

# Driving change in UK housing construction: a Sisyphean task?

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## Abstract

This report captures context, analysis and insights following research into the productivity challenges of constructing new homes in the UK, and particularly with respect to Modern Methods of Construction (MMC) that produce 3D/volumetric model homes. Government targets of 300,000 new homes annually are far out of reach for traditional builders and the limited pool of skilled labour that is critical for their methods. Factory-produced homes promise quality, speed and scale, but the firms delivering this approach – typically new entrants – struggle to realise a viable business model. This research uncovered industry perspectives that highlight compounding issues in the current context which make the situation untenable, including misaligned skills and disconnects between onsite and offsite work, slow and unpredictable regulatory approvals, a lack of consistent demand, and widespread resistance to change. Targeted efforts to better support these methods and firms could help the nation to reach its housing targets. Opportunities to support the sector include shoring-up demand of MMC, supporting a more MMC-oriented skills agenda, and addressing the issues in attaining regional planning and land-use approvals. Initiatives that support these ends are vital to delivering more quality-built, affordable and sustainable homes.

## Contents

Introduction.....	2
Context.....	6
<i>Construction &amp; Housing</i> .....	6
<i>Construction Productivity</i> .....	9
<i>Sustainability</i> .....	10
<i>Modern Methods of Construction</i> .....	11
<i>UK Housing – Current State</i> .....	12
Characteristics .....	16
<i>Business Models</i> .....	16
<i>Capitalisation</i> .....	17
<i>Labour</i> .....	18
<i>Automation</i> .....	19
Productivity.....	21
Sustainability .....	23
Challenges .....	24
<i>Quality</i> .....	24
<i>Storage &amp; Transport</i> .....	25
<i>Risks</i> .....	25
<i>Timing &amp; Delays</i> .....	26
<i>Flexibility</i> .....	27
<i>Driving Change</i> .....	27
<i>Costs</i> .....	28
<i>Supply Chain</i> .....	29
The Way Forward.....	32
References .....	34
Appendix.....	37

## Introduction

King Sisyphus was immortalised by Homer along with the unique punishment assigned to him by Zeus: he was to spend eternity rolling a boulder up a steep hill, only to see it tumble down before it ever reached the top. A seemingly simple task endlessly proving to be hopeless. In the UK, great hopes to transform housing construction is appearing to perhaps be somewhat of a Sisyphean task. Driving overdue change in building new homes is plagued by compounding negative forces that seem to make it an impossible feat. Recognising the vital importance and unique challenges of this sector, The Productivity Institute undertook research to capture industry perspectives on the current dynamics of productivity growth in the housing sector and specifically opportunities for improvement in the face of increasing sustainability requirements and constrained labour supply. Insights from interviews and other research are captured in this report, including an overview of the broader context, practical implications, insights from the industry, and recommendations to improve productivity and outcomes for the sector.

The UK housing crisis is acute, with a need for at least 300,000 new homes annually. Construction productivity is low and productivity growth has been flatlined for decades, despite numerous government initiatives to drive improvements. New homes standards – particularly with respect to sustainability – are higher than ever before and the expectation is that homes built in 2025 and onwards will be carbon neutral. To further complicate matters, skilled labour shortages have posed additional challenges for the sector. So-called “modern methods of construction” (MMC) – including factory-produced volumetric modular homes and panelised systems – have been positioned as a critical part of the solution, but they have yet to gain the needed traction.

On its current trajectory, the UK cannot reach its housing targets for the foreseeable future. Our research seeks to understand the challenges in the sector and to help establish a way forward. We examine factors that impede efforts to improve productivity in the sector. The research commenced in late 2022 with a thorough review of literature about the sector. This research informed the identification of trends and challenges in the industry, and a series of industry interviews have helped to further our understanding.<sup>1</sup> The initial scope focused on three firms in the industry which were identified as both new entrants and the leading independent modular home builders: Legal & General Modular Homes, TopHat and Ilke

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<sup>1</sup> Details of industry engagement is detailed in the Appendix: Interviews (see Table 1) and Discussions (see Table 2)

Homes (established in 2015, 2016, and 2017, respectively).<sup>2</sup> Discussions with others in the industry – from government and industry advisors to demand-side firms – delivered additional insights. With aims to uncover paths to productivity growth in the sector, the research team focused on conditions that would improve the success of MMC, which has the greatest potential to deliver quality homes with speed and scale. It is nonetheless important to note that we do not see growth of MMC as being at the expense of other methods; the UK housing market has sufficient demand for a variety of players and, indeed, innumerable firms must be successful if the UK is to deliver much-needed housing in the face of labour shortages and a vital transition to net zero.

Existing research thus far has revealed significant issues that hinder new housing construction and particularly with respect to the adoption of the most advanced form of MMC: Category 1, which represents 3D (volumetric) factory-manufactured modular homes.<sup>3</sup> This category almost wholly replaces traditional methods of construction by assembling most housing components in a factory environment, with more standardisation, less waste, and minimising the need for skilled trades that are in short supply. Factory-built homes are also widely believed to offer greater efficiency and quality and are particularly well-suited to delivering more sustainable homes. And yet, widespread adoption of this method has not been evidenced and firms continue to struggle, despite significant and unprecedented investments.

Through our research, we have identified five primary issues that are limiting the use of MMC and have been particularly problematic for new firms entering the market to help deliver the unmet demand:

- 1. Labour market requires new skills.** To deliver at pace and meet quality standards, both offsite and onsite aspects of MMC require skills and understanding that differ from traditional methods. Offsite work is oriented towards manufacturing and production, requiring more factory-specific skills than the traditional skills of construction trades. Onsite work continues to require specialised skills, but to incorporate MMC, the onsite skilled labour requires more precise methods than

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<sup>2</sup> At the outset of this research, L&G's factory had capacity to produce 3,500 homes per year. TopHat's capacity was 800 annually with a factory under construction to increase their capacity to 4,000 homes per year. Ilke's capacity was 1,000 per year and they had raised funds to increase their output to 4,000 homes per year.

<sup>3</sup> A cross-industry working group was tasked by the Ministry of Housing, Communities & Local Government to define MMC. According to their definition framework, Category 1 of MMC is defined as "a systemised approach based on volumetric construction involving the production of three-dimensional units in controlled factory conditions prior to final installation. Volumetric units can be brought to final site in a variety of forms ranging from a basic structure only to one with all internal and external finishes and services installed, all ready for installation" (Cast Consultancy, 2019).

required by traditional construction. Until both aspects are properly skilled, the deployment of MMC will be marred by delays and quality issues.

- 2. Projects must better accommodate the unique aspects of combining onsite and offsite methods.** A cohesive link between offsite and onsite work is critical to the success of projects and this has been a major challenge. It is evident that there is often a disconnect between sites and factories, resulting in missteps when the two are inevitably brought together.
- 3. Land use approvals are a massive challenge for the industry regardless of the construction method.** Seeking regulatory approvals from local authorities is consistently the most unpredictable and time-intensive part of the building process and this is especially challenging for MMC. Issues naturally result from under-staffed departments for planning and land-use regulators, and the likelihood that regulations and approvals are used as leverage for political ends, resulting in constant change, uncertainty, and delays. For MMC, the challenges are compounded by a 'liability of newness' and continue to be particularly onerous versus more traditional methods.
- 4. The desire for flexibility limits productivity growth.** Flexibility in home design and materials is desired by homeowners and regional authorities, which can limit the adoption of MMC and productivity gains of factory methods to the construction of social housing. This particularly applies to Category 1 of MMC which has design limitations due to the constraints of a factory environment. Other forms of MMC are challenged by this as well, as true productivity gains in any category come only with high quantities of repeated designs (i.e., less flexibility).
- 5. The industry is not sufficiently incentivised to change.** The construction industry is notoriously slow to change, risk averse, and extremely cautious of trying new methods and materials that may challenge delivery of their product. As a result, change is typically driven by external forces. In the instance of housing, government regulations are the main driving force for change rather than demands from the client/homeowner, as they are indifferent to the process innovations that are the main impetus behind homes delivered by MMC.

These five challenges are substantial and seemingly unrelenting, much like Sisyphus' quest to rest with the boulder at the top of the hill. And yet, we assert that in the UK, there are opportunities to improve outcomes in housing construction. In the current context, the key to unlocking productivity to deliver more homes is largely in the hands of government.

