IMPROVING COLLABORATION BETWEEN ACADEMIA AND INDUSTRY THROUGH USE OF THE KNOWLEDGE TRANSFER PARTNERSHIP

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ABSTRACT

Collaboration between the construction industry and academia has always been difficult. Both sides of the equation have different wants, needs and requirements and these are seemingly at odds with each other. However, it is well documented that, despite the challenges involved, the outputs of such collaboration are seemingly very successful. It is against this backdrop that the United Kingdom Government has recognised the importance of facilitating opportunities and helping in the development of models to assist in overcoming the gap between industry and academia. One of these models is the Knowledge Transfer Partnership (KTP). The KTP model specifically allows businesses to solve issues they have by accessing knowledge and expertise held by academic institutions that otherwise may be out with their reach. In this paper we demonstrate how the Scott Sutherland School (SSS) and Abertay Housing Association (AHA) fostered a partnership with the aid of KTP funding to test/ monitor a solution to upgrade some of their non-traditional housing stock. We found that a deep relationship developed during the initial stages of drafting the funding proposal set the foundation for the rest of the project to date. The partnership has allowed both parties to benefit - AHA has new found knowledge of the performance of their existing housing stock, whilst SSS has added knowledge of steel house behaviour to its expertise of other house types.

Keywords: *Collaboration; Funding; Knowledge Transfer Partnership.*

1. INTRODUCTION

It is well known that there has been a historical disconnect between the construction industry and academia (UKCES, 2013). Today, in what has become a global market, industry research and development has moved away from traditional in-house research (Lambert, 2003) while it is acknowledged that industry needs to become innovative in order to remain competitive (Jachimowicz and Umali, 2000). This has resulted in a need for both industry and academia to collaborate so that research outputs can be successfully translated into industry practice (Blismas *et al*., 2009). Benefits of partnerships which cross this divide are not the sole preserve of the industry partner - the academic partner also gains from collaboration in the receipt of funding, fostering relations with industry, published outputs and the potential of tangible output of their research.

However, the challenges faced with bridging the gap cannot be downplayed. Jones and Clulow (2012) found the following obstacles:

- lack of trust over issues such as intellectual property;
- uncertainty about the potential benefits of working together;
- difficulty on both sides of finding the time for initial exploratory conversations;
- disparity between types of outputs that would make such collaborations seem worthwhile;
- businesses may be seeking saleable products, academics prize excellent research outputs and publications;
- universities may not find industry problems interesting enough to address;
- industry ascertains if a university could help them solve their business challenges.

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This paper describes one method available in the UK which promotes and funds collaboration between industry and academia - the Knowledge Transfer Partnership (KTP). The paper will be set out in three distinctive sections:

- a description of the KTP strategy and process,
- the development of a project where the Scott Sutherland School(SSS) has collaborated with Abertay Housing Association (AHA) in Dundee, Scotland
- brief analysis of initial outcomes of the project

The project in question evolved from a challenge AHA faced in the thermal upgrading of existing properties. They made an initial approach to SSS with a view to developing and testing innovative methods/ materials which would improve building performance without compromising the structure and fabric of their properties.

2. KTP PROJECT BACKGROUND

2.1. KTP BACKGROUND

The KTP is an initiative administered by Innovate UK, which facilitates the application of new knowledge, technologies and skills to improve a company's productivity and competitiveness. Innovate UK is an executive non-departmental public body, sponsored by the Department for Business Innovation and Skills (BIS). The Department for BIS is the Department for Economic Growth (BIS, 2016). The department invests in skills and education to promote trade, boost innovation and help people to start and grow a business. In 2015 Innovate UK celebrated its 40th year since its first project. The projects aim to develop innovative solutions to industrial challenges in order to aid a company's growth within their market.

Essentially the initial role of Innovate was to facilitate the "bringing together" of two disparate parties (industry and academia) so that each party could clearly see the many benefits that collaboration would bring.

Within each project there exists a trilateral relationship between; a KTP research associate, the knowledge base partner (academic institute) and the company partner. The KTP associate facilitates the transfer of knowledge from the knowledge base partner to the company, and they tend to be a recent university graduate. The knowledge base partner supplies the associate with the relevant knowledge for the project and assists in the development of research. The company partner, through facilitation of the project, is able to provide the knowledge base partner with raw data for research outcomes. Both parties provide the Associate with supervision throughout the project period. The company partner tends to be a business but can also be Local Authority, environmental or educational body. A fourth party, Innovate UK, oversees the process to ensure all parties are fulfilling their obligations and the project is progressingtowards agreed outcomes (refer Figure 1) (Innovate UK, 2015a).

