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THE FUTURE OF OFFSITE IN HOUSEBUILDING

C.I.Goodier* and W.Pan[†]

*Loughborough University, Department of Civil and Building Engineering,
Loughborough, Leics, United Kingdom, LE11 2NS

e-mail: c.i.goodier@lboro.ac.uk

Web page: www.lboro.ac.uk/departments/cv

[†] Plymouth University, School of Architecture, Design and Environment, Plymouth, United
Kingdom, Devon, PL4 8AA

e-mail: Wei.Pan@plymouth.ac.uk

Web page: www.plymouth.ac.uk/schools/ade

Abstract. *UK housebuilding has evolved since the Second World War into a diverse and complex industry, continually trying to respond to multiple demands for quantity, quality, environmental sustainability and affordability. In response to this, offsite construction technologies seem to offer advantages of higher quality, faster build times and more cost certainty, as well as potential high-volume production and high environmental credentials. In order to investigate the potential for offsite in housebuilding, it is important that a long-term perspective is taken, informed by futures methodologies and techniques. The reasons for this are debated here, and we conclude that in order for the housebuilding industry to respond to the myriad challenges that lie ahead, it must take a longer-term view, and be more adaptable and responsive to changes, from both within the sector and in society generally.*

Keywords: housing, futures, offsite, MMC

1 INTRODUCTION AND BACKGROUND

Houses are homes for people. More than any other consumer product, housing influences how people feel, how people behave, and how people live as a society¹. The significance of housing supply has been highlighted in the Barker Review², “*Housing has profound and often unappreciated impacts upon our lives. It directly affects our quality of life, our health and well-being. Housing also affects our national economic well-being: the rate of economic growth and our prosperity*”.

It is generally accepted that the housebuilding sector feels that it is being squeezed between the economic downturn and increasing Government demands to build more houses, build them quicker and build them to higher standards, e.g. increased space and better environmental performance. Offsite production and modern methods of construction (MMC) have been promoted as part of the solution to addressing these challenges^{3,4}.

When we buy homes we expect them to last for 50 or 60 years, or even longer, but how do we know how we will be living and working this long into the future? We need to consider whether the conditions and needs we know today will become radically different. Getting to grips with long-term extreme uncertainty and enhanced complexity is not something that traditionally comes easily to engineers or designers^{5, 6}. Future housing requirements are, to a degree, qualitative and are influenced by changing aspirations, values, and tastes. One critical future uncertainty is whether the UK's population - likely in the future to comprise a more diverse mix of cultures and ethnicities - will continue to follow this same trend of attitude to housing, or whether society's attitudes will evolve, leading buyers, occupiers and hence suppliers to think differently. Future patterns of development will be influenced by a variety of demographic, economic, socio-cultural, political, technical and environmental factors.

This paper discusses some of the key issues, factors and trends that are impacting upon the UK housebuilding today and in the next decade. It is based upon a book by the authors recently commissioned by the RICS to look at the Future of Housing⁴. The evolving concepts and definitions surrounding offsite technology is first of all introduced, together with a brief history of the sector. The recent housing under-supply and economic downturns have had a massive influence upon the industry, the impact of which is introduced here. As well as these current challenges to the housebuilding industry, the slow take-up of sustainability and the 2016 zero carbon target are also current preoccupations within the sector, and hence these are also then discussed. From this the opportunities for offsite are debated, together with a discussion on, and a claim for, the need for a more adaptable housebuilding industry in the UK.

2 BACKGROUND

The history of UK housebuilding since the Second World War has demonstrated significant changes to its market, structure and form of building, as well as being the subject of a significant number of government and expert reviews and studies.

There have been three housing **market** booms since the end of the Second World War, which were the mid 1950s to the early 1970s, the early 1980s to the early 1990s and the late 1990s to the late 2000s^{7, 8}. During the last boom, UK house prices had been rising for 10 years, and started to fall from autumn 2007 as a result of the world financial crisis and the resultant recession. Since spring 2009, there have been signs of a partial recovery in the housing market, with growing prices by January 2010 by 10 percent from the spring 2009 trough⁹.

In parallel with the housing market changes, there have been remarkable evolutions to the **structure** of the supply side of the UK housebuilding industry, which were reflected in the transition from the local housebuilders of the 1930s, through the regional diversification of the 1960s, to the national housebuilders of late 2000s⁷. A consequence of that was the increasing contribution to new-build housing by private housebuilders since the 1950s, reaching an overwhelming dominance (over 80%) since the mid-1980s¹⁰.

