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Equipping construction workers with sustainable building skills: A focus on Leeds

An ESRC Impact Accelerator Funded Project

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Images sourced from: Roberts et al., 2005, Latch and Citu UK (left to right)

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SUMMARY

Buildings account for 30% of total UK greenhouse gas emissions. In order to meet the legally binding 80% reduction target of CO₂ emissions by 2050 it has been estimated that we would need to achieve almost 'zero carbon' standards for 25million UK homes. For ambitious sustainable buildings to be retrofitted or constructed, new configurations of technologies need to be installed. The role of the construction industry worker has been largely neglected in policy development debates and mechanisms have not produced vocational training schemes for trades. Leeds, home to the only construction-focused College in England with leading city-scale sustainability and building energy research, has the opportunity to pilot new approaches in building performance, social value and lean construction training which will help address skills gaps, and respond to the Industrial and Clean Growth Strategies.

Key Messages

- 1. Sustainable construction skills are essential in meeting an 80% reduction in CO₂ emissions.**
- 2. Key themes for skills development are a) building performance, b) social value of construction and c) lean construction skills.**
- 3. Collaborative schemes to address these skills shortages could be trialled in Leeds, on schemes such as the South Bank project.**
- 4. These priorities align with the Social Value Act, Industrial Strategy and Clean Growth Strategy.**

Why sustainable construction?

Construction is one in the UK's largest economic sectors, with a turnover of £360bn, employing 3.1 million people (ONS, 2017), or 9% of the UK workforce.

Buildings accounted for 34% of total UK greenhouse gas emissions in 2014 (CCC, 2015). Since the creation of the Climate Change Act (2008), there has been greater attention on creating a more sustainable built environment. According to the Construction Leadership Council (2017), sustainable buildings are designed and constructed to high environmental standards to minimise energy requirements, reduce water consumption, use materials which are resource efficient and of low environmental impact (low embodied energy or carbon), reduce wastage, conserve and enhance the natural environment, and safeguard

human health and wellbeing.

In order to meet the legally binding 80% reduction target of CO₂ emissions by 2050, from 1990 levels (HM Government, 2008) it has been estimated that we would need to achieve almost 'zero carbon' standards through the addition of energy efficiency measures to 25million UK homes (Davis and Oreszczyn, 2012). Measures include building insulation, efficient boilers and low-carbon heat options such as heat pumps or connection to district heating schemes (CCC, 2017). Employers and education providers must work closely together to ensure skills provision align with what employers need (Leeds City Council - LCC, 2018a).

Leeds context

Looking ahead, the population of Leeds is anticipated to rise from 755,136 in 2010 to 860,618 in 2028 (LCC, 2012). The Core Strategy states that 70,000 (net) new homes will be accommodated between 2012 and 2028. Leeds City Council (LCC) implemented The Leeds Standard in 2014, a quality specification including energy efficiency development being used for new build Council Houses, and aims to influence wider housing (LCC, 2016a). It provides a specification for the Housing Growth Programme and acts as a guide and influencing tool for market-led housing.

The construction sector in Leeds is expected to grow by 16% during this decade (LCC, 2011a). The Leeds City Region LEP area has 11,170 construction businesses, 102,600 construction jobs with planned construction investment of £11bn (CITB, 2016).

The report 'Building for Tomorrow Today: Sustainable Design and Construction' (LCC, 2011b), summarised the policy context and established voluntary standards for Leeds City Council. This included encouraging developments of over 1,000m² or more than 10 dwellings to meet the standard set by the Code for Sustainable Homes, or BREEAM for non-residential development, with checklists for developers to aid good practice. This requires post construction review certificates.

From 2001 to 2016, the average energy performance of homes across Leeds improved, this was measured by the Standard Assessment Procedure (SAP)². The increase in SAP value was 58.7 to 62.6 (Knowland, 2017). In contrast, nationally the direct CO₂ emissions from heating buildings rose between 2014 and 2016 (CCC, 2017). An interim target of SAP value 69 by 2020 and ensuring no properties fall below 54, or 'E' by 2030 has been set, so urgent work is needed.