Government is uniquely positioned to advance the industry by applying three levers that can simultaneously address the present challenges:

- 1. Drive demand creation for MMC.** Government can go further to incentivise builders to use MMC through beneficial taxation schemes and grants, land access, regulation, and mandates that encourage greater adoption of these methods. In addition, as a significant owner of housing and construction projects, government bodies can drive change as a major client in the sector. Category 1 firms, in particular, need greater assurances of consistent and sufficient demand to support the large capital requirements of their business model. Encouraging more widespread adoption will ensure MMC gains more traction so that these businesses can be viable and the method more common, which will deliver more homes at speed and with fewer issues.
- 2. Deliver an MMC-oriented skills agenda.** Bringing MMC to a site requires specialised skills to ensure projects are successfully completed. More skilled and semi-skilled labour and construction management teams need to better understand and deliver on the unique requirements of MMC, including more precise tolerances to incorporate MMC into sites. It is also important that offsite teams understand the onsite work. Further education, coordination and communication can alleviate many of the issues that have arisen when offsite components arrive on a build site.
- 3. Ensure efficient and pragmatic government approvals.** It is critical that the current systems for regional planning and land-use approvals are transformed to simplify the process and speed up decision making. The current system is onerous, inflexible, and unpredictable for all players and is particularly challenging for MMC-driven projects. Months to years of delays in planning and approvals result in excessive delays for construction projects that could otherwise be delivered in weeks to months.

These three actions – ensuring demand, training for different skills, and improved regulatory processes – will pave the way for dramatic improvements in the pace of new homes construction and enable much-needed productivity growth in the housing construction sector. These moves will not only support Category 1, but all categories of MMC and the housing sector more broadly. MMC – and Category 1, in particular – has been positioned as an important part of solving the challenges of the affordable housing crisis, transition to net zero, and skilled labour shortages, and it is imperative that it succeeds if the country is to



meet its housing targets. It is evident that current market dynamics are not delivering the necessary conditions for MMC to deliver on expectations, but this can be changed.

MMC-driven projects have the potential to deliver much-needed volume in new homes construction, but it is currently under-represented and uniquely challenged to be a dependable, viable, high-volume solution. Government intervention can do more to benefit the industry as a whole – both MMC and traditional construction methods.

Delivering high-quality affordable housing faster and at scale requires a diverse, vibrant, and innovative industry. In the face of unprecedented challenges and a natural resistance to change, we need targeted initiatives that will better equip all industry players to deliver homes.

The remaining sections of this insights paper will review the current context of construction and housing in the UK, including productivity and sustainability. An analysis of the characteristics unique to MMC Category 1 follows, along with a further discussion of the implications related to productivity and sustainability, and the many challenges that are particularly difficult with respect to Category 1 of MMC. The paper concludes with recommendations to better support the sector and a research agenda to help advance work in this space.

## Context

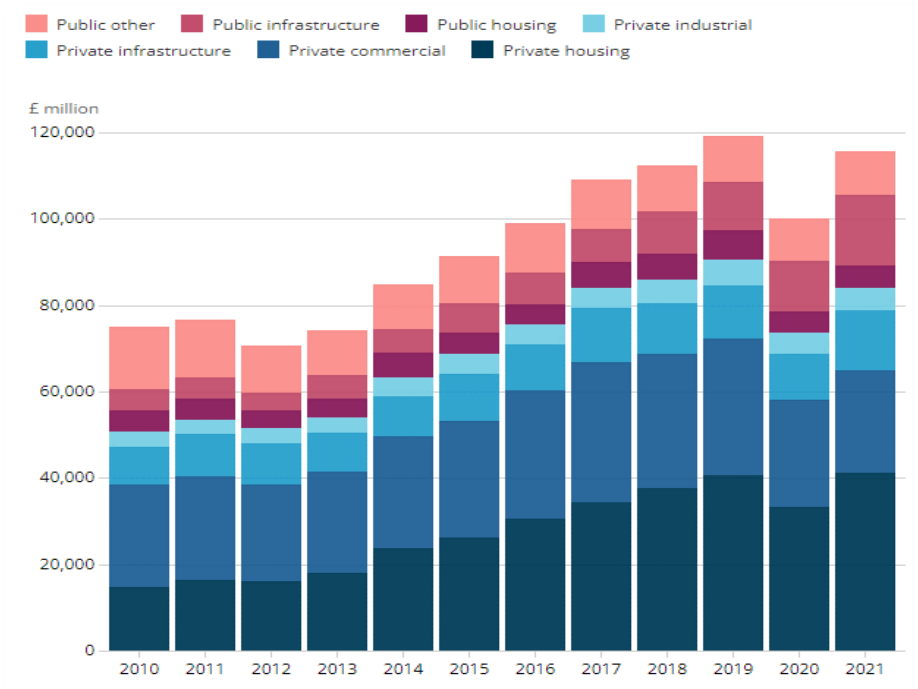
New housing construction in the UK is a complex and fragmented market, dealing with land-use regulatory approvals, new and changing product performance standards, labour shortages, emergent business models, new methods, and evolving materials. The visibility is high, with governments, businesses and individuals having vested interests in new housing developments. In the following sections, we provide an overview of the context at a national level, including economic impact, productivity, sustainability, MMC, and the current state of the UK housing market. We also explain the value systems at play.

### *Construction & Housing*

The construction sector represents 6% of the UK economy and, in 2021, the value of new construction work grew by 15.3% to £115,579 million, although this is still below pre-

pandemic levels.<sup>4</sup> New public and private housing represent over 40% of construction work (see Figure 1).

Figure 1: Types of construction work, current prices, non-seasonally adjusted, Great Britain, 2010 to 2021



Source: Office for National Statistics - Construction statistics, Great Britain: 2021 (Table 1.1, 1.2, 1.3)

In 2013, the UK government published a strategy for the construction sector in *Construction 2025*, with ambitious targets to achieve by 2025:

- 33% reduction in both the initial cost of construction and the whole life cost of assets.
- 50% reduction in the overall time from inception to completion for new build and refurbished assets.
- 50% reduction in greenhouse gas emissions in the built environment.
- 50% reduction in the trade gap for construction products and materials.<sup>5</sup>

In 2016, *The Farmer Review, Modernise or Die* published deep concerns about the skills and labour issues in the sector. Upon the report's release, Mark Farmer, report author and chief executive of Cast Consultancy, said:

<sup>4</sup> Office for National Statistics (ONS), 2022

<sup>5</sup> *Construction 2025*, 2013

The construction industry is in dire need of change. What is clear to me following the nine months spent conducting this review is that carrying on as we are is simply not an option. With digital technology advancements pushing ahead in almost every other industry and with the construction labour pool coming under serious pressure, the time has come for action. The construction industry doesn't have the impetus needed for this change, it requires external action to initiate change.<sup>6</sup>

The review made ten recommendations for the sector spanning recruitment, training, and governance. One of the recommendations homed in on the need for increased research and development (R&D) spending and incentives to encourage offsite construction and modern building techniques and suggested “using the residential development sector as a pilot programme to drive forward the large scale use of pre-manufactured construction, for example, through offsite built or modular housing.”<sup>7</sup>

As part of the government's Industrial Strategy, the *Construction Sector Deal* was published in 2018, which built on *Construction 2025* and *The Farmer Review*, and included several actions to continue the mandate of *Construction 2025*, specifically by focusing on three strategic areas: greater use of digital techniques, offsite manufacturing, and a greater focus on whole life asset performance.<sup>8</sup>

The strategy included a £170 million investment in the *Transforming Construction: Manufacturing Better Buildings* programme, which funded digital and manufacturing technologies to enable better delivery and improved sustainability metrics.