There are over 800 partnerships running at any one time and over 900 associate projects (Galvez-Martos, 2016). These projects cover a broad range of industries, from the public sector, service industries to manufacturing plants.

2.2. KTP FUNDING PROCESS

The KTP is funded by the Innovate UK along with 12 other funding organisations. These funding organisations include Research Councils and a number of other Government departments (Innovate UK, 2015b). The KTP is designed not only to increase productivity and profit for the company partner but also to highlight opportunities, disseminate knowledge and bring together academia and industry, although it is expected that there will be a financial benefit to the company.

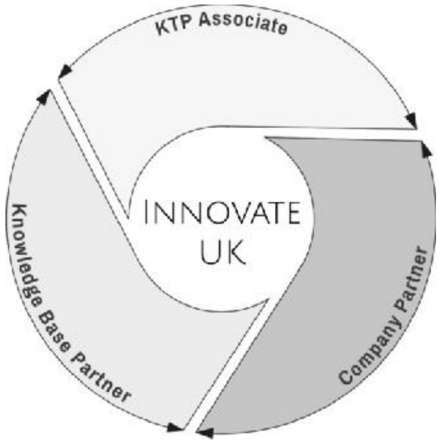

Figure 1: Diagrammatic Representation of KTP Relationships

Small Medium Enterprise (SME) projects can secure funding up to 67% from Innovate UK while large companies can secure up to 50%, in addition to a number of other funding streams within associated sectors (Galvez-Martos, 2016). It is often the case that the company partner will fund the remainder of the project. It is expected that there will be a financial benefit to the company whether it be through increases in profit, reduced production costs, introduction to new markets and/or an improved product. These benefits tend to outweigh the financial input from the company.

For a company to qualify the company it must employ more than 4 members of staff and the proposed project last between 12 and 36 months.

2.3. BENEFITS TO THE PARTIES INVOLVED

All of the parties involved in the trilateral agreement are expected to benefit from the relationship.

The associated benefits from structured training and experiential learning. There is access to a £4,000 training budget which allows the associate to acquire a variety of on and off the job training, also benefiting from two compulsory modules covering; management, finance, leadership and teamwork. They can also benefit from professional qualifications which vary depending on their area of expertise. Associates are also encouraged to undertake a higher degree during the term of the project. 41% of associates register for a higher degree, of which 67% pass their chosen degree (Galvez-Martos, 2016). Finally they gain professional experience in their chosen sector from being exposed to a variety of different work situations. 60% of associates are offered and accept a post at their host company upon completion of the project (Galvez-Martos, 2016). The KTP's focus on training and hands on experience equips the associate with an impressive skill set that will vastly increase their employment prospects.

The company partner benefits from the knowledge brought by the associate and knowledge base partner to solve a problem in an innovative way. The process of this may result in the production of new products, technologies, or processes that improve productivity and/or profitability. For every £1m of government spend the average benefits to the company amounted to an £4.25m annual increase in profit before tax (Galvez-Martos, 2016). The company benefit from the knowledge base partner's expertise and awareness of the funding streams available for projects such as this. Therefore they benefit from external funding that otherwise would not have been available. The knowledge developed during the project is disseminated to the company staff through training sessions, improving their expertise and the way they carry out their jobs. Once the knowledge is transferred to staff it will remain in the company and become part of the standard operating procedures ensuring the long term benefits. The associate is encouraged to become involved with the daily running of the business as well as their project which can improve the efficiency of the business. In addition to all of this, there is a clear expectation that the company partner will see financial benefit from the project outcomes - IT WILL MAKE PROFIT!

The knowledge base partner gains further insight and research into their existing body of knowledge and expertise. It is expected that the knowledge base partner will disseminate findings through academic journals conference papers, trades journals etc. Funding pays for academic input to the equivalent of half a day per week. It is also expected that new knowledge will feed into undergraduate and post graduate learning. On average, each KTP Associate project produces 3.6 new research projects and 2 research papers (Galvez-Martos, 2016). This adds to the existing catalogue of data already possessed by the Knowledge Base partner and accommodates continued research to be conducted. The production of high quality research in innovative sectors enhances the reputation and standing of the knowledge base partner among other institutions and potential industrial partners.