The changes of the market and structure of the industry have certainly influenced the evolution of the **forms** of housebuilding, which suggests a paradigm of changes from

conventional site-based methods towards a more dynamic combination of methods involving a greater use of offsite production technologies, industrialised techniques and systematic building philosophy¹¹. Marked examples supporting this paradigm include the use of precast concrete panelised systems in the 1950s and 60s¹², timber framed construction in the 1970s, and a range of offsite production technologies including modular building, volumetric preassembly, non-volumetric preassembly and subassembly and components¹¹ following the recommendations by Egan¹³ which were further expanded to include some innovative on-site methods of construction under the banner of modern methods of construction (MMC)¹⁴.

2.1 Concepts and definitions

Offsite construction is the manufacture and pre-assembly of components, elements or modules before installation into their final locations⁵. It includes component and sub-assembly, non-volumetric pre-assembly, volumetric pre-assembly, and modular building¹¹. MMC is the term used by the UK government¹⁴ to describe a number of innovations in housebuilding, initially as a mechanism for funding for social housing, but having evolved as a banner of innovative offsite and on-site techniques for improving quality and efficiency of housing supply. Most offsite methods may be considered to be MMC and the vast majority of MMC techniques are covered by the offsite categories. On-site MMC techniques include examples such as thin-joint blockwork, insulated formwork, brick slips and tunnel form construction. Many other terms exist, including 'offsite', e.g. offsite construction/fabrication/manufacturing, 'pre', e.g. pre-assembly, prefabrication, 'modern', e.g. modern methods of house building and 'building', e.g. system/non-traditional/industrialised building^{15,3}.

2.2 Housing under-supply and mismatch in nature

The number of annual dwelling completions in the UK since the Second World War reached the peak (425,830) in 1968, but had been on a steep downward trend until the early 1980s when entering into a fluctuant plateau around 200,000. In 2001 the construction of new houses (173,770) fell to its lowest level since the Second World War. Over the ten years to 2002, output of new homes was 12.5% lower than for the previous ten years². Despite a gradual increase from 2001 to 2007, the number of housing completions dropped dramatically in the face of the downturn since autumn 2007, with the annual completions in 2009 estimated below 150,000.

At the same time, a significant rise in the number of households in the UK has been reported. DETR¹⁶ indicated a forecast increase by 3.8 million between 1996 and 2021 (based on 1996 statistics), equivalent to around 150,000 each year. Barker² and ODPM¹⁷ suggested that there will be 39,000 more new households formed in the UK each year than previously thought, i.e. up from the estimate of 150,000. The Joseph Rowntree Land Enquiry¹⁸ suggested that around 225,000 new homes will be needed each year in England alone to meet the demand arising from demographic changes and other needs up to 2016. According to the latest CLG Live Table, the number of households in the UK has been projected to gradually increase, from the current 27 million to 33 million by 2031.

2.3 The economic downturns

Over the past forty years there have been four downturns in which real house prices fell nationally, i.e. in the mid-1970s, the early 1980s, the early 1990s and recently from autumn 2007 to spring 2009. The nature and extent of the downturns reflect many factors, such as macroeconomic fluctuations, interest rates, regulatory and tax changes and shifts in credit conditions as identified by Ball¹⁹, which should cover wide-ranging factors in political, economic, socio-cultural, technological, environmental and legislative aspects. ConstructionSkills²⁰ suggested that the private housing sector has suffered most in the latest downturn, taking the level of activity down to below that seen in the depths of the 1990s recession in real terms.

A further but marginal decline is projected for output in 2010 but over the whole of the 2010 to 2014 period UK construction output is expected to average 1.7% growth each year²⁰. However, the balance between public and private work will change. As economic conditions improve, stabilisation and then recovery are expected for the private housing, although the timing of the upturn will vary across markets. In contrast, the public sectors are facing expenditure cuts in constraining growth in public debt (see the Pre-Budget Report²¹). There are signs of rising levels of both mortgage approvals and loans in recent months, while these indicators are not returning to what would be considered 'normal' levels. Lending conditions still remain tight.