These initiatives raised awareness and drove momentum in the sector, including new funding and policy initiatives that supported building better homes, faster, and for less. In keeping with the government's priorities, Homes England – the government agency tasked with accelerating the pace of house building and regeneration – stipulated that to qualify for its funding and land deals, partners must deliver 25% of homes using MMC (any combination of the seven categories, from finished volumetric module through to more evolved site processes, could be applied to meet this threshold).<sup>9</sup> These efforts were

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<sup>6</sup> Cast Consultancy, 2016, p. 2

<sup>7</sup> Cast Consultancy, 2016, p. 1

<sup>8</sup> *Industrial Strategy: Construction Sector Deal*, 2018

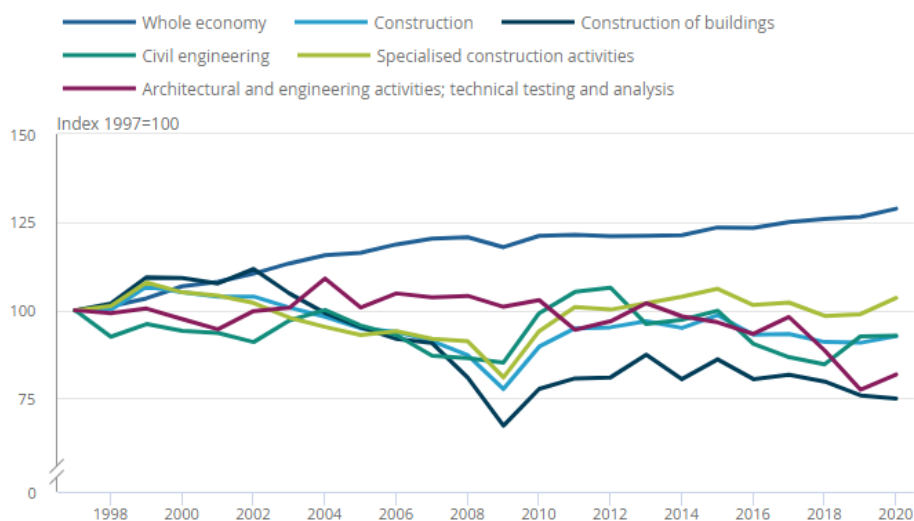
<sup>9</sup> *Guidance: Apply for Affordable Housing Funding*, 2020

expected to help improve construction productivity, and – vitally – support the industry in meeting the 300,000 annual new homes target established by the government in 2018.<sup>10</sup>

### Construction Productivity

The struggle for industry – and the country as a whole – is that construction productivity in the UK has remained relatively unchanged for over fifty years. The sector continues to be a significant drag on the nation’s productivity, with the construction of new buildings delivering the lowest productivity performance (see Figure 2).<sup>11</sup> Over the last 30 years, government-led initiatives have been launched to improve the performance of the UK construction sector, of which the 2018 Construction Sector Deal and associated UKRI Transforming Construction Challenge are among the latest initiatives. While progress has been made, construction continues to fall behind the productivity growth in other sectors and the economy overall.

Figure 2: Output per hour worked, construction industry and sub-industries and whole economy, UK



Source: Office of National Statistics. “Productivity in the construction industry, UK: 2021”

Productivity in construction is a global challenge, particularly with respect to driving productivity growth. Globally, the UK is among McKinsey Global Institute’s “outperformers” for the sector in terms of construction labour productivity and productivity growth. The top performer, Belgium, is a clear outlier and has sector productivity growth that exceeds their total economy. Belgium demonstrates achievable targets for other nations: offsite

<sup>10</sup> Government Announces New Housing Measures, 2018

<sup>11</sup> In 2020 – versus the 1997 index of 100 – output per hour worked was 128.8 for the whole economy, 92.7 for construction, and 75.0 for the construction of buildings.

prefabrication is widely used, and mechanisation is maximised. Some companies in the UK are following this path, but only to a limited extent. The approach in Belgium – with labour costs 4 percent higher than France, Germany, and the Netherlands – net unit labour costs that are an impressive 15 percent lower due to higher productivity.<sup>12</sup> For the UK, productivity growth has been stagnant and there are clear routes to improvement, but not without significant change and investments.

## *Sustainability*

In terms of net-zero targets, there are two main components to consider in new housing construction: embodied carbon and operational carbon, which together make up the whole life carbon of a structure. Embodied carbon includes material sourcing, fabrication, transportation, and installation through to demolition, dismantling and disposal at the end of a structure's purposeful life; operational carbon includes the emissions from day-to-day energy consumption while in use.

It is widely understood that embodied carbon is the greatest challenge in new housing construction with net zero ambitions out of reach for the foreseeable future. Net zero operational carbon is already an achievable target for some builders, but hurdles remain. One builder recently installed homes with theoretical net-zero operational carbon, but the initial actual data in-use is still being collected.<sup>13</sup>

New homes in the UK are now required to have CO<sub>2</sub> emissions that are at least 30% lower than standards from 2022<sup>14</sup> and, in 2025, the expectation moving forward is for homes to meet the Future Homes Standard, which stipulates that homes built to this standard will produce no operational CO<sub>2</sub> (assuming decarbonised supply) with 75% to 80% lower emissions than those built to current standards.<sup>15</sup>

Early research with industry stakeholders suggests there is consensus in the industry that volumetric modular home manufacturing is the best way to deliver net zero solutions and this is particularly applicable to affordable housing. In a conversation with a leading construction consultancy, they claimed that the precise specifications required for a net-zero building can only be done at scale with a manufactured solution, so they see a clear case for offsite construction to deliver these types of homes.<sup>16</sup> The exacting nature of factory-produced

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<sup>12</sup> *Reinventing Construction: A Route to Higher Productivity*, 2017

<sup>13</sup> Discussion 10

<sup>14</sup> *New Homes to Produce Nearly a Third Less Carbon*, 2021

<sup>15</sup> HM Government, 2022

<sup>16</sup> Discussion 3

modules, and their low tolerances, results in a tightness of fit that is critical to supporting operational carbon efficiency.

### *Modern Methods of Construction*

Discussions of new homes construction in the UK typically contemplate builds using either traditional methods of construction or MMC. These methods can be seen as a spectrum from traditionally built timber and brick homes, through to those using a mix of traditional and modern methods, to those that are almost completely MMC, such as the Category 1 volumetric modular homes that arrive onsite largely finished. The present research largely refers to MMC from Category 1 which represents three-dimensional structures (i.e., volumetric) that are assembled in a factory rather than onsite.

Category 1 represents the most complete alternative to traditional methods and holds significant potential to deliver productivity gains while also exceeding current sustainability standards. This method benefits from an offsite approach which can deliver more scale, precise tooling, less waste, and greater quality control than onsite construction work, which is difficult to scale, more manual, more variable, and with significantly more waste created. Category 1 is also well-suited to building affordable homes, where it is more acceptable to have a repeated design that can deliver more homes, cost savings, and productivity gains.

In the UK, planning and policy from Homes England and the Department for Levelling Up, Housing and Communities (DLUHC) clearly see MMC as a key aspect of tackling the productivity challenge in construction. A government official told our team that the benefits of MMC are there for firms that reach a critical point, and they are working to support these firms.<sup>17</sup> Homes England has made at least two significant investments in modular home manufacturing, including a 4% stake in Homes by Urban Splash<sup>18</sup> and a £30m investment in Ilke Homes.<sup>19</sup>

In conversation with one industry representative, he emphasised the need to increase the pace and sustainability of new homes being built. He suggested that in facing the crises of skills, housing, and climate all at the same time, MMC is helpful – though not a panacea.<sup>20</sup>

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<sup>17</sup> Discussion 7

<sup>18</sup> Berry, 2022

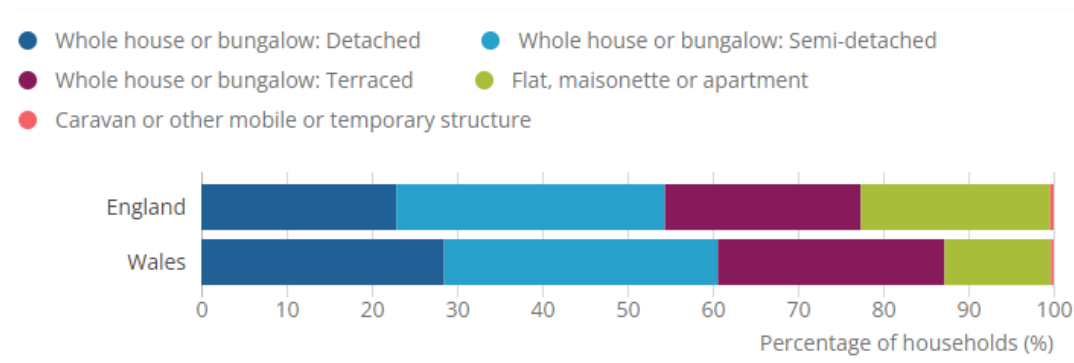
<sup>19</sup> *Housing Minister Unveils £30m Boost for 'Construction Corridor'*, 2019

<sup>20</sup> Discussion 5

## UK Housing – Current State

The 2021 census counted 24.8 million households in England and Wales, with almost 80% (19.3 million) living in a whole house rather than an apartment (see Figure 3).<sup>21</sup>

Figure 3: Accommodation type, 2021, England, Wales, all households



Source: Office for National Statistics – Census 2021

Tenure, whether a household rents or owns their accommodation, is an important part of this picture and can be subdivided further:

- 32.8% of households own the accommodation they live in outright.
- 29.7% own their accommodation with a mortgage, loan, or shared ownership.
- 20.3% rent their accommodation privately.
- 17.1% are in the social rented sector (e.g., local council or housing association).<sup>22</sup>

These homes are not enough for the country's needs and there have been calls to greatly increase housing construction. It is widely understood that the UK is dealing with a housing crisis, particularly with respect to affordable housing. In research commissioned by the National Housing Federation (NHF), it was estimated that 8.4 million people in England are living in unaffordable, insecure, or unsuitable homes, including:

- 3.6 million people living in an overcrowded home.
- 2.5 million unable to afford their rent or mortgage.
- 2.5 million in "hidden households" they cannot afford to move out of, including house shares, adults living with their parents, or people living with an ex-partner.