To summarise, there are a number of possible benefits to each party in the agreement. The associate gains expertise, knowledge, experience and improved employment potential. The company partner's primary benefit is expected to be profit gain, however there are also possible benefits from; better informed staff, new technologies, new products, funding and a generally more competitive business. The knowledge base partner benefits from further research and publications in one of their areas of expertise. As a result of this the academic reputation of the institute is elevated and becomes more attractive to future industrial research partners and prospective students.

3. EVALUATIVE CASE STUDY

3.1. PROJECT TEAM

This KTP project team includes; The Scott Sutherland School of Architecture and Built Environment (SSS) as the knowledge base partner acting as academic advisor, Abertay Housing Association, Dundee (AHA) as the host company acting as company supervisor and the associate, a recent graduate (BSc Hons. Building Surveying) of the School. In addition to this, the project has been appointed a representative from Innovate UK who oversees all of the KTP projects in the North East of Scotland.

3.2. PROJECT ORIGIN

The Scott Sutherland School of Architecture and Built Environment at Robert Gordon University has been involved in applied research in the field of building fabric upgrades for a number of years (Abdel-Wahab and Bennadji 2013; Buda *et al.*, 2013;Gutiérrez-Avellanosa and Bennadji, 2013). It was while presenting their findings from one such project at a Scottish Federation of Housing Associations (SFHA) conference in Scotland that it came to the attention of AHA. AHA were aware that the Energy Efficiency Standard for Social Housing (EESSH), which places a legal obligation on social landlords to achieve a minimum Energy Efficiency (EE) rating in their entire housing stock, was due to be enforced in 2020. The EE rating is measured in the Energy Performance Certificate (EPC). Many of the newer properties will already meet the new EESSH targets, which require an EE rating of between 65 and 69 depending on the house type and fuel source, while some of the older and non-traditional housing stock will struggle to meet these targets. With this in mind AHA identified a number of non-traditional steel frame houses that require a more innovative improvement solution to meet these targets. It was at this point AHA approached SSS and together they developed a research proposal to submit to innovate UK for consideration.

3.3. FUNDING APPLICATION

The process of securing funding for this project involved the incremental development of the proposal and this resulted in AHA and SSS meeting frequently to discuss the challenge, develop the research question and understand how working in collaboration will facilitate the development of a resolution. This formed the basis for the development of the research proposal.

Having identified the problem, the type of solution they would require and how they could achieve this in their research proposal, AHA and SSS then begin to explore the funding options available to them. SSS highlighted multiple funding streams available to a project of this nature to AHA and they began assessing their options. The result was, together AHA and SSS found that the KTP initiative was the most applicable to the needs of both parties and project itself.

A project proposal was developed by both parties collaboratively which included:

- A description of the project
- The project aims and objectives
- Proposed project outcomes
- Intellectual Property agreement
- And, a full breakdown of the project costs.

The project costs included; associate's salary, project consumables, any required software and hardware, associate training budget, the knowledge base supervisor's time and travel and subsistence. It also had to outline where profit would be made on the successful delivery of the project. It was very important to demonstrate the financial benefits to the company in order to secure the funding. It was then a question of presenting the proposals to Innovate UK and waiting to hear whether they had been successful.

The project secured 67% of the funding from Innovate UK and the remaining 33% was provided by AHA. Once the funding had been secured the project was ready to begin. An associate was appointed in August 2015 with slightly modified project outcomes to take account of progress made by a previous associate. The project is now nearing the halfway point of the 21 months program and the initial findings from a pilot scheme have begun to be collated and analysed.

A significant (but indirect) outcome of the funding application process was the development and cementing of the partnership between SSS and AHA. The application required substantial amount of details and both partners had to work together to ensure that the application was worthy of submission. By the time the funding bid was submitted, the partners knew each other extremely well and a close bond had been formed before the project had begun in earnest.

3.4. PROJECT DETAILS

The project is an investigation into the performance four types of steel frame dwellings in Dundee, Scotland. The properties in question are of non-traditional steel frame construction, built in the period between 1926 and 1928. Four types of steel frame properties have been identified on the site, although findings from the project will be pertinent to a wide variety of steel frame properties in many locations. Due to the nature of these properties there are a number of risks to building performance when applying standard wall insulation to them. AHA did not have previous experience of carrying out improvement measures to properties of this type, or the technical knowledge to effectively analyse the available options. AHA sought to acquire this knowledge through collaboration with SSS.