3 TAKE-UP OF OFFSITE AND MMC IN HOUSEBUILDING

Despite the use of offsite technologies in UK housebuilding being recorded back to post First World War, the extent of such technologies usage has been seldom recorded. However, at least a quarter of the government-funded new-build homes since 2003 were constructed using at least some offsite techniques reported that nearly half of the surveyed builders, developers and social housing organisations claimed to have used offsite manufacture in the last ten years whilst the usage within most firms was less than one-quarter of their unit completions. The majority of the firms used panellised construction, but less than one-fifth utilised volumetric approaches. A recent survey of the leading UK housebuilders by Pan et al.²² confirmed that the level of overall application of offsite in housebuilding was low. They also found that the extent of offsite utilisation for apartments was slightly higher than for individual houses and that some highly documented offsite techniques, including complete modular building, bathroom/toilet and kitchen pods and flat packs, plant modules, and complete wall panels, actually only applied currently to a very limited extent in housing. Although more than half of the participating housebuilders were planning to increase their use of offsite (by volume) by around one-fifth on average, these firms were still concerned about the risk associated with the use of offsite, particularly more complicated volumetric and complete modular techniques. The findings of these surveys substantiate the perception of an overall growth of offsite usage in housebuilding, but the nature and extent of offsite practice also reflect the real and perceived barriers to a wider take-up of such technologies^{23,5}. This is partly due to the traditionally slow uptake of technological innovation in housebuilding, and arguably concurs with the view of '*construction as a low tech, low innovating sector*'²⁴.

Pan et al.²² examined the strategies of large housebuilding firms with regard to their current and future use of offsite technologies. Their results indicated that more than two thirds of the responding firms considered the incorporation of offsite into their basic house design, whilst the rest left the incorporation of offsite to fairly late stages, such as detailed planning application and pre-construction. Many respondents explained that the early incorporation of offsite into their basic house design mainly applied to volumetric systems, modular building and some more advanced panellised systems. Offsite components, sub-assembly and some open panellised systems were often considered at later stages.

To try and encourage the use of MMC, and to help create more high quality, sustainable, efficient and cost effective housing development, the Design for Manufacture (DfM) Competition was launched in April 2005. The challenge was to build homes with a construction cost of £60k, at 2005 prices, and a minimum space requirement of 76.5 m² gross internal floor area alongside a demanding set of design and quality standards. Six housebuilding consortia turned their designs into real. DfM set out to challenge and disprove the assumption that lower cost means lower quality. The DfM Competition did not specify MMC but challenged housebuilders to utilise whichever construction systems and technologies they believed would help them achieve the aims of the Competition. Interestingly, all housebuilders elected to use MMC systems. After the competition the HCA²⁵ concluded that MMC has the potential to:

- reduce the time for on-site construction, due to more factory based production,
- reduce build costs through reducing time spent on site and by improving efficiency,
- reduce the amount of material used and wasted,
- improve health and safety, and,
- enhance the living experience for residents.

Housebuilders, building new houses for private sale, are more reluctant to adopt MMC (apart perhaps from timber frame, which itself is often debated whether it is actually a MMC). They value cost and time savings too, but alongside other factors. House buyers have traditionally been resistant to MMC, possibly influenced by memories of post-war prefabs, system build houses of the 1960s, and Ronan Point. Housebuilders also need to manage the pace of build-out to maximise profits from a site; sheer speed may be relatively less important.

There is less resistance to the use of MMC for flats. In many cases a developer will pre-sell a proportion of the flats in a development before making a start on works, but the flats may not be occupied, or the remaining flats sold, until the block is substantially complete. Therefore, speed of construction is more critical than in low rise developments, and the cost and speed advantages of MMC weigh relatively more heavily.

4 CURRENT CHALLENGES FACING UK HOUSEBUILDING

4.1 General reluctance to innovation

Generally speaking, construction is not innovative enough¹³. This is the same in the housebuilding sector. The Barker Review² suggested that, in the housebuilding industry, production techniques are inefficient and there is a reluctance to innovate and adopt offsite manufacture and other innovative production techniques/MMC. In turn, this restricts the builders' ability to 'ramp-up' production to cope with market demands. The industry has been characterised as comprising: low levels of responsiveness to demand; a cautious approach to investment in brownfield development; and low levels of innovation². Concerns with housing built by MMC are held by a wide range of industry players²⁶.

The Callcutt Review¹⁰ refers to 'sharply divided' opinions on utilising offsite and MMC, *"its advocates point out that MMC techniques are already in common use for commercial buildings without any obvious loss of performance or amenity to users. Critics point out that, by comparison with traditional methods, it requires considerable up-front investment in manufacturing plant which offsets the savings from faster construction times, and is likely to leave MMC as an uncompetitive option until demand has greatly increased"*. The Review also acknowledged that enough new homes, particularly for RSLs, are being built using MMC to offer solid experience of the advantages and limitations, in construction and in use. There is no significant barrier to adopting MMC if it can be demonstrated as a cost-effective alternative to traditional methods.