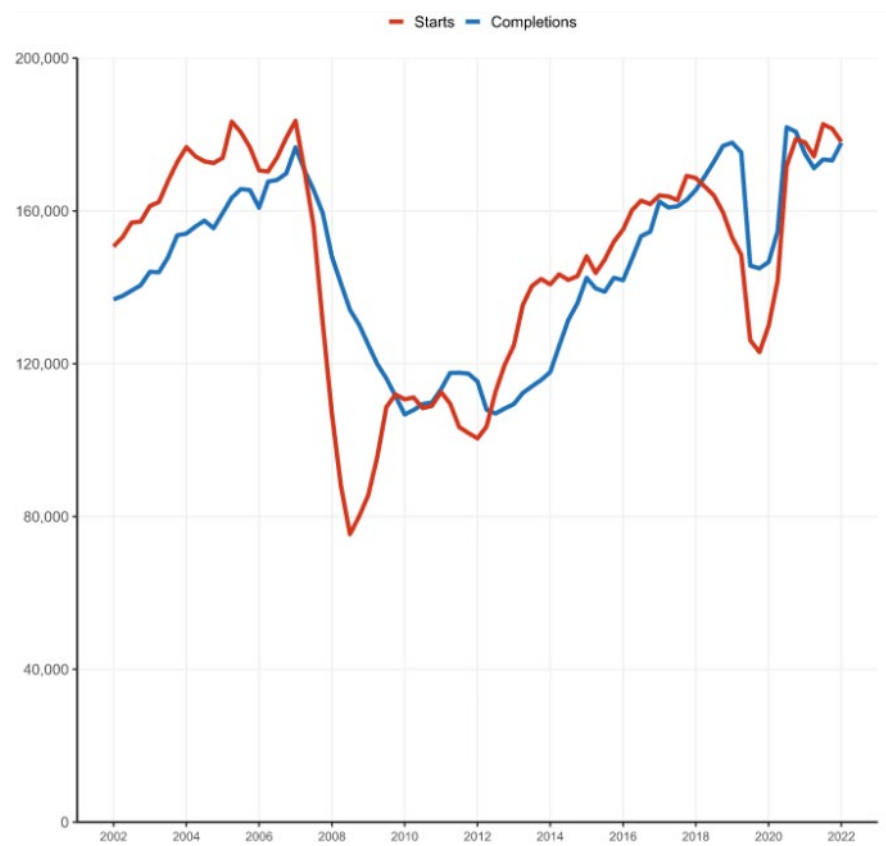
<sup>21</sup> Office for National Statistics (ONS), 2023

<sup>22</sup> Office for National Statistics (ONS), 2023

- 1.7 million in unsuitable housing (e.g., multi-story homes for elderly with mobility issues).
- 1.4 million in poor quality homes.
- 400,000 are homeless or at risk of homelessness – including people sleeping rough (e.g., on the streets), living in homeless shelters, temporary accommodation, or sofa-surfing.<sup>23</sup>

The NHF estimated that around 340,000 new homes need to be supplied each year, of which 145,000 should be affordable homes.<sup>24</sup> The government has set a target of 300,000 new homes per year by the mid-2020s, which far exceeds current supply (see Figure 4).

Figure 4: Trends in building control reported estimates of starts and completions, 12-month rolling totals (not seasonally adjusted), England, 2002 to 2022



Source: DLUHC, 2023

Given the pace required and the sustainability expectations, it is hoped that factory-produced modular homes can be an important part of the solution. While traditional home builders can

<sup>23</sup> Bramley, 2019

<sup>24</sup> Bramley, 2019



continue to provide most new homes, modular homes present an opportunity to accelerate and expand the supply of new homes. One industry representative we interviewed felt that speed was on the side of modular and made it a preferred solution:

Technically, it's quicker. If you didn't have delays in planning, delays in ground, weather – these can hold you back. It's cleaner, it's less waste. And it should be quicker. The units come on the back of a lorry. So, if your site is set up, then it's like Lego. Yeah. Zipping up. Done.<sup>25</sup>

The factory-built modular homes are particularly well suited to the affordable homes market and – with the calibration of a factory environment – they are well suited to meet sustainability requirements, too, due to their precise production methods and reduced waste.

Importantly, with factory-produced homes, the value is in the completed product and the manufacturers are thus incentivised to deliver at pace. In contrast, some builders participate in more speculative land developments where the profit is largely driven by land valuations that can ultimately result in the delay of delivering completed homes; others are motivated to build fewer, larger homes, which can also be a path to greater profits.

A fundamental issue is that the construction of the structure of a house is a relatively small portion of the overall housing development process and not always where the profits are made. The business models are quite unique in this respect. For private sector developers, profits are largely in gains from acquiring the land and attaining approvals for new developments. For social housing contractors' profits are indeed in construction but the structure is only one part of the project and – when MMC is used – a large portion of that is outsourced.

Another vital factor in all of this is the monumental challenge posed by the regional systems for land-use regulation and approvals for developments – colloquially known as “planning”. The issues were consistently raised in interviews and discussions with industry. We were told that planning departments are typically under-staffed and at risk of being politicised, as they are one of “the few levers that government has around house building, so they perpetually tinker with it. So, it's also incredibly volatile.”<sup>26</sup> It is this volatility that perhaps is most problematic, with builders and manufacturers unable to accurately predict the planning timelines.

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<sup>25</sup> Interview 8

<sup>26</sup> Interview 1

In addition to a lack of resources and competing priorities, one interviewee shared that some of the issues stem from the risk appetite within planning departments:

In the private sector, delivery of a programme is king, and that delivers your revenue, your return. In the public sector you're supposed to wear two hats. You're supposed to wear a delivery hat and the "protect the Council from risk" hat. And sometimes that "protect the Council from risk hat" is the hat that lots of people wear. And it shields them from risk as well. But they forget about the delivery risk. The biggest risk to us as a country is not delivering anything. But that's sort of forgotten because the immediate "protect us from risk" – that comfort blanket we have – is easier to hold onto, and it feels dangerous, and it feels uncomfortable, to do something different. And they have lay people challenging them constantly [...] so therefore every decision you make as, say, as a planning officer, needs to be checked, double checked, re-double checked and... it's a waste of time – so, "where's the risk?" You're constantly looking for that risk. You're looking for that challenge and you will try and put measures in place to mitigate the challenge and that risk.<sup>27</sup>

An imperative of regulatory and land-use approvals is that local decision making is a crucial expectation and democracy facilitates the principle that people, through their elected representatives, have the right to play a role in shaping what is built in their neighbourhood. These are important and long-standing expectations but unfortunately do result in friction and challenges, which lead to uncertainty and delays.

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<sup>27</sup> Interview 8

## Characteristics

Discussions with industry and research in the initial stages of this project enabled the research team to identify important commonalities and differentiators in the industry, particularly with respect to the three modular firms selected for further study. Each of these is discussed in turn below.

### *Business Models*

It became apparent to the research team that Category 1 MMC represents an emerging business model in the sector that is a marked departure for the industry. Aside from the need for significant investment and patient investors, the firms under study are expecting profits from the structure they build, rather than the land it sits on.