The initial project phases included for full surveys to be undertaken of each property type to identify design and defects specific to these properties. This information was gathered by the associate and added to the existing knowledge of the construction type in question. This provided a platform of knowledge from where to start the process of designing and analysing various insulation methods.

AHA, in conjunction with a third party designed three Internal Wall Insulation (IWI) solutions. The process of designing these solutions involved close collaboration with SSS and it was agreed that a period of testing and monitoring should be undertaken on a selection of pilot properties before the full implementation of a solution.

The pilot properties allowed the project team to strip the properties back to reveal the primary structure and identify the construction and condition. This process would prove invaluable as more properties were accessed and common defects noted. This added to existing research undertaken by the Building Research Establishment (BRE, 1989) which had also discovered similar construction and condition. As a result of the findings, changes were made to the three IWI solutions to make them more appropriate to the buildings.

The research/ testing strategy involved in-situ monitoring of a number of parameters and included:

- Air Tightness Testing (ATT),
- Infrared Thermography (IRT),
- Internal air quality measurement,

- Relative Humidity (RH) measurement,
- Air Temperature (AT) measurement,
- Heat flux measurement,
- Surface temperature measurement.

By measuring these factors over a period of over 12 months the effectiveness of each solution could be tracked and compared against alternatives.

Once the monitoring data has been analysed the most suitable option or options can be selected. As there are four types of steel frame properties in this area it is possible that more than one option will be required and in some cases it may be necessary to use more than one system in an individual property. As the works rollout for the full program of 90 non-traditional steel frame buildings the monitoring will continue. Then a maintenance plan can be designed around the findings to ensure the properties have the greatest life span possible.

3.5. BENEFITS TO THE PARTIES INVOLVED IN KTP PROJECT

There are many benefits to the parties involved in KTP project specifically; SSS, AHA and the associate, some of which are clear and others are more subtle.

AHA has benefited from the knowledge base partners substantial knowledge of similar projects and detailed analysis of proposed building fabric upgrades. The academic partner has brought a scientific approach to the investigation and identification of defects. This will ensure that, not only, are the upgrades providing the greatest improvement of life span of the properties but also in tenant comfort, health and reduced utility bills. AHA has also gained invaluable information from the monitoring process that has been undertaken throughout the pilot stage. This will allow them to create more effective maintenance programs to get the most out of these properties over the coming years. They have had the benefit of an additional member of staff dedicated to working on the project. The solution and, more importantly, the process of designing a solution can be disseminated by AHA as this problem is not restricted to homes in Dundee, but the UK and broadly speaking, the world. There is also potential to patent one of the insulation systems and sell the intellectual property rights to this.

The associate has gained a large amount of industrial experience and has been exposed to a wide variety of scenarios improving his understanding of the sector. The level of personal responsibility is far greater to that which would be possible in private practice and has developed the associate’s skills in areas pertinent to the project and his future career. The associate has the benefit of a training budget of £4000 as well as two 2 tailored training programs organised by Innovate UK. To date the associate has undertaken training in Air Tightness Testing (ATT), infrared thermography, project management, finances, leadership and team working. The associate has been encouraged to and has submitted an application for an MRES degree on the subject of the project, which will add to his academic competencies.

SSS have been involved in research on building performance improvement work for a number of years. It is expected that the outcomes of this project will add to the knowledge already developed at SSS. It also allows the research to be added to the universities course syllabus, disseminating the information to the next generation of young professionals.

Both SSS and AHA have benefited from the publicity that a project such as this attracts. To date both organisations have been involved in presentations about the project. In addition there has been attention from local and national MSP’s and local radio stations.

4. INITIAL FINDINGS

4.1. BACKGROUND TO MONITORING

The monitoring strategy within each of the pilot properties is outlined in section 3.4. The underpinning theory behind the selection of the specific elements being monitored is as follows: the temperature and

RH measurements across the wall fabric allow to ascertain if condensation is occurring within the cavity, the ATT undertaken before and after shows the improvement in the buildings air tightness, the air quality measurements allow to ensure, the building is not made detrimentally air tight, IRT surveys allows the visible improvements in the properties' heat retention, and the heat flux allows a comparison between theoretical and actual U-value measurements of the wall fabric.

