Increasing the prevalence of offsite construction in housing association developments: conceptual and pragmatic challenges

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Abstract

Offsite construction is increasingly being presented as a way to increase housing delivery and reduce the housing crisis. Housing Associations play a pivotal role in the delivery of affordable homes and therefore offsite construction could be beneficial in alleviating the crisis. For offsite construction uptake to increase, the conceptual and pragmatic challenges surrounding offsite housing in relation to evolving social domestic needs to be explored and better understood. The purpose of this paper is to discuss the viability of offsite construction as not only a full-service solution to social housing provision, but an integral strategic partner for meeting the range of specialised fabrication needs for these new properties. A literature review is carried out to explore the conceptual and pragmatic challenges encountered by HAs adopting offsite construction methods. The paper also investigates which the housing tenures are most suited to offsite construction technology. The paper highlighted that whilst individual case studies and example homes offer one mode of justification for Housing Associations to move forward, it is the cumulative effect of cost savings, sustainability, specialised skill sets, labour reduction, structural innovation, and rate of construction that should be weighed and incorporated into this consideration-making process.

Keywords: housing associations, offsite construction, strategic management

Introduction

Since the housing crisis of 2008, the delays in housing starts and completions has resulted in a widespread housing shortfall in the UK that has challenged policymakers and developers to re-evaluate their position on modern methods, acceleration techniques, and technological opportunities (Killian et al., 2016). Whilst traditional construction continues to serve as the primary mode of new housing fulfilment, recent evidence suggests that in order to meet the future needs of UK households and fulfil a more diversified spectrum of housing solutions, modern methods and offsite techniques are of critical importance (Charlson and Dimka, 2021; Wilson and Barton, 2021).

As a central agency responsible for providing adequate and quality housing to residents throughout a given region, UK housing associations (HAs) are defined as ‘not-for-profit social landlords that provide homes and support for around 6 million people all around England’ (NHF, 2021, p.1).

With pressure to accelerate the rate of delivery for such social housing solutions that are affordable and high-quality, the viability of offsite manufacturing is a pragmatic consideration that must be weighed, assessed, and considered for meeting future needs.

Whilst a growing body of literature has critically explored the advantages and potential limitations of prefabricated, modular, and offsite construction practices, the lack of consensus and dependency upon traditional methods of construction has led to conceptual and ideological gaps that are continuing to threaten the long-term viability of this modern solution. For HAs, organisations that are confronted with a need to accelerate the rate of construction and mitigate the longstanding reputational threats of low-quality, low-efficiency housing, the practical opportunities of offsite housing are significant. The current investigation was undertaken to critically assess the range of needs and expectations related to HAs in the UK, exploring the conceptual and pragmatic advantages and challenges surrounding offsite housing in relation to these evolving domestic needs. The following sections will expand upon an overview of offsite solutions in the UK and explore an array of case study examples that not only confirm the viability of offsite solutions for domestic housing associations, but justify additional engagement with prefabrication and modularity as a strategic means of domestic problem solving in residential construction.

Background to Offsite Housing in the UK

Despite its modern characteristics and seemingly emergent popularity, Killian et al. (2016) report that prefabricated construction has a long and robust history in UK construction, with London's Crystal Palace, built in 1851, serving as one of the earliest examples of this modular, purpose-built structural solution. Subsequent exploitation of offsite solutions by Churchill following WWII promised more than 250,000 homes in a single year; however, with just 160,000 actualised structures completed, many of which were criticised for their poor standards and performance, the viability and value of prefabrication waned (Farmer, 2019). Following WWII and the accelerated imperative of post-war homebuilding, the concept of prefabrication or modular construction was characterised by a negative aesthetic, functional, and structural connotation (Wilson, 2018).
With many domestic residents still residing in post-war housing constructed during an accelerated phase of recovery and rehabilitation, the concern regarding prefabricated solutions to existing

housing gaps and residential delays shapes both consumer and developer support for these technologically advanced modern methods of construction (Wilson, 2018).

The UK is currently facing an array of shortfalls that have elevated the viability and potential importance of offsite housing and prefabrication to a position of systemic and strategic opportunity. For example, there is a severe talent shortage in this industry as both labour and skilled positions remain unfilled, pressuring contractors to import foreign companies and tradespeople at higher costs and longer delivery timeframes (Vernau, 2019). Further, the limitations of modern construction materials and installation systems are negatively impacting the overall quality and environmental performance of traditionally built homes, creating lifecycle effects that are magnified by lower cost, affordability-oriented structures (Vernau, 2019). Whilst offsite construction may include full-scale residential solutions, there are a variety of partial and component-based opportunities that could potentially augment the lagging state of various hurdles that delay and undermine the delivery of performance in this industry. Pan and Sidwell (2011, p.1082) report that there are four levels of options associated with offsite construction technologies including 'component and subassembly, non-volumetric pre-assembly, volumetric pre-assembly, and modular building.' By integrating one or more of these solutions into modern construction, the onsite burden is reduced and specialised manufacturing techniques can be exploited to address the systemic gaps and limitations that are negatively impacting industry performance.

In early research regarding offsite housing in the UK conducted by Pan et al. (2007), evidence suggested that a lack of knowledge or experience with such technologies was a primary limiting factor that motivated contractors to avoid offsite solutions. However, such findings failed to identify the entire scope of the varied challenges, as later demonstrated by Pan et al. (2008) who confirmed that modern methods of construction were being avoided by contractors on the basis of their complexity, their higher cost basis, and their impact on construction scheduling and delivery (e.g. delays, unreliable forecasts).