One industry executive we spoke with suggested that there is a thesis emerging around how to address the “structural deficit” in housing: a new supply chain is needed, and modular suppliers are an important part of the solution as they are more incentivised towards completion in contrast to a developer that may slow down until land valuations are higher.<sup>28</sup> A government official described the more traditional approach of volume house builders:

[They are] in the business of selling little pieces of land for large amounts of money and putting a house on. It is an inconvenient process of making it worth something to a consumer. The house is an accidental requirement as opposed to what their business is. Their business is taking land through planning and getting large amounts of value for all that, that small parcel. And which is why the product on top of it is the minimum product possible to achieve that outcome. They are very good at what they do in terms of delivering a product for a price.<sup>29</sup>

This approach has worked for the traditional construction firms, but unfortunately also results in constrained and delayed supply for the market, as the incentives are mis-aligned with the drive to deliver more homes, faster, sustainably, and of sufficient quality.

We were told that government representatives are talking to house builders and are explaining that “there's another business model available to them whereby if you can build faster, perhaps you could sell faster as well but with different tenures, different products.”<sup>30</sup> The modular firms under study are at the forefront of this model – they are the early

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<sup>28</sup> Discussion 5

<sup>29</sup> Interview 1

<sup>30</sup> Interview 1

adopters. These firms have some common traits, such as their focus on the built structure rather than on land, but also notable points of differentiation. They are all manufacturing high quality and sustainability-minded affordable homes using Category 1 MMC, but there is some variation in their business models, including the activities they engage in – from superstructure manufacturing to full-site development and ongoing property management – to their cost structure and financing sources, partnerships, corporate structure, and other important operational and strategic considerations.

### *Capitalisation*

The funding of Category 1 firms is particularly unique for the construction sector and the three firms we spoke with each had access to significant resources. The requirements for delivering scale in volumetric factories are extensive and expensive, from the massive space required, to the equipment and staff training, and design and innovation cycles to improve efficiencies. These upfront costs require significant financing and are unique to volumetric manufacturing.

Investors in these firms appear to understand patience is required, but there are limits. Legal & General Modular, for example, had accumulated £174m in losses over six years before they announced the closure of their factory in May of 2023. In 2021 they had reported their first revenues (£12m) alongside losses of £37m.<sup>31</sup> Sir Nigel Wilson, CEO of the parent company, had equated these early years to the expensive realities of research and development, like that experienced by Tesla, pharmaceutical companies, and others.<sup>32</sup> TopHat and Ilke Homes have reported revenues but continue to be unprofitable; in the most recent fiscal year, they reported losses of £19.4m and £41.3m, respectively. TopHat recently announced a further £70 million investment<sup>33</sup> and Ilke Homes recently entered administration in June 2023 after announcing it was facing an imminent financial shortfall<sup>34</sup> and was in talks with possible new investors.<sup>35</sup>

An executive of one of the firms succinctly characterised the capital requirement: “If you are just a middle of the road under-capitalised modular builder, you will not succeed. You need well-capitalised businesses who can benefit from continuous improvement in manufacturing over time”.<sup>36</sup> And yet, as the recent failures in the industry have shown, capitalisation alone does not ensure success.

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<sup>31</sup> *Annual Report & Financial Statements, 2021*

<sup>32</sup> Gardiner, 2022

<sup>33</sup> Twinch, 2023

<sup>34</sup> Gardiner, 2023a

<sup>35</sup> Gardiner, 2023b

<sup>36</sup> Interview 3

## Labour

The labour market is an important dimension of these business models, and it is a significant differentiator vis-à-vis traditional construction methods. Notably, one of the firms was “born out of the skilled labour shortage.”<sup>37</sup> One of their founding firms had an opportunity to grow because of the demand for affordable housing, which was their “sweet spot”, but they could not grow because of “the number of joiners, electricians, plumbers, bricklayers that are available in the UK – it’s a diminishing resource.”<sup>38</sup> The construction workforce has been described as “an aging, shrinking, increasingly expensive resource”, with an average age of 50, net outflow of 20,000 per year, and where “a plumber inside the M24-25 earns more than the GP.”<sup>39</sup> An executive from a firm that works with a range of construction methods, from traditional to MMC including Category 1, said that they have been running out of skilled labour over the last 20 years. He shared that human resources are their biggest issue and slows down innovation, and that Brexit has compounded their problems with respect to maintaining labour supply.<sup>40</sup>

An executive from one modular firm noted that, “there’s a lot more deskilled labour than skilled that are looking for work right now”<sup>41</sup> and this is the realm each of the modular firms are focused on. He added that of the three top modular firms, “all of us try to get to as little skilled labour as possible. When I started, we were at about 60% skilled labour. We’ve gotten that down to about 10-15%. We still like to have some skilled labour in the factory, though, for various reasons, but we’re, I mean, I think 10% is probably the right number, but we’ll get it lower.”<sup>42</sup>

The “deskilled” market is more optimal for them in several respects, as another firm noted that hiring from the industry generally proved more challenging – workers with traditional construction experience struggled with the precise and repeatable work required in factory production of homes.

A consultancy executive noted that the skills agenda needs to catch up with industry changes so that a local workforce can supply an MMC project that comes into the area.<sup>43</sup> The modular firms we spoke with have found a workaround for this problem. They each had factory teams from all walks of life – teachers, retail, etc. – which they facilitate through

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<sup>37</sup> Interview 4

<sup>38</sup> Interview 4

<sup>39</sup> Interview 4

<sup>40</sup> Discussion 3

<sup>41</sup> Interview 3

<sup>42</sup> Interview 3

<sup>43</sup> Discussion 5

onsite training. The training delivers new careers for team members, and they have very little turnover.

The firms each developed their own training centres but took slightly different approaches. One modular factory delivered a 12-week course on building modular homes, covering everything from foundation to windows. Everyone working in their factory had completed the programme and could work on any aspect of the build, apart from plumbing and electrical that requires licensed professionals.<sup>44</sup> Another factory delivered more specialised training – focused on tool skills and processes – and each team member was ultimately working on only two or three of the factory’s 400 to 450 standard operating procedures (SOPs). They believed “their key resource is a reliance on semi-skilled workers” and shared the following:

About 93% of the direct workforce here has the job title ‘team member’ and they will all earn the same salary, and they will be asked to do whatever task we train them to do. So, we don’t have people knocking about that we will call joiner or plumber. We have people that do plumbing tasks and joinery tasks.<sup>45</sup>

It has been an evolution for the firms, and one characterised their earlier stages as “almost like we were using unskilled labour to do artisanal tasks because there wasn’t enough definition in the design.”<sup>46</sup> Between design changes and a focus on SOPs, they seem to have solved some of these issues, but ultimately were not able to reach financial viability.

All three modular firms also noted that they were motivated to tap into the opportunity for more female representation in the field. At one, the workforce was 19% female, and they were targeting at least 30% in the near term.<sup>47</sup> The construction industry average in the UK is 86% male.<sup>48</sup> An executive of one of the other firms noted that women feel more comfortable and safer in a manufacturing facility rather than on a construction site and that they appreciate the consistency of their wage and working hours.<sup>49</sup>

## Automation

The three modular builders studied sit on a spectrum in terms of their approach to automation. A factory tour of one modular builder demonstrated minimal automation, apart from laser cutting of cargo container-sized cross-laminated timber (CLT) panels at the first

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<sup>44</sup> Interview 7

<sup>45</sup> Interview 4

<sup>46</sup> Interview 4

<sup>47</sup> Interview 4

<sup>48</sup> *Number of People Employed in the Construction Industry from 1st Quarter 1997 to 1st Quarter 2023, by Gender (in 1,000s)*, 2022

<sup>49</sup> Interview 3

stage of housing production.<sup>50</sup> Another professed to a traditional approach to automation, relying almost exclusively on proven CNC machines (i.e., computer-controlled tools).<sup>51</sup> At the other end of the spectrum, one builder will be using KUKA industrial robots in their new factory, representing the most advanced automation of the cases under study.<sup>52</sup>

Through discussions and one factory tour, we learned about their pragmatic approach to automation. They believed that productivity improvements come both from design and manufacturing, and “the trick is in standardisation, repeatability, automation.”<sup>53</sup> When they started out, everything was manual. They worked on design and processes first, and then “developed it to the point where we believed that we could start the automation on some processes.”<sup>54</sup>