Leeds has an old housing stock, when compared with national data, shown in Figure 1. Older housing is typically less energy efficient than new housing. Therefore, meeting further targets will

² SAP is the tool used to generate Energy Performance Certificates, with a maximum value of 100, or band 'A' and lowest value 1 or 'G'

require specialist skills and co-ordination between Government, businesses and citizens (Gouldson et al., 2017).

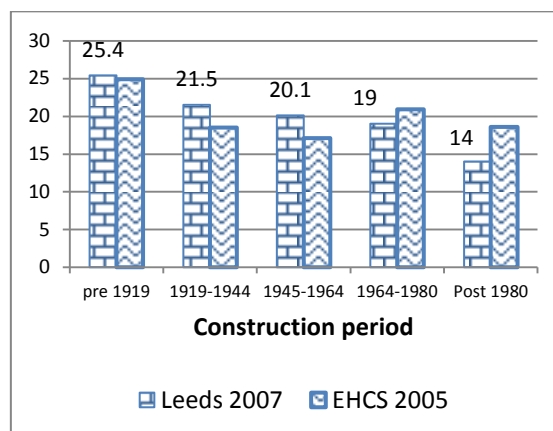


Figure 1. Percentage of Leeds (LCC, 2007), and English, (English Housing Condition Survey) housing from each construction period

What is the challenge?

To construct ambitious sustainable buildings and achieve high energy performance standards, new configurations of technologies need to be designed and installed (Killip et al., 2018). However, there is often an energy performance gap between designed and as-built buildings (Zero Carbon Hub, 2014). A lack of energy performance related training, knowledge and collaborative working on construction projects is one factor contributing to this gap (ZCH, 2014). Furthermore, culture and embedded behaviours in the construction industry are not always aligned to enable delivery of designed buildings; team members change frequently and construction workers may be unaware of the role they play (ZCH, 2014).

The construction industry is complex and interconnected with uncertain processes and developing sustainable buildings requires new knowledge to be developed and diffused through a highly fragmented industry supply chain (Peterman et al., 2012). Previous policy related to sustainable building, for example in retrofit, has focused on the installation of individual technology 'measures', as oppose to considering the whole supply chain as a collective 'system' (Killip et al., 2018). Sustainable construction encompasses refurbishment of existing buildings and fabrication of new buildings; both on-site and off-site.

Many buildings which will be present in 2050 are already built, the lowest figure represented for this is 75% of current stock, depending on rates of demolition (SDC, 2006). It is *technically possible* to reduce total household CO₂ emissions by more than 80% by 2050 through the addition of energy efficiency refurbishment measures (Johnston et al, 2005), but this will require a significant shift from current practices within construction and connected industries, and in policy making.

The skills challenge

The Farmer Review titled 'Modernise or Die' (2016) - commissioned by Government and published by the Construction Leadership Council- identified actions to reduce the industry's skill shortages, with a focus on business models and offsite new housing construction. The report set out ten recommendations for the construction industry, four of which included skills training, either through funding, improving further education, long term investment planning and influencing commissioning behaviour for skills and innovation in the sector.

The Industrial Strategy (BEIS, 2017a) highlights the desire of the UK government to support the construction industry shift to clean energy sources and efficient new materials and to continue to develop sustainable construction practices. As part of this, the 'Transforming Construction' programme is receiving investment of £170m, aiming to drastically overhaul construction techniques and dramatically improve energy efficiency, with a focus on bringing together construction, digital technologies, manufacturing, materials and energy sectors to develop off-site construction and smart infrastructure. The 'sector' deal for the construction sector under the Industrial Strategy has reiterated the challenging target to reduce built environment emissions by 50% by 2025. Originally set out in Construction 2025: strategy (2013).