Despite such domestic limitations, Taylor (2010) would later conduct a value-added assessment of the offsite sector and its contribution to the construction industry, determining that as demands

for sustainable construction, emphasis on project efficiency, and shifting client expectations redefined the core practices in this industry, the scope of offsite contribution was forecasted to grow significantly. In 2013, the gross value added by offsite construction stood at more than £4.8 billion (Taylor, 2010).

Updating this study with more recent data, Taylor (2020) recently observed that gross value of the offsite industry in 2018 had eclipsed £6.8 billion, contributing a gross value added of £1.73 billion or 5.9% of all domestic construction work. This is a significant increase in industry growth and value-added contributions, and therefore, confirms a long-term forecast for integrated opportunities in offsite construction throughout the UK industry.

Whilst offsite housing and prefabricated solutions are becoming mainstream supplements to traditional housing methods, empirical evidence presented by Li et al. (2018) suggests that because the manufacturing phase itself is viewed as additional (e.g. outside, supplied, third party), the experience and qualifications of the contracting team with manufacturing technologies is critical to fulfilling exemplary projects. Central to overcoming resistance to offsite housing solutions, Durdyev and Smail (2019) confirm that site and installation planning competencies must be assessed, leveraging the skills and experience of specialists to augment those traditional construction skills that are wielded by the primary contractor or project developer. For example, size-specific considerations related to prefabricated slabs or entire residential structures are likely to impact transportation, site preparation, regulatory oversight, and other critical risk factors that could threaten the post-viability of transport and installation (Li et al., 2018). On site lifting capabilities, installer qualifications, and quality assessment capabilities are also critical considerations that determine whether the contracting agency and its staff are sufficiently qualified to utilise offsite construction techniques (Li et al., 2018).

Advantages and Limitations of Offsite Housing

Advantages

As firms adopt more innovative, technology-enhanced construction practices such as building information management (BIM), the capacity to exchange information fluidly and in real-time across informational channels is fundamentally altering the structure and conditional inefficiencies of this sector (). As an industry, Ayinla et al. (2020, p.223) remind that construction has ‘long

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since been associated with inefficiencies,' consequences of inertia and resistance to change that are led by 'traditional procurement and methods of construction.' Through an in-depth, systematic review of the past literature regarding offsite construction, Brissi et al. (2021) observed that more than 84% of the selected studies prioritised the improved quality and value associated with product manufacturing, performance, installation, and defect management. Other key factors that highlight industry-specific benefits including a reduction in labour costs, improved health and safety on the construction site, and a specialised and selective adherence to government regulations and incentives (Brissi et al., 2021).

In a field-based analysis of offsite construction advantages, McGraw-Hill (2011) observed that such techniques have myriad benefits including shorter delivery times, sustainable construction solutions, and the reduction of building defects and rework. Material advantages are of significant consideration in offsite initiatives, as Miles and Whitehouse (2013) demonstrated waste reduction upwards of 90% in new housing construction, substantial declines in energy consumption and traffic movements due to direct, just-in-time delivery solutions, and a long-term lifecycle reduction of more than 20% in total building energy costs. In the pursuit of a triple bottom line approach to sustainability (social, environmental, economic), Jiang et al. (2019) propose that by adopting offsite, prefabricated construction methods, the positive contribution to sustainable building outcomes can be measured over the structural lifecycle with gains reported at all phases (e.g. fabrication, installation, operation). In fact, a comparative case study presented by Du et al. (2019) confirmed that prefabricated buildings consume less energy and produce lower CO2 emissions during the construction process due to a reduction in human activities, avoidance of inefficiencies, improved material solutions, and lower occupied emissions.

With key factors such as cost savings, labour reduction, energy consumption, and material waste significantly impacting the environmental impacts of the property, the sustainable advantages of offsite construction maximise the lifecycle profile of the building and reflect net positive effects that can be used to justify method-based decisions (Du et al., 2019; Jiang et al., 2019). Despite the functional and systemic advantages of offsite construction, evidence from a systematic review of this field of research by Brissi et al. (2021) confirms that costs are a principal, driving force in selection decisions, with most researchers seeking opportunities for cost reduction over the project

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lifecycle. By adopting real time, information-supported BIM systems, Mostafa et al. (2020) propose that value for money and cost-benefit calculations can be developed that are based upon visual, systemic, and relational simulations that allow contractors, designers, and builders to actively participate in the fulfilment of key housing stages.

Prefabricated and modular components, for example, can be incorporated into the design and various stages along the construction timeline with broader site or structural impacts weighed virtually in order to either justify the solution or amend the plans to maximise efficiencies (Mostafa et al., 2020). Where costs are of primary concern, builders and developers can weigh the net impact of building decisions on phase-based delivery of housing systems, ensuring that the selection of offsite solutions is not only justified, but that it will support the value-added targets of the evolving project (Brissi et al., 2021).