One firm had invested £4 million in an “automated-ish production line for making the full external walls. Automated-ish means for substantial CNC machines.”<sup>55</sup> The machines were primarily for material handling, cutting, drilling, and inserting screws. This level of automation added safety benefits and eliminated about one third of the labour required for those processes. The machines put roughly 2,000 screws in each module and had taken 29 tons of manual handling out of each day. They emphasised the established history of the technology: “critically it is all proven technology. So, it's seeing equipment from the 1990s in a new application [...] my career is littered with blue sky projects that didn't work. So, this is this is all technology that everyone knows is going to work.”<sup>56</sup>

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<sup>50</sup> Interview 7

<sup>51</sup> Interview 4

<sup>52</sup> Interview 3

<sup>53</sup> Interview 4

<sup>54</sup> Interview 4

<sup>55</sup> Interview 4

<sup>56</sup> Interview 4

## Productivity

The firms we have spoken with discuss productivity in very pragmatic terms. Of the three volumetric firms, they clearly see productivity gains in their means of production. One responded to a question of productivity with the following perspective:

We convert it into a Sterling figure by multiplying by the labour rate. But what everybody talks about here is, what's the headcount per module? So, it's people per module and that's, you know, that's a number in the 60s that we're heading into a number in the 40s, but it was a number that began with the one that had two zeros after it when we started. So, we were way above £20,000 a module when we started, we're now below eight and we're heading for six.<sup>57</sup>

Another firm stressed the importance of automation for productivity gains. Their current factory was running a shift of roughly fifty people, producing two modules each day. In their new factory, with advanced automation, they expect to have roughly twenty-five team members producing sixteen modules each day.<sup>58</sup> The net result is sixteen times the output, with half the labour.

These firms are realising what a government official emphasised to our team in terms of offsite construction and MMC:

It has become a growing priority for government – it has been for a while from an industrial strategy perspective, looking at competitiveness in the economy and productivity, and then which sub-sectors in the economy are particularly bad. Construction is at the bottom of productivity, the least digitised, less automated, and therefore presents the biggest challenge. The biggest opportunity too, for transformation.<sup>59</sup>

Automation is critical to delivering material productivity improvements, but this opportunity is closely tied to standardisation and repeatability. Productivity improvements come both from improvements in product and component design and from enhanced manufacturing practices.

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<sup>57</sup> Interview 4

<sup>58</sup> Interview 3

<sup>59</sup> Interview 1



One firm characterised the productivity journey as a lean manufacturing process inspired by the Toyota Production System:

At the beginning my strategy coming in here was to have a strategy that I would call effective than efficient and sort of loosely based on a Toyota principle that says you work out how you're going to build something, you work out how your process is going to work, and you iterate, you iterate. And when you're happy with the process, you start your efficiency journey.<sup>60</sup>

The volumetric firms suggested that there were little to no productivity gains on offer through traditional construction:

Any productivity that they're going to take, they've already taken it. When they were making the pyramids, they took the productivity there. So, the only productivity on site really is material technology. So, the cost of building a house every year goes up, cost of building our houses in a manufacturing setting will come down.<sup>61</sup>

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<sup>60</sup> Interview 4

<sup>61</sup> Interview 4

## Sustainability

To achieve net-zero carbon emissions in housing, managing for embodied carbon – from construction, materials, and transport to eventual decommissioning – is a significant challenge. Each of the firms studied made commitments to deliver on sustainability targets, but to varying degrees.

The most ambitious had focused on carbon emissions from their earliest stages, and report that their homes have less than 5% of the embodied carbon of a traditional home.<sup>62</sup> One stated that their core products were forecast to become carbon-neutral over their lifetime, including emissions created in the construction phase. They also had an offering which they promoted as a net zero carbon efficient home, with no energy bills and no additional costs to purchase versus a traditional home. The other firm had begun delivering net-zero carbon homes before they ceased production.

The materials used have a significant impact on the carbon emissions. In terms of the structure itself, timber is generally seen as the most sustainable option, particularly in comparison to steel and concrete, though some note that steel and concrete could be repurposed upon deconstruction.<sup>63</sup> The firms in this study currently use domestic suppliers for almost all components. Only one of the firms was working exclusively with timber for framing. One firm had stated they intended to move towards more global suppliers, which they expected would provide significant cost savings<sup>64</sup> but would need to be accounted for in their carbon impacts as well.

None of the volumetric firms we spoke with felt that building sustainable homes was more onerous or more expensive than building less sustainability-minded homes. For these firms, minimising carbon impact is a natural part of their method due to the precise methods and waste minimisation that a factory environment enables. They can further improve sustainability through supply chain and materials, which are effectively component decisions that do not substantially alter their processes or costs.

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<sup>62</sup> Interview 3

<sup>63</sup> Hyams, 2023

<sup>64</sup> Interview 4

## Challenges

Volumetric MMC is not without its share of challenges. Some buyers, including two we interviewed, expressed concerns about quality in the industry. One organisation is positioning themselves as an intermediary of sorts, connecting housing providers and local authorities with MMC suppliers and offering support and assembly. They made it clear that quality issues were part of the reason they were created.<sup>65</sup> Another firm shared a detailed “pros and cons” list that they had provided to their volumetric provider – the shortcomings were significant and far exceeded the positive comments.<sup>66</sup> While this housing provider would prefer to use modular housing, it struggles to see its merits given recent experiences.

### *Quality*

The three modular firms reviewed represent investments of over £500m, but deep pockets must be matched with consistency and high quality. Other offsite/MMC firms have struggled to survive due to quality issues, despite their ample capitalisation. Ilke Homes and Legal & General Modular are the latest failures in the UK, but not the first high profile closures. U.S.-based offsite firm Katterra launched in 2015 and secured \$1b investment in 2018. By mid-2021 it had filed for bankruptcy after accumulating over \$2b in total investments.<sup>67</sup> Their failure has been largely attributed to poor quality control. Similarly, the UK-based modular firm Homes by Urban Splash launched in 2016 and had significant investments, including from Japan’s Sekisui House and Homes England. However, it entered administration in 2022 after a series of problems resulted in defects in their homes and key customers lost confidence in the firm.<sup>68</sup>

For one organisation supporting housing providers and local authorities in delivery of MMC-crafted homes, quality issues are at the heart of their decision to set up their own assembly hub, where they could control the final stages of the manufacturing process and deliver enhanced quality and control.<sup>69</sup> They believe this approach will benefit both the suppliers and customers and deliver improvements in quality. The organisation’s representative sees benefits for suppliers:

In a volumetric factory, if we could take your modules when they’re just coming around the corner and they’re not quite complete, we take off a huge bottleneck for you. Our problem is you’re sending those

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<sup>65</sup> Interview 2

<sup>66</sup> Interview 5

<sup>67</sup> Kruppa & Massoudi, 2021

<sup>68</sup> Berry, 2022

<sup>69</sup> Interview 2

modules out – because of that pressure – incomplete, and you’re trying to finish them on site. That means you’re not ready, it’s inefficient, quality drops dramatically, you miss things, and you’re sending different people to site to fix things that aren’t doing that job in the factory because you need them in the factory.<sup>70</sup>

He emphasised the issues that led to forming their organization: “We’re seeing leaks. We’re seeing MEP<sup>71</sup> put in incorrectly. We’re seeing bad workmanship on plaster boards and fixings and all kinds of things. So, we’ve said, send your 80% complete modules to our factory and we’ll finish them.”<sup>72</sup>

Delays stemming from quality issues have been problematic for the industry and continue to tarnish the reputation of modular. Two current developments in Bristol – one by L&G Modular and one by Ikea-backed BoKlok (with TopHat as supplier) – are significantly delayed. BoKlok are behind schedule by at least a year on homes already committed to families, and they have cited challenges regarding the supply chain, materials and labour as driving the issues.<sup>73</sup> L&G Modular was confronted with a 6-month delay when the brick façades installed onsite in Bristol had to be dismantled and reconstructed.<sup>74</sup> It is understood that this was actually due to the foundations, which had a tolerance that was outside the required specifications which presented issues for the onsite masonry work to install the façades.<sup>75</sup>

### *Storage & Transport*

Storing volumetric units until a site is ready requires a significant amount of space, which the volumetric suppliers currently maintain. For one firm, L&G Modular, the units had a major – and well publicised – issue with mould. Another supplier confessed to us that they had the same issue earlier but managed to resolve the matter with better ventilation to manage moisture in the stored units. Transportation can be problematic, too, given the large sizes of the units. Road restrictions and managing transport – for example, whether a police escort is required – seems to vary across the country.