The Construction Leadership Council published a Sustainable Building Training Guide (CLC, 2017). This sets out recommended Learning Outcomes for sustainable building, aimed at construction trades, building services engineering trades, managers and

supervisors and designers. The construction trades section is divided into the themes of:

- Low energy/ low carbon building
- Sustainable products
- Waste, reuse and recycling
- Water and whole build process

The low energy section (CLC, 2017) includes:

- Principles of building performance and associated costs
- Principles of air-tightness
- Effective insulation
- Ventilation and air quality
- Overheating

However, much of the refurbishment aspect of this work will be carried out by small and medium size enterprises, many of whom have established ways of working (Killip, 2008; Maby and Owen, 2015).

The Green Deal, previously funded by the Government through the Green Deal Finance Company, was intended to stimulate demand for sustainable renovation of UK homes. Government funding was cut on July 23rd 2015, just over two years after launch, due to *"low-take up and concerns about industry standards... in a move to protect taxpayers"* (DECC, 2015). The role of the construction worker has been largely neglected in policy development debates (Owen et al, 2014) and policy initiatives aiming to reduce energy consumption in buildings have not produced vocational training schemes (Janda and Parag, 2012).

The diffusion of sustainable construction processes in new build has been slow. The primary drivers are statutory, through Buildings Regulations and the Climate Change Act along with the rising cost of energy. These drivers have been far outweighed by barriers including skills and knowledge, and economic challenges of capital costs, lack of public awareness and demand and the resistance of the housebuilding industry to change (Heffernan et al., 2015).

This section has explored the nature of the challenge faced by the UK construction industry. A skills shortage is only one part of the multifaceted challenge of sustainable construction, connected

with other factors relating to refurbishment, new build and off-site construction. The next section will explore opportunities from undertaking this difficult transformation.

What are the opportunities?

Despite the many challenges outlined above, Leeds, both as a city and in a city region, offers a range of opportunities and initiatives which could be used to support collaboration and overcome the challenges, achieving a step change in the amount and quality of sustainable construction in the city. The low-carbon construction market has the potential to create sustainable jobs (Rosenow et al, 2014), potentially hundreds of long term, skilled jobs in Leeds (Gouldson et al., 2017).

The Leeds City Region's Better Homes Yorkshire programme, is supporting 1,200 households across the Leeds City Region out of fuel poverty through energy efficiency measures (LEP, 2017). Further private households are set to be assisted through the Leeds City Region Warm Homes programme launched in December 2017. With 320,600 households across Leeds (LCC, 2011c), there is scope for further action.

Leeds has positive initiatives bringing people together to co-produce solutions to create urban change (Chatterton et al., 2018), such as through the Leeds City Lab aiming to bring people together to plan how to do things differently and make Leeds a better place to live (LCL, 2018). University of Leeds Living Lab (2018) follows a similar ethos, aiming to get students and staff participating in experimental projects to create a more sustainable campus.

Zero Carbon Yorkshire (2017) aims to put Yorkshire at the forefront of a clean, green and renewable energy focused development. This has sub-working groups including the Buildings group, also known as the Association of Conscious Builders (AECB) Yorkshire Group (ZCY, 2018). This is a collective of volunteers with specialist knowledge including architects, educators, construction professionals and the general public, which could be used to further promote city-scale approaches piloting new approaches in construction training.

The Leeds Standard mentioned above sets an on-site requirement to achieve level 4 energy standards for the Code for Sustainable Homes. The Standard specifies orientation, fabric, heating and hot water standards, including maximising solar gain, a fabric first approach with U-values³ of 0.15W/m²K or lower for walls, floor and roof and 0.8W/m²K for windows, aiming for 1 air change per hour or less and 'low levels of heating' with electric only properties to be explored and solar hot water for larger houses (LCC, 2014).

Local training for tradespeople is needed to help them understand information such as that specified in the Leeds Standard. In addition, accessible information required for tradespeople to understand how to avoid risks related to retrofit (Maby and Owen, 2015). The key risks include thermal bridging, moisture related defects and unsafe assembly of approved products.