Figure 1: Model of Key Opportunities

Limitations

Whilst developers may pursue offsite solutions as a formative basis for their accelerated production scheme, Pan et al. (2007) have observed that site-based limitations including planning, logistics, and supply chain challenges can inhibit the efficiency and viability of such offsite solutions. Most of these limitations are related to a lack of engagement or contractor support for offsite solutions, reducing the transferability of some traditional finishing practices and requiring developers to strategically revise their modes and standards of practice (Pan et al., 2007). Specifically, perceived or actual cost premiums were identified in a survey of 100 UK-based builders as the primary reason for avoiding offsite construction (Pan et al., 2007), a concern which Pan and Sidwell (2011) undertook to dispel in more recent analysis of lifecycle costing involving construction, maintenance, and energy considerations. In fact, through a case study comparison of five UK-based construction projects, the researchers confirmed that whole home costs of £60k were attainable using offsite construction to cover preliminaries, foundation, superstructure, services, overheads, and fees (Pan and Sidwell, 2011). Most importantly, the evidence presented by Pan and Sidwell (2011) confirmed that progression and industry development towards higher competition and higher construction efficiency would systematically reduce the pricing variances between offsite and traditional housing over time.

As UK firms explore the potential advantages of offsite housing manufacturing, they are confronted with the range of systemic hurdles that have impacted various forms of industry innovation for decades, namely the modes of procurement. In an interview with UK developers, Charlson and Dimka (2021, p.16) revealed that the lack of 'appropriate procurement options and applicable forms of contract' served as primary barriers to the adoption of offsite methods. With manufacturers of built materials, fabricated structural systems, and designs serving as the primary agents of delivery, the transition away from site-built to offsite-built housing requires the active participation and engagement of a diversified private sector (Charlson and Dimka, 2021). This transfer of responsibility requires the adoption of modern construction methods and technologically advanced skill sets which Blismas and Wakefield (2009) observe are lacking in existing firms as traditional methods persist in diluting the scope and scale of offsite demand. The underlying justification for committing both physical and human resources to the specialisation of

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offsite construction capabilities is predicated upon the financial and systemic viability of this modality as an alternative to traditional construction (Blismas and Wakefield, 2009). Determining whether such alternatives are financially viable, justifiable, and advantageous requires a commercial commitment that will ultimately serve as the primary antecedent to industry evolution and growth.

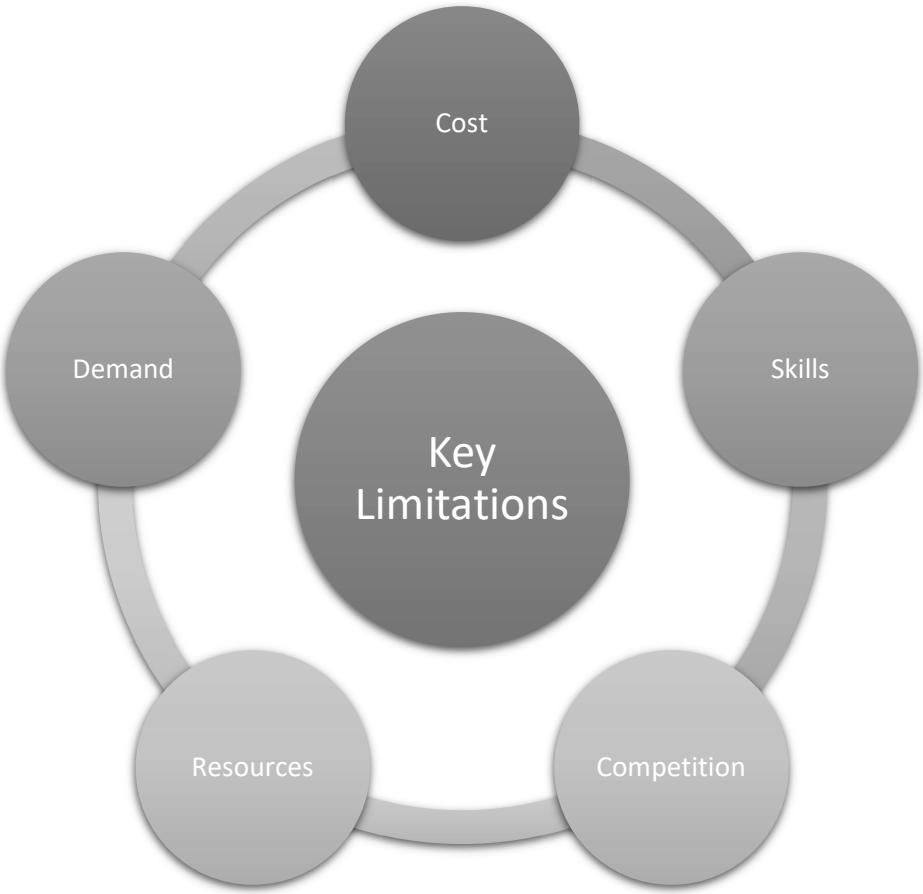

Figure 2: A Model of Key Limitations

Housing Associations and Offsite Housing

Despite an increasingly robust history in UK housing deliveries, offsite construction is often confronted with industry resistance, particularly in public housing sectors where government officials are challenged to justify value for money. Rowley et al. (2020), for example, have observed that the delivery of affordable social housing by government agencies is threatened by a variety of concerns including changing housing prices, economic conditions, demand-side variables (e.g. employment, wage growth, investment yields) and supply side variables (e.g. land

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supply, construction efficiency, labour costs, planning regulations). The resultant bullwhip effect in housing supply, a phenomenon initially observed by Wheaton (1999) in relation to private sector housing fulfilment, results in an over-under supply model that, whilst progressing towards natural equilibrium, is at risk for cyclical changes and delays.

Therefore, MacAskill et al. (2021, p.3) argue that where the primary 'goal of affordable housing is to achieve equilibrium', thereby eliminating the need for a waiting list or stricter qualifications, gap mitigation strategies (e.g. housing transfer, expedited construction methods) are needed to overcome systemic gaps in the housing supply.