### *Risks*

From a buyer’s perspective, the biggest risk regarding volumetric MMC is the ability of the supplier to provide the units. Past business failures have resulted in “modular graveyards” across the country, where partially completed developments will likely never be completed.

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<sup>70</sup> Interview 2

<sup>71</sup> MEP: Mechanical, Electrical and Plumbing

<sup>72</sup> Interview 2

<sup>73</sup> Cork, 2022

<sup>74</sup> Turner, 2023

<sup>75</sup> Interview 7

Unlike traditional construction or even Category 2 of MMC (2D panelised structures), volumetric units are too precise for another builder or manufacturer to step in and complete a project. One interviewee summed up the issue and possible mitigating factors, such as step-in rights:

Greystar had control over that factory as well. They had step-in rights. So basically, if that manufacturing business failed to perform, they could take over the business and get it done. Vision also has two manufacturing facilities, one in Bedford, one in Wales, which means if you had a fire in one of them, in theory you've got the same team, you got the intellectual property. You can actually shift production to the other facility, whereas most other manufacturers in the country are single factory operations, which means you have a single point of failure and risk in that factory.<sup>76</sup>

### *Timing & Delays*

Proponents of MMC suggest that its speed is one of its greatest benefits. Our research, however, presented mixed opinions about whether speed was indeed a benefit of this approach. One demand-side executive said that volumetric MMC is not a perfect solution for the industry because the MMC part of a project is only about 30% of a build and typically has nothing to do with the delays.<sup>77</sup> MMC only provides the structure for the house. Prior to that the site must be laid out with all the roads and drainage, and the foundations for each house must be laid together with service connections. Once the modular structure has been erected, it is usually clad in brick, timber, or stone and the roof tiled to make it acceptable to local communities (and hence the planners). MEP and kitchens also must be installed. One interviewee clarified this point:

So, we've got an understanding – we understand MMC isn't always quicker, because we know those wet trades on site will be slow. But when we looked at all three [volumetric firms], there was no one delivering the home in four weeks. They were delivering things in the factory quickly, but when it came to actually putting things on the ground and people moving into homes, it wasn't – it didn't seem to be any quicker than traditional house building.<sup>78</sup>

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<sup>76</sup> Interview 1

<sup>77</sup> Discussion 6

<sup>78</sup> Interview 8

In defence of volumetric, an executive from one modular firm suggested that “if there is a delay on site, they should be happy they're using modular because they'll be getting it done faster” and added, “I think it's a big deal because, again, time is money, as you know in construction. So, it's a mitigating factor for sure”.<sup>79</sup>

### *Flexibility*

In discussions with one firm that leverages the full spectrum of construction methods, the team emphasised that one of their biggest issues with volumetric modular homes is a lack of flexibility in terms of design. They believe this constraint – inherent in the factory setups and manufacturing ethos of some firms – limits these homes to one-, two- and three-bedroom affordable housing units. They do not envision how factory-manufactured homes can ever satisfy the needs for larger homes and demands of a mid-level (or higher) market segment.<sup>80</sup>

One volumetric builder believes, in contrast to other modular providers, that they can at least provide more flexibility in design. They run their manufacturing on SAP,<sup>81</sup> which, they assert, is unusual in the space, and allows them to make design changes without necessarily impacting throughput. They have also moved towards using robots rather than factory bridges and CNC machines: “everything is robotics and the reason we are using robots is because bridges constrain you over time, you get locked into their dimensions. And with robots we're not locked in.”<sup>82</sup> Their solution sounds promising but has yet to be proven – their more advanced factory is under construction and will not be producing homes until 2024.

Flexibility in production is another challenge for Category 1. If there are delays in the site preparation, which is not uncommon, this generates a storage problem and impacts carefully planned transports from the factory to the site. Each of the firms studied must contemplate storing the units as there is typically no space for them onsite until their intended lot is prepared for them to be installed. To be efficient, factory production needs to be scheduled well in advance, this contrasts with more traditional methods where onsite production can be flexed day by day.

### *Driving Change*

Volumetric firms are also contending with a liability of newness that has slowed their growth, as can be expected with a new offering in a highly regulated industry. A government official we spoke with characterised the move to MMC – and particularly volumetric – as “a

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<sup>79</sup> Interview 3

<sup>80</sup> Interview 5

<sup>81</sup> Software for managing business processes

<sup>82</sup> Interview 3

transitional shift in the way that we build” in the UK.<sup>83</sup> He noted that it has been largely government led, because they believe in the potential and opportunity of MMC. While there are a handful that have jumped headlong into the market, he believes there are plenty of others that have been “watching at the sidelines.”<sup>84</sup>

One modular builder had been working to challenge conventions, particularly with the National House-Building Council (NHBC), which provides warranties for new homes in the UK. They had partnered with Knauf to run tests at a facility in Belgium, so that they could bring strong data to the discussions.<sup>85</sup> And yet, the pace is glacial. From providing evidence that new methods and approaches are viable, their experience was that it took a minimum of two years to see change in the standards.<sup>86</sup> Make UK Modular, the trade body for the country’s MMC Category 1 builders, is now in their second year and works to raise awareness and understanding of volumetric housing.

## Costs

In speaking with the manufacturers, they appear to be at a cost advantage versus the traditional builders in terms of both materials and labour. At first blush, material costs seem to be comparable in the near term.

An executive from one firm in the space clearly sees a cost advantage for volumetric housing manufacturers:

Well, it costs us about £2.5 to £3 a foot to ship our house. Right, let’s say £3. I can assure you that we get £3 of labour savings in the factory. And reduction in waste, at least that much. So, whereas people used to think that theoretically modular should be more expensive, I think theoretically it actually should be less. Now you do have the overhead of the factory, but in fairness, if you can go faster on the site for affordable housing or build to rent, you have less overhead on site because you have less prelims<sup>87</sup> to carry.<sup>88</sup>

Another manufacturer explained that while the cost of construction will go up every year, “as a manufacturing business, we’re on a cost decay curve. So, we’d expect to be, you know, my

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<sup>83</sup> Interview 1

<sup>84</sup> Interview 1

<sup>85</sup> Discussion 10

<sup>86</sup> Discussion 10

<sup>87</sup> “Prelims” (preliminaries) in construction is a group of items necessary to complete a project but that do not become part of the finished work – for example, site overhead, access permits, scaffolding, site offices, site security, powering the site, etc.

<sup>88</sup> Interview 3

DNA is I've got a reduced cost every year."<sup>89</sup> He added that his material costs might be more expensive in some respects, but they make up for it in terms of their efficiency:

Our material cost will be more expensive. So, we've got steel frame. Material cost is more expensive also because we've got to put it on the back of a truck and transport it. We've got some schemes in Hastings where you know, as far as I'm concerned, that's France. So yeah, you're heading the length of England on the back of a truck. So, you do need more material to allow it to make that journey. So, we'll be more expensive in material. That said though, you can compare unit by unit so we shouldn't pay more for a window than traditional construction. We shouldn't pay more for floorboards than we do. We won't compete online on material. What we will do is we'll compete on efficiency. So, we will be able to do it. People being paid slightly less money working at 95% efficiency. I'm going to guess that labour efficiency on a building site is a number in the 30s and they're going to be earning twice the rate.<sup>90</sup>

This manufacturer also noted they have a strategic procurement team with a five-year plan to take 28% out of their material costs. The team is currently finding opportunities where they have secured savings of up to 20% on some materials.<sup>91</sup>

### *Supply Chain*

Several aspects of the supply chain complicate matters for home builders in the UK, and the realm is both of practical and strategic relevance to volumetric builders. Volumetric business models amplify the criticality of their supply chain, incentivise vertical integration, and lead to extensive customisation of the materials and machinery they need to procure. It is also their greatest cost, and thus their greatest opportunity for cost savings.