Both refurbishment and new build skills could potentially be addressed using the Further Education technical education curriculum (BEIS, 2017a) aiming to spread education on techniques for smarter, more efficient energy use and generation (Templeman, 2014). Furthermore, the national Clean Growth Strategy focuses on off-site manufacturing and factory production of homes, in addition to innovation in low carbon technologies and UK supply of materials such as timber (BEIS, 2017b).

Stemming from the Clean Growth Strategy is a focus on working with a reformed, strategic and industry-led Construction Industry Training Board, using Apprenticeship Levy funding to provide new skill development opportunities and 'T Levels'. 'T Levels' are technical study programmes due to sit alongside apprenticeships for 16-19 year olds (DoE, 2017). They will be shaped by industry panels and include structured work placements. The first three T Levels scheduled to be taught in 2020, includes one on construction. As part of these plans, £34m is expected to expand innovative UK construction training programmes.

³ U-values are a measure of thermal conductivity, with a lower value representing lower conductivity

Leeds is home to the only remaining specialist construction college in the UK, originally established in the 1960's and now with a new site in Hunslet, currently training over 6,500 students (LCB, 2018) from the city region, and beyond. Leeds College of Building is engaged with 2,500 employers (LCB, 2017), and received an Ofsted 'Good' rating for part-time and apprenticeship courses (Ofsted, 2017).

The planned regeneration of the South Bank in Leeds provides a significant opportunity to deliver sustainable construction, including meeting the requirement for a minimum of 10,200 new homes across the City Centre by 2028 (LCC, 2018b). This area will include the development of a Climate Innovation District (Citu, 2018). This could be a catalyst, not only for new jobs and improved communities but for new methods of training and innovation in delivering sustainable buildings. Insights from the South Bank pilot project could be shared for other communities from the UK, and further afield.

What are the benefits?

The Leeds City Region Enterprise Partnership aims to stimulate growth that will create jobs and prosperity (LEP, 2018). With four main priorities, including Priority 2: Aiming to provide skilled people and better jobs and Priority 3: Clean Energy and Environmental Resilience. Complementing this for the city is the Leeds Climate Commission, established in 2017 (Can-do Cities, 2018); an independent voice providing authoritative advice and monitoring progress towards meeting carbon reduction targets. Benefits of meeting these targets, such as the creation of specialist jobs and cleaner environments, are primarily social. If skills in sustainable construction specifically are increased, this could unlock economic, social and environmental benefits. This is particularly the case for accessing competitive construction jobs within the £11bn planned investment in construction in Leeds (CITB, 2016), which could assist in enabling Leeds to respond to the Government's Industrial and Clean Growth Strategies.

The UK Social Value Act (2012) requires those who commission public services to consider wider social, economic and environmental benefits before starting a procurement process (Cabinet Office, 2016). Social enterprises, which are a blending of a commitment to resolve social challenges with commercial enterprise, offer an approach to meet these goals, but are underrepresented in construction (Loosemore, 2015).

In construction, socially orientated approaches require leadership to change procurement practices, to address the social issues whilst enabling capacity, tools and skills to support and measure the social impact. Clients have a critical leadership role to instigate and enable these changes. Social enterprises provide an opportunity to enable construction companies to benefit local communities, help create more sustainable environments and the most disadvantaged in society. This would need to integrate new types of business model perceived as too uncompetitive into a highly competitive industry with established relationships (Loosemore, 2015).

Social value can be at odds with the need for speed in many construction projects, but local authorities and LEP's have the ability to prioritise this during the planning process of new construction projects. Economic growth has long been assumed to be at odds with sustainable development, Leeds could demonstrate that both are achievable using approaches such as those set out in *The Economics of Low Carbon Cities: A Mini-Stern Review for the City of Leeds* (Gouldson et al., 2017).