Central to the primary economic advantages of offsite housing identified by the NAO (2005) are the volumetric housing benefits that provide housing associations with distinct advantages including earlier rent recovery, a shorter borrowing period, less project delays, and less on-site inspections. Forecasting upwards of 80% fewer project defects and upwards of 80% compression of the time to delivery, the findings presented by Miles and Whitehouse (2013) also confirmed a direct benefit to the house builder and a significant, broader social impact due to the accelerated delivery of high-quality, often affordable housing solutions. As developers weigh the functional and systemic advantages of offsite construction, Ismail et al. (2021) confirm that higher quality, higher efficiency prefabrication will not only reduce the operational costs and emissions of the property over time, but will prescribe a future structural standard that dramatically improves the broader standard of practice in the construction industry.

Underscoring the characteristics of offsite construction, Ayinla et al. (2020) propose that there are several process classifications related to procurement, production, and assembly that can be used to define and systematise contract definitions. Figure 3 outlines such process-specific characteristics, highlighting the range of diversified solutions available to HAs for managing procurement, production, and assembly. Importantly, this model does not fundamentally alter the core foundations of housing construction; instead, it supplements or substitutes offsite manufacturing for the array of traditional construction processes that would have been completed in situ.

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Class	Instances	Description
Procurement Process	Traditional Design-bid-build	Consultants design, contractor constructs the works, limited contractor influence on design
	Design and Build (DFMA)	Single contractor to design and build the work
	Management Contracting	Manages and contracts work to other contractors to construct
	Construction Management	Construction management represents client and coordinates all work contracts
Production Process	Static	Prefabricated elements are manufactured in one position and materials, services, and personnel are brought to fabrication point.
	Linear	Production process is sequential across individual discrete stages
	Semi-Automated Linear	Similar to linear with automated lines and dedicated stages
	Automated Linear	Linear production with sequential stages that are automated
Assembly Process	Pure Prefab	Controlled environment prefabrication with only assembly and install completed onsite
	Hybrid Prefab	Both on and offsite prefabricated components assembled together to form complete structure
	Partial Prefab	Mix of offsite produced components and onsite in situ components

Figure 3: Offsite Construction Processes (Adapted From: Ayinla et al., 2020)

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Residential Housing Gaps and the Future of Urban Housing

Following decades of under-performance and a persistent growth in domestic population, Barton and Wilson (2021) report that there is a need for up to 345,000 new homes to be constructed annually. The problem with this expectation is that the rate and scale of construction is unrealistic given that more than 1 million net additions were targeted for the 5-year period from 2015-2020, a goal that was not met, and according to historic statistics, will not ever be met at the current rate of production (Barton and Wilson, 2021). Figure 4 visualises the three tiers of new housing starts in the UK over the past two decades, highlighting the critical role of private enterprise and the increased, compensatory role of housing associations since the 2008 financial crisis. Where HAs were responsible for an average of just 10.8% of the new starts from 2000-2007, since 2008, this percentage has increased significantly to more than 19.4% of the annual housing starts (Source: MHCLG, 2021).

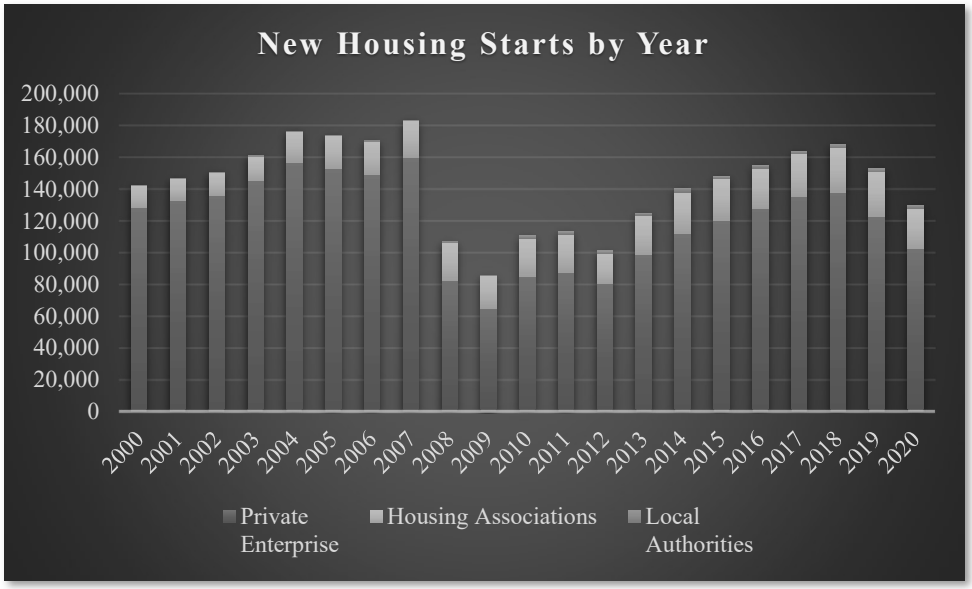

Figure 4: New Housing Starts by Year (Source: MHCLG, 2021)

Mirroring the housing starts modelled in Figure 4, Figure 5 demonstrates the new housing completions that were reported since 2000. Between 2009 and 2016, the average new housing completion rate was 3% less than the start rate. In 2019 and 2020, the completion backlog was resolved, with finished new homes exceeding 15.1% of the start rate in each year. Confronted with the Covid-19 crisis, however, Davidson (2020) reports that builders are forecasted to deliver

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2/3rds less homes between 2020 and 2021as lockdown effects, demand changes, and supply chain hurdles impact housing stock and completion viability.