The combination of in-situ and one-off monitoring methods allows to build a picture of how each of the IWI wall systems is performing and measure the level improvement each has on individual properties. This means that a critical analysis of each option can be undertaken, ensuring the most effective solution and can resolve any issues prior to the full works being carried out. The cavities within the pilot properties were free from ventilation in order to assess whether there is a need for it before undertaking the works in the remaining properties.

For the purposes of this paper, initial findings from one property within the pilot phase are presented.

Figure 2: Pilot Study Property (Dundee, Scotland)

4.2. Results from Initial In-situ Monitoring

It is known that most species of fungi cannot grow unless RH exceeds 60% therefore maintaining an internal RH between 40-60% minimises the risk of adverse health effects (Arundel *et al*., 1986). In Figure 3, the results gathered over the first three months show that the average RH level lies within this parameter. It should however be noted that the max RH does exceed these parameters at isolated points. This shows that, despite the improvements in the air tightness of the building fabric (see section 4.3), there is still sufficient ventilation to maintain safe and comfortable indoor RH level.

The RH within the cavity is exceptionally high in this property, with the average values exceeding 90%, as can be seen in Figure 3, for almost the entire three months period. It must be noted that the cavity has not been vented so that the project team to assess its requirement. Exposed steel will corrode at 60% RH (Roberge, 2000).Therefore the very high values indicate that there is a high probability that corrosion will occur. With such high RH levels it is likely moisture will occur on the internal face of the steel, as a result internal timbers and exposed areas have been covered in protective water resistant membranes.

Figure 3 shows the average external RH ranges between 70-98%, this exceeds the 60% threshold required for steel to corrode. With this in mind the requirement for ventilation becomes immaterial, as potentially exposed steel will corrode at the levels naturally occurring externally. The process of installing ventilation could also increase the likelihood of exposed cut edges to this effect.

The internal air quality within the property is being monitored to assess the impact of the upgrades we are carrying out. CO_2 was chosen as the parameter to measure, this can be used as a benchmark for the levels of other gases present within the property. "CO_2 at very high concentrations (e.g. greater than 5000 ppm) can pose a health risk" (ASHRAE, 2013). As seen in Figure 4, the average CO_2 level does not exceed 1500ppm. This shows that the CO_2 level is not dangerous to occupants. It can be observed from the range of 90% of the data that the CO_2 level does peak and trough from this level. This is expected as the monitors were situated within bedrooms, where the CO_2 levels build overnight and clear during the day.

We are reassured that at no time does the CO_2 level exceed 3500 ppm. This suggests, as with the internal RH, that despite the thermal improvements the occupants' health or comfort within the property has not been jeopardised.

4.3. EPC AND ATT RESULTS

An EPC was completed for the property before any works had been undertaken. The result was an EE rating of 55 which placed it at the bottom of the 'D' band. Once the IWI, new triple glazed windows and new external doors had been installed within the property the new EE rating was 79. This placed the property in the top of the 'C' band and well surpassed the target EE rating of 65 required for this type of property in the EESSH. This is a vast improvement for properties of this type and by exceeding the EESSH targets help to ensure the properties will meet future EE targets set by government.

The EPC improvements are supported by ATT results from the tests undertaken before and after the completion of the works in the property. The pre-works ATT showed the property had an air permeability at 50 Pascals of 12.9 m³/h/m². This is a poor air permeability rating, however due to the age and construction of the property is in line with what would be expected. The post-works ATT show a reduction in air permeability of almost half, with a new air permeability at 50 Pascals rating of 7.6 m³/h/m². This is a great improvement especially given there has been no detrimental impact to the internal air quality, section 4.2.