Solutions

A workshop held in Leeds in January 2018 gathered sixteen participants who brought expertise in sustainable building, city wide planning and development or training and skills, from research, public and private sector organisations. This workshop generated a set of priorities to respond to the challenges outlined above and capture the opportunities for Leeds described in the previous section. Three key themes arose from the day; building performance, the social impact of construction and lean construction:

- **Building performance:** Understanding what shapes building energy use, including attention to detailing which maintains performance when different building components are installed together and a ‘clerk of works’ role with oversight of the whole project.
- **Social value:** Valuing the social benefits which construction and the built environment can have in communities, as opposed to just measuring value by financial gain.
- **Lean construction:** usually off-site manufacture and on-site assembly; considered as a way of thinking and constructing to minimise waste and optimise efficiency.

Examples of each theme follow in Boxes 1 to 3.

The **Stamford Brook** project’s staff training scheme, led by researchers at Leeds Beckett University, aimed to provide knowledge and skills necessary for building low-carbon, air-tight dwellings in the mainstream housing industry. Training included thermal bridging detail with illustrative examples using Stamford Brook Working Details. Key messages were to design air barriers carefully, be clear about where barriers are and seal the barrier if it is punctured or incomplete. This was provided as part of a two-way exchange where those on site provided their own ideas on how to improve buildability or reduce costs. The construction process report indicates that this was one of the major successes of the project, and subcontractors found it interesting and useful (Roberts et al, 2005).

Box 1. Example of building performance training

The social value of construction is communicated to trainees at **Latch (Leeds Action to Create Homes)** through their work in refurbishing derelict and run-down houses in Leeds for people who were previously homeless, or in housing need (Latch, 2018). Most of the refurbishment work is carried out by Latch staff and volunteers, some with previous building experience and some learning skills on site. This includes achieving high levels of energy-performance to save tenants money on energy bills. Latch then maintain the properties and provide ongoing support to tenants.

Box 2. Example of social value training

Lean construction principles, which combine craft and mass production (Krafcik,1988) are core to the approach adopted by **Citu** in their custom-built Leeds factory. Citu train staff in-house to manufacture components which can be assembled on-site to create low energy demand homes. This includes entire walls encompassing structural elements, plumbing, electrics, finishes and window openings. The lean approach includes waste reduction, adding value, variability reduction, cycle simplification, transparency, focus on process and continuous improvement (Koskela, 1992).

Box 3. Example of lean construction training

The key skills areas identified for these themes, the targeted learners, delivery method and incentives to train as suggested by workshop participants are summarised in Table 1 at the end of the paper. Some elements of each theme could be translated to other themes but included is the information provided by meeting attendees. The three themes also include consideration of:

- Minimising waste
- Optimising efficiency of either the building performance or the construction process
- Consideration for the whole construction process as opposed to one element of the build
- Digital technologies
- Suitable for trades people

The lean approach should be targeted at trades people with an interest, approach or background in manufacturing, as oppose to purely ‘traditional’ construction processes such as brick laying and wet plastering. The building performance strand should be delivered to trades people, as well as those training to be ‘clerk of works’ or site managers.

A variety of learning methods are identified with on-the-job training a core element of building performance and lean construction principles. Classroom learning was suggested for elements of all themes, but the practical requirements should not be overlooked and whilst e-learning may be beneficial for some of the theory, it is not a one-size-fits all approach for technical detailing which requires hands on experience and practice. The social value of construction could be incorporated into T-Levels or new apprenticeship routes, however the building performance and lean skills may require a variety of delivery methods.

Local Government could incentivise training by requiring trades people working on Council funded, or approved projects to be certified by accredited courses, or possess 'Gold CSCS cards'. The Construction Skills Certification Scheme (CSCS) provides evidence that those working on construction sites are adequately trained to do so by providing cards for individual crafts and occupations (CSCS, 2018). The Construction Industry Training Board could potentially validate courses which assist in overcoming the skills gaps identified within these themes, to provide industry standard courses.

Potential links in with Leeds activity

In Leeds, projects such as the South Bank development could pilot new approaches, which could be studied and rolled out further afield. This development will include new build, off-site manufactured homes and renovation projects.