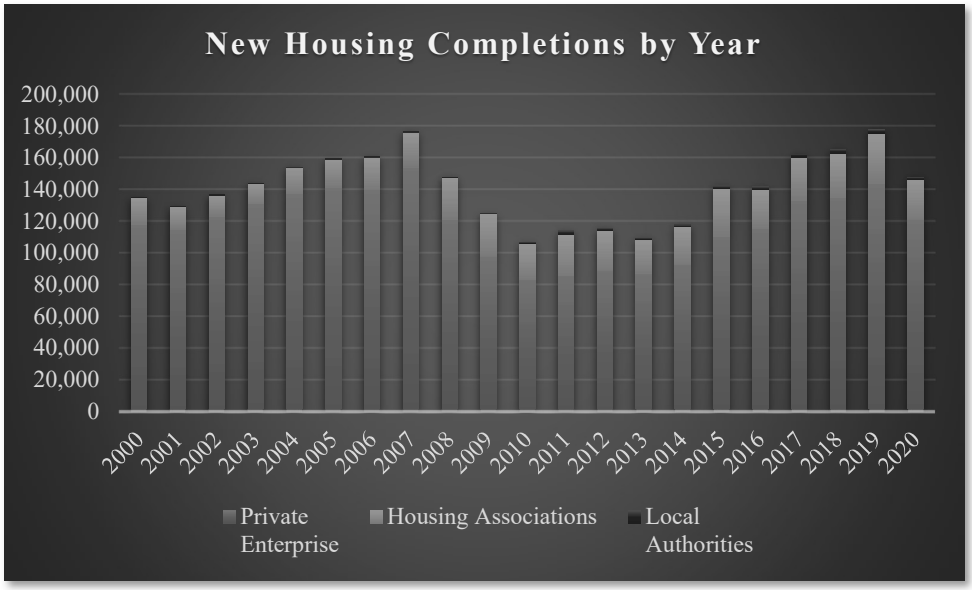

Figure 5: New Housing Completions by Year (Source: MHCLG, 2021)

Despite the potential advantages of offsite housing (e.g. efficiency, low waste, accelerated production, lower cost) identified by proponents of this field, Killian et al. (2016) observe that both home buyers and builders in the UK are often biased against prefabricated and offsite construction due misguided perceptions regarding quality, performance, and innovativeness. In fact, a survey conducted by Pan et al. (2008) regarding offsite construction in the UK observed that many builders were dissatisfied with offsite options because of the complexity of the build cycle, the lack of mass customisation or design preparedness, and the various delays affecting the accuracy of the delivery forecast. However, with demand forecasts suggesting that traditional methods will be unable to meet future demand and the increasingly mainstream proposition of offsite construction seeking to redefine perceptions and normalise prefabricated structures, the potential advantages of these techniques are of significant influence for domestic housing fulfilment.

In a recent analysis of housing by need, Bramley (2018) reported that England requires around 340,000 new homes annually, of which 90,000 will be social rent, 25,000 will be shared ownership, and 30,000 will be intermediate rent.

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Subdivided regionally, high-population sectors like London (32,983) and South East (26,250) will require the most social rent houses at proportions that regionally increase the need-specific profile of housing association intervention in dwelling construction. Bramley's (2018) calculations forecast regional variations in housing development classification according to socio-economic need, with social housing demands increasing for regions in England with higher population pressures. Figure 6 distils the weighted segmentation of regional new housing forecasts (out of 340,000 total new homes per year) by the percentage of social housing needed for each region. In those regions like London and South East where social housing will form a significant basis for new construction, affordability, efficiency, and goal-achievement are of particular concern as residents are confronted with the realities of a housing construction marketplace that is currently not adequately prepared to meet these changing, rapidly expanding needs profiles (Bramley, 2018).

