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Off-site housing construction: a response to the crisis?

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TAKEAWAY FOR POLICY MAKERS, STAKEHOLDERS AND RESEARCHERS:

- **There is a diverse, rapidly growing off-site construction sector in the UK operating at a range of scales**
- **It is developing ad-hoc, innovative housing projects ranging from boutique self-build to 'drag and drop' temporary accommodation**
- **There is a lack of strategic thinking and joined-up knowledge around what the sector can offer in terms of housing provision and how to overcome key challenges**

WHAT ARE THE CHALLENGES:

- **The sector and policymakers are navigating extremely uncertain fiscal and policy contexts**
- **There is a lack of capacity in planning and procurement to work with the off-site sector**
- **There is a lack of evidence around the experience and impact of living in off-site-built homes and communities**

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Off-site housing construction: a response to the crisis?

In 2016, the UK government set its target of building one million new homes by 2020. This was in response to long-term structural failures in housing supply, especially at the affordable level. At the same time, the construction sector faces potential post-Brexit skills shortages and an ongoing technological revolution. One outcome of these trends has been a growing interest in homes constructed off-site using automated and modular systems. Off-site construction refers to the broad spectrum of design, fabrication and assembling activity that takes place beyond the installation or build location. It is not a new concept – perhaps most famously associated in the UK with the iconic post-war 'prefab' home – but it is one with growing influence in the UK. When a home is built offsite, it means a significant percentage is constructed in a factory and then shipped to the site and assembled.

Yorkshire has emerged as a significant region for a nascent off-site housing construction industry both as a client seeking to increase and diversify local housing supply and as the site for a number of innovative firms. Off-site house building has evolved substantially in the last century – from heavy prefabrication methods to lightweight constructions with high added value, functional to the rapidity of production cycle and with a lower use of resources, easily mountable and adaptable to context variability. However, this has increased the complexity of the supply chain and raised questions about what skills and technologies are required to sustain this young industry. The growth of the sector is also reinforcing longstanding concerns around patterns of land ownership in the UK, about infrastructural capacity and about the efficacy of planning systems. Politically, it is perhaps ambiguous, seemingly in alignment with transient 'pop-up' urban design, whilst also opening new opportunities for community self-build and new experiments in sustainable place-shaping.

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To better understand how assorted stakeholders are engaging with these issues and questions that cut across technical, political/policy and social themes, we set up a new knowledge exchange network in summer 2018. The network was a collaboration between academics at the University of Leeds and colleagues at Bauman Lyons Architects and Leeds City Council. The network was designed to be interdisciplinary, bringing together knowledge from social science, architecture, sustainable construction and policy and planning and its mission was to facilitate dialogue and knowledge transfers between academia, local government and private sector. During 2018, we organised a series of events involving the participation of around 50 representatives from key stakeholders and companies involved or interested in off-site housing construction across the region and nationally including: Leeds City Council, Bauman Lyons Architects, Leeds Beckett University, West Yorkshire Regional Combined Authority, Citu, Leeds Community Homes. At the University of Leeds, the project was led by Dr Andrew Wallace (School of Sociology and Social Policy), Dr Ornella Iuorio (School of Civil Engineering) and Dr Kate Simpson (Sustainability Research Institute). In this report, we present findings from our research and knowledge exchange activities, identify challenges facing the industry and suggest directions forward.

Portrait One: Mass Bespoke

Mass Bespoke is a user-centered building system combining the benefits of Mass production and Bespoke Design. The process is digitally enabled and draws on Building Information Modelling to create adaptable designs. The primary superstructure is constructed using structural cassettes fabricated from engineering boards such as Orientated Strand Board or Plywood cut using Computer Numerical Control (CNC) in an easy to assemble way.

