatives for electricity generation in a residential building, *Renewable and Sustainable Energy Reviews*, Volume 110, Pages 101-117

Quality indicator: *Renewable and Sustainable Energy Reviews* is a **key Q1 journal** (Renewable Energy, Sustainability and the Environment), and all papers undergo a rigorous process of peer review.

4. Details of the impact (indicative maximum 750 words)

Research undertaken by the group has had a demonstrable impact in a number of areas, where the type of impact can be clearly identified and supported by evidence. There is also a clear causal connection between the underpinning research and the areas of impact.

Impacts on production

Dandara is one of the biggest volume housebuilders in the UK and work referenced in this case study has led to fundamental changes for the organisation. It is enabling the mass house building industry, including its supply chain, to re-evaluate its technology and processes. The application of the research findings has had considerable benefits including improved processes, technology, skills and knowledge, significant performance improvements leading to the achievement of sizeable reductions in greenhouse gas emissions, lower energy bills for home residents and more comfortable homes. [1]

Work undertaken and led by Deveci has been cited nationally as an exemplar of off-site housing manufacture, and for their low-energy consumption and approach to procurement. [2] and [3]

Impacts on practitioners and delivery of professional services, enhanced performance or ethical practice

This research has also facilitated a deeper understanding of the performance of Passivhaus Homes in Scotland across industry, including housing associations. This understanding is vital to embedding widespread application of PH in the mass market volume housing sector. It will also enable Scotland to meet its CO₂ reduction targets in 2030 and address the performance Gap.

The completed research set out a clear process for evaluating and highlighting what was required to achieve PH, ultimately leading to adoption of the standard by volume housebuilders which has gone on to have a clear economic impact within the mass market. The impact is clearly evidenced by Dandara homes adding a **new product** [4] on to their housing types, implementing changes in their standard heating, ventilation and airtightness levels, altering their supply chain, developing site management and training their staff to further develop their skills. Taken together these actions have resulted in significant improvements in **energy use** and **emissions**. [1]

Impact on knowledge and perception

The research has demonstrated that PH and low-energy approaches are not only a very environmentally friendly way to build housing, but also financially viable for volume housing. The outcome from the research generated valuable data and lessons, which could be utilised by other mass housing suppliers, designers, providers and developers which, in turn, can make a significant contribution towards meeting the Scottish national targets for net zero. [5]

Impacts on commerce and the economy

The research concerning the retro-fitting of older properties was undertaken in direct collaboration with industry partners Kishorn Insulations. The studies undertaken (led by Bennadji) have had a significant increase in the contracts won by Kishorn Insulations, with contracts rising from 43 in 2015 to over 110 per annum in the years 2018 to 2020. This rise in contracts is a direct result of the collaborative research and represents a significant financial impact for the industry partner, aside from the environmental impact of the project itself. [6] [7] [8]

Impacts on the environment

Work undertaken by Bennadji studied the application of novel materials to achieve energy performance improvements in existing stone houses. Over a period of 18 months, energy use (for heating) reduced by 56%, which represents an immediate and positive impact on the environment. [8] [9]

Furthermore, large scale public debate and associated events organised by the submitting researchers in collaboration with external partners represented a significant pathway to impact. These included a significant event with the Pebble Trust, a Scottish charity supporting a more sustainable, equal and low-carbon society, and which attracted an audience of over 150 people. The events made it possible to impact on a wider understanding of how buildings can be modified and retrofitted to have a lower environmental impact, and how building owners and occupiers can be supported to undertake such work. [10]

4. Sources to corroborate the impact (indicative maximum of 10 references).

[1] Testimony from Dandara

[2] A&DS (2019) *Using offsite construction for housing delivery in Scotland* cites the work of Deveci (Heritage Way, Fraserburgh) as an exemplar practice based and applied research being used to support the promotion of energy-efficient housing using innovative methods of off-site construction and low-carbon technologies. <https://www.ads.org.uk/blog-offsite-for-diversification-not-standardisation-a-reflection-on-ads-new-housing-case-studies>

[3] Coverage of opening for 'Heritage Way', including contribution from Scottish Housing Minister Kevin Stewart MSP <https://online.aberdeenshire.gov.uk/apps/news/release.aspx?newsid=4800>

[4] Dandara product brochure ("The Rowan Passivhaus"), including confirmation of collaboration with RGU. Available on request.

[5] Press coverage of Integra House <https://architectsdatafile.co.uk/news/rgu-shortlisted-in-international-building-innovation-award/>

[6] Confirmation of work with Kishorn <https://kishorninsulations.co.uk/case-studies/bogendollo-house-fasque-estate> and;

[7] <https://www.ciob.org/media-centre/news/2014-winners-international-innovation-research-awards-announced>

[8] Testimony from Kishorn Developments Ltd

[9] Further award for work with Kishorn, including confirmation of significant energy savings <https://projectscot.com/2019/01/turning-up-the-heat-in-aberdeenshire/>

[10] Details of event with Pebble Trust: https://www.eventbrite.co.uk/e/sustainable-renovation-tickets-74278853049?aff=efbeventtix&fbclid=IwAR2qwWgo4NTREvSSzL28Fa9OZHA-Ha-56IhK_JpDj1la6poWVl0rsX8qoUk# and <https://www.pressandjournal.co.uk/fp/news/aberdeen/1891590/architects-to-reveal-secrets-of-retrofitting-historic-buildings-to-save-energy-at-conference/>