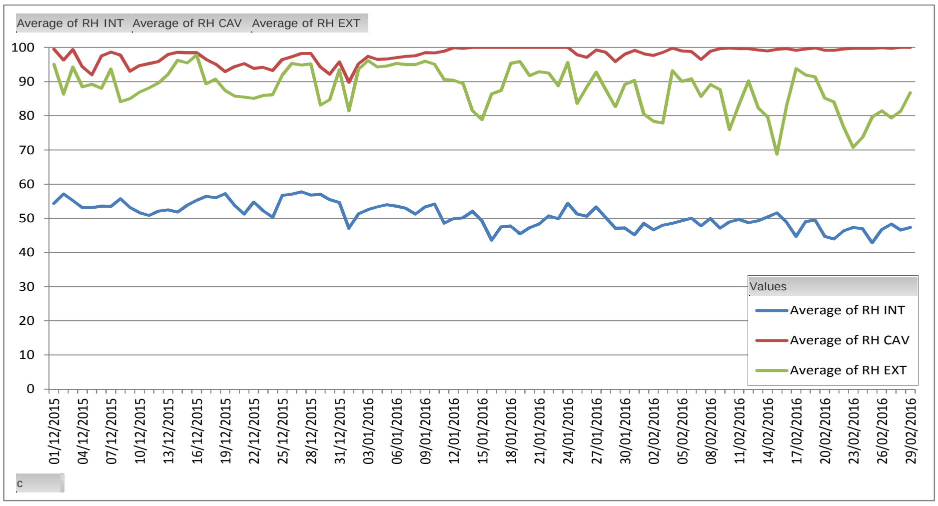

Figure 3: RH Readings over the Months of Dec 2015 to Feb 2016

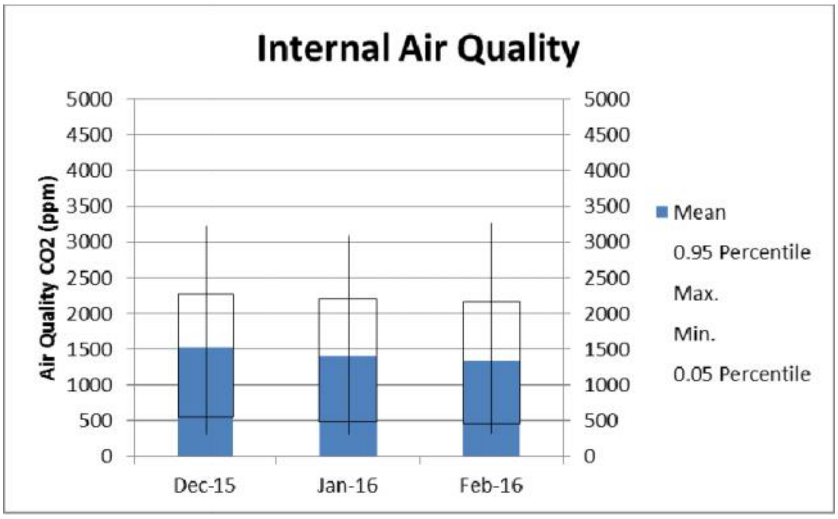

Figure 4: Internal CO_2 Readings over Dec 2015 to Feb 2016

Comparison of the before and after EPCs demonstrate the real cost savings within this property. Providing the same quality of finish and level of improvement within the remaining 89 properties, there is not only a cost saving benefit to individual tenants but to the local community as a whole. The real cost saving in heating and electricity to each tenant within one of these properties is £591.00 a year. Over the 90 properties in question this amounts to £53,190.00. With these tenants having an additional £591.00 per household a year, there is more disposable income to be spent in the local community. This results in a more affluent community with better local amenities. In addition to the financial benefits there are also environmental benefits, there is a reduction of 51 kg CO_2/m^2/year per household. Across the entire 90 properties in our project this amounts to a total carbon saving of 4590 kg CO_2/m^2/year. As environmental change becomes an increasingly important national and global issue, it is vital that improvements such as these are made to all underperforming properties.

5. SUMMARY

The KTP project between SSS, AHA and the associate is proving to be a success. Strong relations have been forged between the knowledge base partner and company partner. This has been the case from the early inception of the project which required them to come together to address the problem they were facing, through to the full implementation of the agreed project. All of the parties have learned in the progression of the project and that knowledge has been and continues to be successfully communicated between the whole project team. The knowledge being developed is innovative in its nature and of great benefit both academically and to the commercially. In addition to this the associate is acquiring a wealth of new skills, training and industry experience. This project has been a good demonstration of collaboration between industry and academia which has resulted in positive outputs for everyone involved.

5.1. WAY FORWARD

The project is due to conclude in April 2017 and the intention is to continue to collect and analyse data and communicate this to AHA. It is expected that results of the in situ tests will be disseminated through journal papers and conferences. On completion of the project, each party will report back to Innovate explaining how the outcomes have been met. The associate has commenced an MRes degree based on the project and will be expected to complete by the end of 2017.

When the project is at completion, it is intended to investigate the consequential benefits that the house upgrades have brought to the occupiers and to the local community. It is expected that there will be a reduction in energy consumption and associated costs and improved quality of life brought about by living in a warmer, healthier environment and without the strain of fuel poverty. There may be a knock on effect to the economy of the local community as the populace will potentially have more available spending money.

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