Sourced from www.massbespoke.com

Our Findings

1. What does the UK off-site sector look like?

Off-site construction is enabling the construction industry to change the way it builds for the first time in over 40 years[1]. It is set to grow. Government is pushing hard to digitise the construction industry in the Construction 2025 Act and the Construction Sector Deal recently secured. During 2018, The Transforming Construction Challenge has enabled £170m of investment from UK Research Innovation with £250m match industry funding[2]. This is planned to enable new construction processes such as the development of offsite modular components. UKRI (2018) forecast this to enable buildings to be constructed 50% quicker, 33% cheaper and with half the lifetime carbon emissions. The Construction Leadership Council is engaging industry on this through the Innovation in Construction and Smart Technologies work streams.

Firms

The off-site housing sector covers a wide spectrum of firms from those seeking to 'factory build' at scale to supply chains of architects, engineers, builders and craftspeople who are more aligned with the self-build market. An off-site manufactured home can be assembled on site in as little as two days. The proportion of home construction which uses off-site methods depends on the nature of the project with anything from a single build component to 95% of the entire home, which some companies are currently aiming for.

Technologies

The technical and aesthetic range of off-site built homes is wide. The variety includes: timber frames and Structurally Insulated Panels (SIP), structural steel core and modularised systems, concrete panel systems, timber frames and panels, timber frames and straw bale (Modcell), cross laminated timber and even shipping containers!

Digital tools

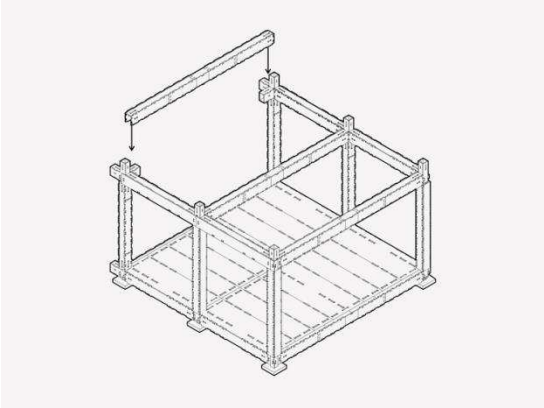
Digital tools are offering new opportunities for off-site construction. For example, Building Information Modelling allows each building component to be specified and costed per item, much quicker than previously. The construction industry is aligning with manufacturing industries and components can be designed and printed, or designed and cut using CNC

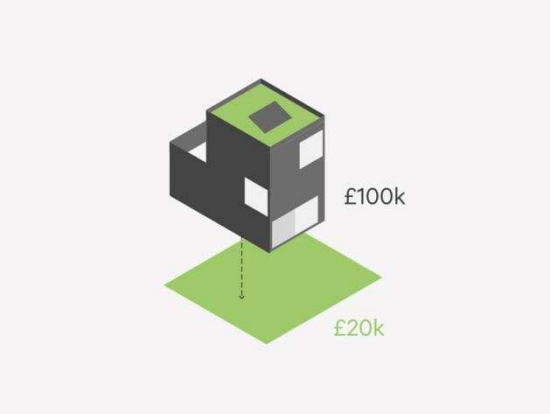
[1] Pitts, M (2018) Transforming Construction blog, Innovate UK. Available from: https://innovateuk.blog.gov.uk/2018/07/06/transforming-construction/ [Accessed 14/11/18]
[2] UKRI (2018) Transforming Construction. Available from: https://www.ukri.org/innovation/industrial-strategy-challenge-fund/transforming-construction/ [Accessed 14/11/18]

machines. Digital platforms with user-friendly interfaces can now be accessed by householders who can input into the 3D modelling and visualisation processes of their bespoke self-build home. Data can be stored and new housing archetypes stored for the next householder to explore. This standardisation can have wider benefits such as ensuring building performance meets designed targets, or allowing future maintenance to be planned at the design stage. Virtual Reality headsets can aid clients to visualise the proposed building at design, build and occupancy stages.

Portrait Two: Wiki House

Wiki House enables the client to customise the design of their home using a user-friendly digital interface which enables coding to inform CNC machines of geometry of the structural frame. An open access data library provides standard building designs which can be adapted to suit before entering the library of construction technologies including structure materials, fit out, envelope, services and site considerations. The open source data is developed by professionals including architects, designers, engineers and builders. The assembly process can be carried out by any able-bodied person.