A line manager on the floor of one factory explained to our team that supply chain delay is the only challenge they encounter on a regular basis.<sup>92</sup> An executive from one of the other firms stressed that to get efficiency in the factory, you need the right materials at the right place and at the right time. He stressed why this is a particular challenge for housing manufacturers:

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<sup>89</sup> Interview 4

<sup>90</sup> Interview 4

<sup>91</sup> Interview 4

<sup>92</sup> Discussion 8



If you have interruption on your line, there's a cascading effect that you don't get on site, so if they don't deliver a kitchen on time on site, it's not a big deal because they deliver in three days from now, it's fine. They'll work on something else. That's not the case in the factory.<sup>93</sup>

In terms of vertical integration, one manufacturer was moving towards greater control at both ends of their production line. With their steel frames, for example, they found that for £4,000 worth of steel, they were paying £12,000 for each frame.<sup>94</sup> This realisation led them to move towards doing their own steel rolling and frame assembly onsite. They also found quality, labour, and timing issues impacted their control of onsite installations, and they were assembling a national installation team that would move around the country to lead their site installations, with the intention of ensuring no one crosses the threshold of the building on site if they are not a member of their team.<sup>95</sup>

The customisation level can be quite high, particularly for the machinery to manufacture the modules. One firm was outsourcing more components where it makes sense, such as procuring wiring bundles to minimise electrical work and boilers delivered pre-installed in steel U-frames with copper pipes and meters attached.<sup>96</sup> These items, along with kit electrical panels and segments of connected plumbing, can greatly minimise their need for skilled labour in the production line.

In terms of costs, one firm estimated that 70% of their costs come from materials and just 30% is the cost of labour. They also believe that they are on a reducing curve, even when accounting for inflation: "in real terms the cost is coming down – combination of product innovation, using materials that are you know more efficiently, and with a little bit of innovation."<sup>97</sup> This firm is also ramping up a procurement team that will do more to source materials from the global supply chain, rather than almost exclusively UK-based materials, as their counterparts do.

Two industry consultants suggested that the sector will either continue towards more vertical integration or establish a platform model to achieve this in a contractual form, in effect finding a way to act vertically integrated without actual integration.<sup>98</sup> A platform approach would facilitate transactions across various segments of the industry, effectively serving as a

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<sup>93</sup> Interview 3

<sup>94</sup> Discussion 10

<sup>95</sup> Discussion 10

<sup>96</sup> Discussion 10

<sup>97</sup> Interview 4

<sup>98</sup> Discussion 3

nexus or hub for connecting various suppliers to deliver a project. One organisation – the Off-Site Homes Alliance (OSHA) - is an example of this; backed by twenty-five registered housing providers and local authorities, their approach is to aggregate demand and provide an assembly hub for home components from their approved MMC suppliers. Another firm, Modulous, is a variation of this – they provide software-delivered design services and a “Kit of Parts” which comprises components from an established supply chain that can be brought together to create modular homes onsite.

## The Way Forward

It remains to be seen whether meeting housing demand in the UK is indeed a Sisyphean task. Research thus far has presented significant challenges for the industry, and we believe the recommendations for government – drive demand creation for MMC, deliver an MMC-oriented skills agenda, and ensure efficient and pragmatic government approvals – can help to support greater success in delivering sustainable homes at the pace required.

Industry feedback on this report and its recommendations can further our understanding and advance important work to further transform new homes construction in the UK. Of note, the present research suggests there is promise in other forms of MMC, particularly 2D (Category 2) panelised primary structural systems,<sup>99</sup> and opportunities to leverage platform models to help deliver greater efficiencies and scale. Category 1 is expected to be a vital component of the industry moving forward, and yet this method faces unique challenges that are impossible to ignore and will take time and effort to remedy.

Preliminary research indicates that the nature of Category 2 minimises the challenges faced by Category 1. A factory environment enables both productivity gains and sustainably produced quality components. Storage and transport are easier and more efficient with 2D panels versus 3D volumetric modules, with the former sometimes referred to as “flat pack” while the latter is effectively the delivery of shipping container-sized boxes of air.<sup>100</sup>

Category 2 components are also relatively agnostic in production and application, which presents less risk in terms of selecting suppliers and changing suppliers. Production time appears to be more flexible and the components themselves can be bespoke options manufactured to customers’ unique requirements. Category 2 is also closer to traditional construction methods as the components can be viewed as more consolidated construction materials rather than a substantively different method of construction. One important line of research that this implies is a systematic comparative analysis between Category 1 and Category 2, and their actual (as opposed to theoretical) benefits for improving productivity in new housing production and their potential for achieving net-zero ambitions.

Platform models show potential, too, but have yet to be tested at scale. Organisations like OSHA and Modulous work with various suppliers and methods and are in line with a new

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<sup>99</sup> Category 2 captures a range of pre-assembled panelised components, including basic frames (e.g., stairs, walls, and roof trusses) and enhanced frames (e.g., walls with insulation) to a more comprehensive unit that includes assembled components such as insulated walls with windows and doors, or shingled roof panels (Cast Consultancy, 2019).

<sup>100</sup> Interview 11

initiative from the UK government to assess open-source solutions for new homes construction leveraging MMC (particularly Category 2 and Category 5<sup>101</sup>).<sup>102</sup> While still unproven, the flexibility and lower capital requirements of this approach may ensure these firms are better-equipped to weather any issues that challenged Category 1 firms. This is a second important research question that arises from our pilot research.

Successfully delivering quality, sustainable, and affordable homes at scale is a monumental task for the country. What remains to be seen is whether it is indeed Sisyphean. We believe the government-driven initiatives we propose can deliver rapid and material change in the sector that will enable Category 1 firms to fulfil their much-touted promise. Volumetric housing is needed alongside other forms of MMC and traditional methods – each is vital for the country. The success of all potential house builders is the only way the UK can hope to meet its housing targets in the foreseeable future.

We implore government to heed these recommendations and facilitate improved conditions for industry to do its part. Concurrently, it is vital that research continues to uncover pathways for optimal output and greater productivity in the sector. There are many opportunities to explore and support, including Category 2, platform models, and other methods. Category 1 will also require further insight and ongoing analysis as it continues to evolve and search for more surety and viability – it is imperative that this method finds a business model that works, so that these firms have a better way forward and can realise their potential.

To increase sector productivity and deliver quality-built, sustainable, and affordable homes, it is vital that we reach delivery of these homes at a pace not yet achieved... and yet seemingly achievable.

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<sup>101</sup> Category 5 is defined as “a series of different pre-manufacturing approaches that includes unitised non-structural walling systems, roofing finish cassettes or assemblies (where not part of a wider structural building system), non-load bearing mini-volumetric units (sometimes referred to as ‘pods’) used for the highly serviced and more repeatable areas such as kitchens and bathrooms, utility cupboards, risers, plant rooms as well as pre-formed wiring looms, mechanical engineering composites, would fall into this category” (Cast Consultancy, 2019, p. 13).

<sup>102</sup> Gayne, 2023

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## Appendix

Table 1: List of Interviews

	Firm Type	Role of Interviewee(s)	Date	Duration
1	Government agency	Senior Manager	20-Jan-2023	55 mins
2	Consortium	Director	26-Jan-2023	65 mins
3	Category 1 manufacturer	Executive	10-Feb-2023	60 mins
4	Category 1 manufacturer, Developer	Executive	17-Feb-2023	54 mins
5	Housing association	Director (1), Senior Managers (4)	29-Mar-2023	97 mins
6	Industry trade association	Director, Senior Manager	30-Mar-2023	76 mins
7	Category 1 manufacturer, Developer	Executive	20-Apr-2023	66 mins
8	Government agency	Senior Manager	24-Apr-2023	40 mins
9	Housing system provider	Executive	26-Apr-2023	62 mins
10	Housebuilder	Director	27-Apr-2023	47 mins
11	Housebuilder	Director	27-Apr-2023	47 mins
12	Category 2 manufacturer	Manager	22-May-2023	89 mins
13	Consortium	Director	19-Jul-2023	62 mins



Table 2: List of Discussions and Other Activities

	Firm Type	Role of Participant(s)	Activity	Date
1	Category 1 manufacturer, Developer	Executive	Conversation	13-Dec-2022
2	Government agency	Director	Conversation	16-Dec-2022
3	Industry consultancy	Director (2)	Conversation	16-Dec-2022
4	Industry trade association	Manager	Conversation	20-Dec-2022
5	Industry consultancy	Executive	Conversation	20-Dec-2022
6	Housing association	Managing Director	Conversation	9-Jan-2023
7	Government agency	Senior Manager	Conversation	12-Jan-2023
8	Category 1 manufacturer, Developer	Executive, Senior Manager, Manager	Factory Tour	25-Jan-2023
9	Industry consultancy	Director	Conversation	16-Feb-2023
10	Category 1 manufacturer, Developer	Executive, Director (2)	Factory Tour, Presentation	21-Mar-2023
11	Industry trade association	Director	Conversation	27-Apr-2023