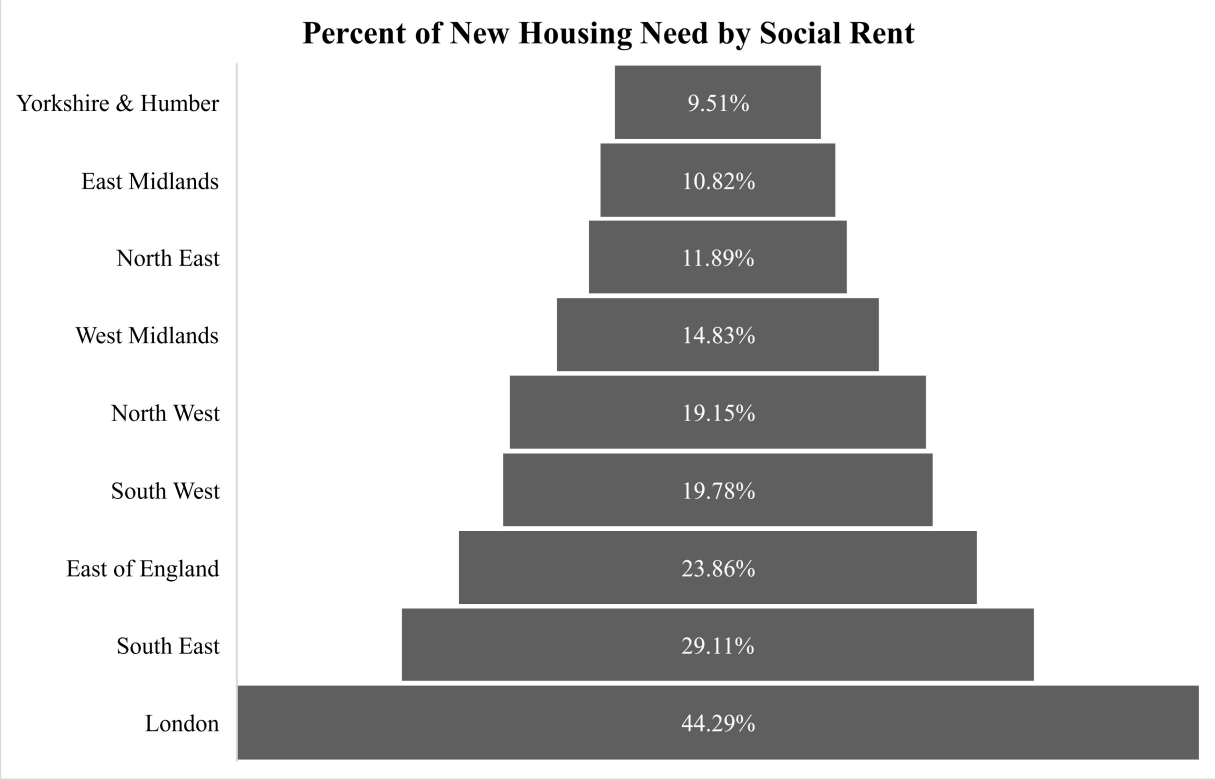

Figure 6:Percent of New Housing Need by Social Rent (Adapted From: Bramley, 2018)

One critical consideration in UK housing provision is the role of land allocation in framing the scope and capacity of new residential deliveries.

Dunning et al. (2021, p.1) remind that despite the scalar opportunities associated with public land held by local authorities, these resources are 'not a panacea' and as a result, are 'subject to several practical constraints that may exacerbate problems arising from the financialization of planning for housing.' Physical conditions, for example such as site topography and buildability, floodplain encroachment, and green/brownfield construction all challenge the efficacy of expansionary development (Dunning et al., 2021). Conflicts between local authorities and private developers also create challenges, with profit levels, value for money, and regulatory preconditions (e.g. % affordable, sustainability) creating barriers to contracting and competitive investment initiatives (e.g. consortia funding (Dunning et al., 2013).

Geographic Deprivation and Housing Association Responsibilities

Beyond these contractual and systemic considerations are a significant geographic concern which Crook et al. (2016) have outlined as a deprivation index relative to housing association expansion and regional positioning. By weighing the concentration of housing associations on a regional scale over time, evidence suggests that since 1998, more than 78% of 'new' housing association locations were located on brownfield sites (e.g. former hospitals or factories) and were subject to agreements requiring 'developers to provide a mix of private and affordable homes' (Crook et al. 2016, p.3393). When paired with low-cost home ownership, Crook et al. (2016) observe that affordable residential structures allocated for public housing become more feasible; therefore, as new developments are planned, the expanding positioning of housing association offerings is mirroring affordability profiles and reclamation initiatives. As much of such construction is now taking place in highly deprived urban spaces as developers plan new purposing for brownfield spaces, the mixed tenure characteristics of these properties are linking public housing to low cost housing offerings, inherently grouping low-income housing within discrete geographic corridors, whilst other, more affluent corridors avoid the influx of social housing investments (Crook et al., 2016).

For housing associations, this form of asymmetric regionalisation has created what Clegg (2019, p.1480) describes as regional 'push pull factors' which create both social (e.g. affordable housing in rehabilitated neighbourhoods) and economic (e.g. increased market value) returns on investment. Due to the ageing state of the UK housing market, much of the investment-based decision-making is being based upon a new build solution, a conditioning which many housing associations have limited or inconsistent experience in navigating. For example, Clegg (2019) weighs the regional advantages of marketisation in the housing market as housing associations actively seek to avoid disadvantaging and economic stratification through value-added investments. These new urban centres, high-quality developments, and innovative residential enclaves are integrative of both lower- and middle-income families and provide opportunities for meeting the diversified needs of a broader platform of social tenants and low to middle-income home buyers (Clegg, 2019). For this reason, the motivational factors such as high-quality, attractiveness, functionality, size, and location which encourage home buyers into a given area are increasingly being incorporated into housing association solutions as the concept of social housing evolves beyond its low-income limitations.

Case Study Evidence

Predicated upon a foundation of what Hopkin et al. (2019) characterises as organisational learning, the transition amongst housing associations away from traditional methods and towards modern construction methods and offsite solutions is increasingly dependent upon justified, purposeful, and experiential integration of new capabilities. Networking effects, for example, encourage housing associations to transfer tacit knowledge across structural boundaries, encouraging behavioural modifications on the basis of direct expertise or emergent innovations (Hopkin et al., 2019). Whilst the justification for the adoption of new offsite methods is likely to be predicated on a variety of influences and performance measures, the emergent platform of high-performing case history and successful integration outcomes is offering a justified frame of industry knowledge for both reference and integration. Accordingly, to demonstrate the evolving proposition of modular, prefabricated, and offsite construction technologies in the UK, it is important to weigh the evidence from several ongoing cases that reflect the systemic, structural, and developmental opportunities and challenges encountered during recent years.