Sourced via http://wikihouse.cc

Building performance

The off-site sector presents as very passionate about the possibility it can produce homes which can achieve designed targets for high levels of building energy performance at a lower-cost with an improved environmental and aesthetic value; one which can be innovate and flexible and therefore potentially disrupt the housing construction sector.

New housing solutions

Local authorities have commissioned some off-site housing solutions, for example, for temporary homeless accommodation or 'in-fill' housing within existing developments. Off-site

is also being used in new eco-friendly developments as well as catering for a growing self-build market both in the form of individual boutique homes and community-led housing movements.

Affordability and scale

In terms of our key research question around the housing supply and affordability crisis, the off-site housing debate does not fit easily into this category. It is covers a spectrum of builders, architects etc and remains very small. This means it is just starting to grapple with how to scale up and is just beginning to encounter systemic barriers. The high initial cost of setting up manufacturing environments is one example of an initial barrier to enter the market for a Small to Medium Sized Enterprise.

Portrait three: Ilke Homes

Ilke Homes focus on providing 'precision engineered homes' which are 20% cheaper to heat than other new homes and 50% than average UK homes. They aim to provide 2,000 homes a year within two years, in partnership with registered providers and developers. To meet this they may install up to six homes per day. The homes have flexible layouts and designed with families in mind. The manufacturing space is the old yellow pages factory. They aim to become an employer of choice and provide over 800 jobs.
Info sourced from: https://www.ilkehomes.co.uk/

2. What are the challenges facing the off-site sector?

As a relatively young sector, off-site faces a number of challenges to bring their products to market.

Politics and planning

Despite recent government commitments and support for offsite, for example via Construction 2025 and The Construction Sector Deal, our participants remained unsure about the nature and extent of statutory engagement with the sector. Indeed some felt political will was lacking. They stated this could be due to a risk-averse statutory planning system, which may sometimes be at odds with modern models of house-building, which have not been entirely tested over the long-term. This was attributed, variously, to: an ingrained 'bricks and mortar' culture, the financial and lobbying power of volume builders and a lack of capacity at municipal/regional

government scales. Conversely, government officers can lack evidence of the social benefit of off-site-built homes.

Skills

A challenge highlighted is finding people with the skills for offsite construction and thinking, particularly during the design and off-site manufacturing stage. Multi-skilled people are often required and there are no specific 'offsite' focused educational training courses at present. Conversely, some systems are encouraging community participation and enabling those with low skills to carry out the final assembly stage, or participate in elements of manufacture. A national working group is currently collaborating to design a new national training framework to deliver core sustainable off-site based modules. This may lead to developers working with local hubs to deliver bespoke courses focused on their own products and systems.

Portrait Four: Citu

Citu promote vertically integrated supply chains and retain their skilled trades people through a 'squad approach' of valued team members. Citu set up their own factory to build the Climate Innovation District and promote a lean approach in construction through adopting engineering manufacturing methods and skills. They have partnered with Leeds Metropolitan University in developing sustainable construction through using timber framed homes built to high levels of air-tightness and insulation values, with digital user controls.

Sourced via www.citu.co.uk

Financing

Off-site home construction requires a new financing model. Housebuilders' trialling offsite manufacturing techniques can struggle to secure finance and insurance due to the new technologies and methods being used and high upfront costs for manufacturing environments. However, there are cases where insurance and finance have been secured successfully.

Cultural resistance

There is a sense amongst firms that off-site has a reputational challenge to overcome in the UK. In part this is to do with the association with 'prefabs' and in another sense this relates to British 'home owning' traditions. Homes are considered important financial assets in the UK where pension pots are vulnerable and social mobility is weak and works to reproduce the political clout of volume builders. Anything that is perceived to threaten this status quo (by, for example, loosening the relationship between land and property) could be viewed with suspicion. There is work to be done, contend firms, to convince the general public of value for money of off-site housing over the longer term e.g. lower heating bills.