- Tool-box talks could be trialled as mandatory on each construction site to ensure each contractor understands building performance.
- Social value could be included as intense training sessions for construction professionals and contractors alike and inform everybody working on the project the long-term impact the project will have on the local community, boosting motivation to do a good job and aiding teamwork.

Locally upskilling the workforce with sustainable construction skills will assist in:

- Boosting specialist skills and sustainable employment
- Contributing to the local inclusive industrial strategy and national Industrial Strategy by enabling a shift to sustainable construction practices
- Contributing locally to the Clean Growth Strategy by developing off-site construction techniques and innovation in sustainable technologies and supply chains
- Constructing sustainable buildings and positive, healthy communities to live, work and play.

About the Sustainability Research Institute

The Sustainability Research Institute (SRI) conducts internationally recognised, academically excellent and problem-oriented interdisciplinary research and teaching on environmental, social and economic aspects of sustainability. We draw on various social and natural science disciplines, including ecological economics, environmental economics, political science, policy studies, development studies, business and management, geography, sociology, science and technology studies, ecology, environmental science and soil science in our work.

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Table 1. Summary of the skills needed, targeted individuals, course delivery and incentives for training

Theme	Building performance	Social value	Lean construction
Course content	Overview of climate change, CO ₂ emissions from the building stock, comfort and health factors	Communication skills	Lean principles (efficiency, less waste, accuracy)
	What building performance targets are trying to achieve: healthy buildings, cheap to run	Awareness of other trades and the whole-process of the build	Manufacturing processes
	Practical issues /common challenges: consequences of missing key 'principles'	Respect of quality and building performance	Digital technologies
	Continuity of insulation and avoiding thermal bridging	Vertical integration of supply chain and feedback loops	
	Air-tightness and air-movement within the space controlling the internal atmosphere and within the fabric itself	Whole lifecycle of buildings	
	Measuring building fabric: thermal, moisture etc	Materials and how they affect construction practice	
Who should be learning	Builders / tradespeople for toolbox talks	Collaborative procurement routes	
	Managers for higher level top-up courses	Digital technologies	
How the course should be delivered	Builders / tradespeople for toolbox talks	All levels and roles / trades	New entrants
	Managers for higher level top-up courses	Wider actors, for example funding bodies where social value tools are used. Clients/developers who can make the link to their own Corporate Social Responsibility / Sustainable Development Goal) plans?	Existing staff
	Toolbox talks on site with whole team (similar format to Stamford Brook)	National Vocational Qualification (NVQ) additions	Blended approach: some on the job, some classroom, minimal e-learning
	Online / virtual tools with pictures and quizzes	T-level courses (especially to build collaborative teams)	New entrants: At college, pre-employment assessment days
	One-week intense course	Formal courses – to set expectations across all trades and enable understanding of all trades – integrated vertical chain	Existing staff: On-the-job, during work
	Higher level for clerk of works specialist, equivalent to site manager with trade experience	Continuous learning should be promoted from the start	On the job delivered by factory managers, line leaders /operatives
Incentives and Opportunities	Stringent targets, such as Passive House air-tightness levels enforced through Building regulations	Time on social enterprise projects as part of the apprenticeship route	Industry apprenticeship routes
	Certifier and building control requirements, e.g. only employing work teams with training certificate	Fitting into existing frameworks	Ambassador talks by lean specialists
	'Gold' Construction Skills Certification Scheme (CSCS) cards essential for tendering on Leeds funded projects	Soft landings scheme and linking building performance to social benefits	Evidence to develop the skills, for industry and individual career benefit plus evidence of market size
	League tables on building performance skills	Life-cycle mentality	Job prospects/ job security
	Leeds City Council required	T-shape course developments	Grants/ Leeds City Region Skills
	Demand for healthier houses		Construction Industry Training Board approved course
			Benefits: improved productivity, cost saving, retention of staff etc
			Certification of off-site skills
			Colleges & Local Enterprise Partnership
			Progression to manufacturing

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