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The following highlights several award-winning projects, outlining the reported achievements and project advantages as they link to offsite construction practices.

Home Group

In 2018, the Gateshead Innovation Village project undertook a systemic comparison of the costs, resource challenges, and procedural hurdles associated with both modular and traditional construction (Prior, 2018). With a budget of £7 million, a combined 41 homes were delivered, 6 which utilised traditional construction methods, 16 applying volumetric methods, and 19 adopting modular housing construction (Home Group, 2021). Further systemic diversity in the form of heating technologies replaced gas fired furnaces with four different electric heating systems that could be evaluated over the home lifecycle to assess installation, servicing, running costs, and functional impacts (CBD, 2019). Three of the four systems met the Government's 2025 Future Homes Standard of 75-80% less CO2, whilst the fourth is being evaluated for opportunities to improve in future iterations (CBD, 2019). Home Group (2021) reports that the ongoing research project utilised five strategic supply partners to facilitate the delivery of high-efficiency, high-quality housing by monitoring, recording, and analysing costs and performance data over the build and operational lifecycle of the homes.

LoCal Homes

Utilising the advanced Eco 200 system, LoCal Homes has developed a high-speed, high-efficiency solution to address the varied needs of local HA throughout the West Midlands (LoCal, 2021). These offsite manufactured homes utilise 200mm thick stand-alone closed panel timber framing with a u-value of 0.18 which LoCal (2021) suggests offers significant savings (greater than £350 per year) for the average home's energy expenses. Figure 7 presents several recently completed projects (LoCal, 2021):

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Figure 7: LoCal Homes offsite housebuilding projects

Project	**Project Value**	**Description**	**Timescale**	**Budget**
Woden Road:	£11,546,000	91 houses and 21 apartments	86 homes in 86 days, 30 homes delivered early	11% savings against budget forecast.
Mill Street:	£1,300,000	14 single person occupancy dwellings with bathroom and kitchen, H-Pod Design including all white goods, floor coverings, off-street parking, cycle ports, and electric charging points.	9 months including civil permitting and ground works	On budget, fully occupied on date of handover.
Darkhouse Lane:	£21,200,000	142 new affordable homes designed to transform factory site into combination of 1- and 2-bedroom apartments and 2, 3, and 4-bedroom houses.	2 years (March 2018-June 2020).	
Portobello:	£1,030,000	40 houses and 22 apartments, 8 accessible houses and 10 bungalows offered for affordable rent and to meet aged 55+ housing needs.	1 year (2018)	
Beechdale:	£9,300,000	56 houses and 24 flats over 3-storeys high.	Nov 2016-May 2018	Completed 12% savings against budget forecast (Design, manufacture construction and integrated supply chain.

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Swan/NU

In 2017, the Swan Housing Association was awarded the 'Best Approach to Modular Construction' award for its strategic investment in its own, purpose-built factory in Basildon capable of creating more than 400 modular homes each year (NU, 2017). Integrated into a £100 million regeneration scheme in Craylands, the investment cost approximately £3 million, was expected to create 60 new jobs, would deliver new homes in 50% of the traditional construction time, save 90% of the construction waste, and initially offer 10% cost savings over traditional builds (Nu, 2017). In 2020, the South East Local Enterprise Partnership (SELEP) awarded £30 million in funding to 14 projects throughout Essex, Southend, and Thurrock that included £4.53 million for Swan's second modular housing facility (Swan, 2020).

With the first factory operating a cross-laminated timber volumetric system, the second, 116,841 sq ft industrial unit will be commissioned to fabricate steel framed modular housing (Swan, 2020). Whilst the combined capacity of these two facilities is expected to exceed 1,000 new modular homes annually, Swan's (2020) accomplishments since 2017 have positioned its facilities to support other regional stakeholders in a fulfilment capacity for future modular home designs. Responsible for managing more than 11,500 residential properties and 8,000 secured in the development pipeline, this multi-facility, modular housing strategy is recognised as a high-efficiency, high-quality solution to the rising need for HA infrastructure solutions (Swan, 2021).

Case Study Review

The evidence presented in these varied case studies demonstrates both the viability and intrinsic value of offsite construction for housing associations. From delivering affordable housing to under-developed or growing areas to rehabilitating existing sites and brownfield spaces, the accelerated rate of structural delivery, high quality housing, and sustainable residential solutions has the potential to fundamentally alter the nature and focus of housing association strategies. In a multi-case study report on various responses to the volumetric housing crisis in the UK, Wallace et al. (2019) reveal that critical hurdles such as regulatory and political ambiguity, stakeholder resistance, and technological gaps have continued to delay the widespread adoption of offsite solutions.

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Yet, when coupled with other triggers and enabling events, there are several pathways to improved offsite construction that will translate the examples presented by LoCal and Swan into market-leading examples for an industry that continues to be confronted by unresolved delays and systemic challenges:

BIM and Digitization: Under the Construction 2025 strategy, government commitments of 50% faster construction delivery, 33% lower costs, and 50% lower emissions require a fundamental revision to existing standards of practice in the traditional construction industry (HMG, 2013). BIM and smarter construction design solutions prioritise real time tracking, site system management modelling and component-based construction practices that not only justify offsite solutions, but compel traditional firms to explore new ways of conducting business and executing their residential deliveries (HMG, 2013).