Technologies and manufacturing

Offsite construction technologies and manufacturing spaces vary widely from timber frame and strawbale construction to steel framed builds, structurally insulated panels and shipping containers. Shared manufacturing spaces could be created.

Portrait five: Reach Homes

Reach Homes use shipping containers to create a range of 100% affordable homes, designed to Passivhaus principles. Starting with one-bedroom 320ft^2 open plan homes made with 60%+ upcycled materials. The shipping containers are water-tight by original design and Reach add Innotherm recycled denim insulation, Earthwool ceiling insulation, Decatherm insulated plasterboard, Insul8ed Complete soft-sheen paint, argon-filled glazing, mechanical ventilation with heat recovery, BIPV solar panels and a solar battery, low-water taps, rainwater harvesting, greywater filtration, LED lighting, green roofing, reclaimed wood kitchens and floors and more. This produces an affordable home (from £35,000).

Info sourced from: https://www.reachhomes.org/designs-1

Transport

Off-site built modules and panels are very heavy and can be difficult to transport, especially across long distances. This not only increases the scope for damage in transit but reduces the geographical scale at which off-site builders can operate. One way round this is to use 'flying factories', temporary structures are assembled near the site and can be moved around easily.

Precision thinking

Off-site construction demands precision design and manufacture as there is not the flexibility and discretion available to on-site builders. You cannot just 'make things fit'. Some companies are looking to hire individuals from manufacturing rather than construction backgrounds as a result.

3. What are the social possibilities / ramifications of off-site-built-housing?

The growth of off-site housing opens up important political and ethical questions regarding accessibility, equity and citizenship. For example, it remains unclear if it will reduce barriers to an affordable home or democratise the home-building / place-shaping process to a significant degree. Overall, it is clear that the systemic problems in the housing supply system also

permeate the offsite sector albeit there are opportunities with this technology to develop new development models, including community-led housing.

The 'land question'

The advent of off-site construction bleeds into debates about the UK's unequal land ownership patterns and how land might be made more readily available for new housing solutions. This issue is particularly important for 'alternative' housing movements looking to democratise place-shaping and city-building. As off-site becomes more efficient, on-site construction could come under pressure which may open up space for new models of community development. One proposal was to exploit off-site to move away from the idea of a 'lifetime' home and embrace transience. Land could be owned collectively then people could have flexible build options on their plot; otherwise they are just servicing debt.

Data and expertise

However, the potential for these new models depends on who can access the tools and knowledge i.e. the extent to which off-site heralds a democratisation of construction and development. Given the large firms that have entered the sector this remains far from clear.

Housing affordability

Off-site firms believe that reductions build price and time taken should become lower, this should allow more affordable homes to be built. However, this is ultimately a political question since low-cost homes require cross-subsidy and government, currently, drags its feet on social housing provision. One firm argued that if builders start from the 'bottom-up' with social rented homes as their core business rather than the other way round it is possible to increase the affordable supply.

Place-shaping

Off-site needs to be integrated into urban 'whole place' master-planning There can be additional benefits of offsite construction in relation to community development. For example, where processes are standardised and working conditions are safe and predictable it may be possible for householders to participate in the build process.

Portrait six: LILAC by ModCell

The Low Impact Living Affordable Community in Leeds was built using panel timber walls insulated with strawbale. This significantly reduced the CO_2 emitted during construction and in total, the LILAC development captured and stores over 1,080 tonnes of atmospheric equivalent CO_2 through photosynthesis during the growth of the timber and straw. The panel manufacturing took place in a local barn which was adapted for use. The co-operative housing members were involved in the build process after the structural timber was assembled and were able to assist in adding the strawbales. In addition to homes, ModCell have built schools, business parks, media centres, retail, visitor centres and even a roof garden!

Sourced via https://www.lilac.coop/ and http://www.modcell.co.uk

What next?

This has been an invaluable period of knowledge exchange. We are looking to build on this by developing a second phase of *empirical* work which will further investigate the direction, impact and opportunities for off-site housing construction in the UK. Moving forward we will be staying in touch with all participants in order that this research has maximum impact on the sector.