Building Performance and Sustainability Goals: Underscoring the commitment to more efficient construction, the UK government has also committed to new standards by 2025 whereby new residential construction must attain a 31% decrease in carbon emissions from 2021 (MHCLG, 2021b). Whilst long-term goals challenge firms to develop strategies for reducing emissions by at least 75% (MHCLG, 2021b), the short-term considerations for new home construction mandate an immediate change in design and system performance. Performative improvements via offsite construction will allow HAs to not only improve the efficiency of their properties, but will improve the quality of life (e.g. cost reduction, high-quality residences) for their social applicants, dispelling many lagging stereotypes about social housing and affordable inefficiencies.

Skills, Contracting, and Collaboration: Whereby traditional housing favours design-build solutions, offsite construction offers the unique opportunity to actively plan, diversify, and integrate modern technologies and structural innovations into a regional design platform (Wallace et al., 2019). Relying upon advanced, technological skill sets that are steeped in innovation and adaptive design, modern manufactured homes will be developed by skilled workers with advanced degrees, clear visions, and adaptive structural solutions (Wallace et al., 2019).

From local partnerships with HAs to manufacturing innovations and bespoke facility development, these skills transition away from one-off residential development to integrative, modular solutions that can be adapted to systematically improve the process of residential construction.

Speed of Delivery, Systems, and Vision: The case study evidence has confirmed that the rate of project delivery can be accelerated as HAs partner with offsite manufacturing companies to develop solutions that leverage the advantages of modular, prefabricated solutions. From schedule planning for installation to component pre-installation and quality inspections, the responsibilities that once required in-depth on-site scheduling and intensive trades negotiation can now be accomplished in a one-stop facility without requiring multiple streams of coordination and planning (Vernikos et al., 2013). Whereas contractor profit margins were once based upon the gap between trades and contracted rates, offsite solutions increase the cost-material transparency, establishing a new standard of oversight and expense mitigation that can be used to improve the overall cost performance of offsite initiatives (Vernikos et al., 2013). As HAs are not looking at offsite construction as a one home solution and are targeting larger scale developments, strategic partnerships with offsite professionals such as those exemplified by LoCal and Swan have the potential to significantly improve the overall cost basis of the structural delivery process, eliminating many of the intermediary costs and waste streams that permeate the traditional construction industry.

Summary and Conclusion

For UK housing associations, the consequences of ever-expanding waiting lists, dilapidated and quality-compromised housing, and delayed construction deliveries have significant socio-economic implications. From rising need profiles of domestic residents to changing patterns of regional affordability, the pressure to accelerate development and accommodate seekers of social housing creates an imperative to alter the nature of new home delivery in the UK. This study has explored the viability of offsite construction as not only a full-service solution to residential building, but an integral strategic partner for meeting the range of specialised fabrication needs for these new properties.

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Whilst individual case studies and example homes offer one mode of justification for HAs to move forward, it is the cumulative effect of cost savings, sustainability, specialised skill sets, labour reduction, structural innovation, and rate of construction that should be weighed and incorporated into this consideration-making process.

Despite decades of history, technological advancements, and hybridised construction solutions, the connotation of prefabrication in the UK evokes images of post-war housing, crumbling walls, mould, and dampness. Few residents from Swan or LoCal, however, would validate such concerns, instead citing the exemplary standards, high-quality fit and finish, and structural efficiency of their residential properties. In fact, as each of these underlying budgets were evaluated and met via dedicated offsite contracts, the case study evidence indicates that additional cost savings and financial returns are potential in an industry that relies upon volume and economies of scale to maximise its efficiency and performance. It is this coordinated commitment to a unified pursuit of offsite housing throughout a given region or network of housing associations that will ultimately transition this industry from a one-off, bespoke solution to a high-value, high-impact transformation of construction in tangible terms of efficiency, cost, and material savings.

Whilst much of the prior research in this field seems to propose that client expectations and demands are a leading cause of resistance to prefabrication, another conclusion can be drawn from the juxtaposition of recent housing association cases and industry innovation: the traditional construction industry is perpetuating the barriers to change. Ultimately, this transition is about formative, functional, and skills-based hurdles which much of the traditional industry is likely to resist. The loss of revenue due to offsite construction, for example, will have severe consequences for traditional home builders. Site-specific trades related to framing, structural supports, and utilities (e.g. electrical, plumbing) will no longer play a central role in the delivery of each individual home. Instead, a paradigm shift from multi-tiered to project-specific contracting will evolve as residential builders rely increasingly heavily upon specialised labour and strategic partnerships with offsite firms. Instead of viewing residential construction as a discrete and structure-specific domain, the future of modern construction practices will be embedded in manufacturing and the capacity-enhancing transition from bespoke to adaptive residential solutions.

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The housing association is beholden to its stakeholders to regulators and local authorities and to its residents. The responsibility of producing and positioning high-quality housing solutions across UK cities imposes an expectation of performance and follow-through that should motivate a transition towards modern methods of construction. Where housing association positioning is weighed by deprivation indices instead of neighbourhood amenities, the evidence indicates a critical gap between the realised standard of modern housing and the idealised standard of socio-economic inclusion. From affordability to structural integrity, this study has confirmed that there are multiple advantages to utilising offsite construction methods to fulfil modern construction needs and accelerate the rate of residential delivery throughout these resource-constrained, resident-demanding institutions. Ultimately, by following the pathways of existing HAs that have already been firmly rooted in technical, structural, and residential justifications, it is concluded that associations considering offsite housing solutions will find motivation to explore opportunities to reframe their build agenda and refocus their residential investment strategy.

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