The recent CLG Report by Ball⁹ also claimed that innovation in housebuilding is relatively slow and, typically, path-specific. Innovation does occur quite extensively in a wide variety of areas, including process management, marketing, customer interfaces, finance, project and product mixes, site layouts, internal designs and fittings. However, many occur in what can be termed the 'development' rather than the direct 'building' part of the housebuilding process. This has had an effect on progress towards the construction of more energy-efficient housing because this programme pushes the industry towards altering the way in which it has traditionally built homes. The downturn has added to the general reluctance to innovation due to the cuts where R&D budgets are often picked. A lower level of new housing output also reduces opportunities to experiment and to innovate. The lower level of innovation and general reluctance to innovation raises a fundamental issue within the industry with the movement towards zero carbon homes²⁷.

4.2 Slow take-up of sustainability and zero carbon

To become more sustainable as an industry and a country will mean changing and adapting our lifestyles, moving towards less energy intensive domestic practices, and seeking alternative technological solutions.

CLG launched the Code for Sustainable Homes (CfSH) in December 2006, which has since become the most significant policy framework for environmental sustainability in housebuilding. The method is based on BRE's EcoHomes version of the BREEAM methodology adapted to relate closely to Building Regulations and government policy. The

method sets mandatory minimum standards against energy, water, construction and household waste, materials and lifetime homes that relate to key government targets and policies. It has six potential star ratings. Since October 2007, Level 6 has required a net zero carbon solution. However, concerns exist over its practicality as it precludes any use of community or off-site based energy systems. The definition of zero carbon is still in consultation^{28, 29}.

The current take-up of the CfSH is low, with overall 17,401 CfSH certificates issued at design stage and 4,883 issued at post-construction stage, during the period from April 2008 to March 2010. The vast majority of the certificates (90%) were issued for the code level 3. These dwellings designed or built to CfSH only represent a very small proportion of the new build homes in industry.

Policies relating to zero carbon homes are having a significant and growing impact, which will constitute a major change in building regulations, and is leading to significant changes in building technologies and site practices⁹. Concerns still exist however, over what is zero carbon, with Housing minister Grant Shapps rescinding from the government's pre-election promise to get the definition of zero carbon finalised "*within weeks*" of getting into office³⁰.

4.3 Skills shortages

The perception that skills shortages represent a challenge to housing supply has been highlighted in a series of studies. Such skills shortages have exacerbated due to the skills lost to the industry during this recession.

The Housing Green Paper²⁷ states the challenge that "*To deliver the Government's ambitions for housing growth, higher environmental standards and better places to live, we need enough skilled workers. However, recruitment and retention difficulties in key areas, as well as skills gaps, present significant obstacles*".

Barker² reported that over 80 per cent of firms find it difficult to find bricklayers, plasterers and carpenters, and wages for skilled craftsmen are increasing faster than in the economy as a whole. The workforce available to the construction industry is shrinking and the demand for skills required for profitable construction increasing³¹. Construction companies are operating in an increasingly competitive environment for skilled labour. New working relationships, through partnering, and changing technologies require new skill. The housebuilding sector even experiences a more acute skills supply problem than construction in general. It suggests that employment issues, an ageing workforce, new skill sets, the increased use of labour from overseas and the emphasis on MMC continue to challenge the housebuilding industry. The Government's agenda for increasing the supply of housing to meet the projected demand, and for the renovation of the existing stock, means that the need for a larger and more skilled workforce is more important now than ever before.

5 OPPORTUNITIES FOR OFFSITE AND MMC

It has been widely documented that both offsite and MMC technologies offer potential for reductions in cost, time, defects, health and safety risks, labour requirements and environmental impact and a corresponding increase in quality, build times, predictability, whole life performance and profits^{2, 11, 1, 25}.

MMC potentially offers a new business model for an offsite manufacturer wishing to diversify into housebuilding or vice versa, thus taking profits from a fully vertically integrated business model which incorporates every element of the process from site development to manufacturing. However, the Callcutt Review¹⁰ warned of such diversifications by arguing that the 'current trader' business model of housebuilding is very different from manufacturing, with quite distinctive opportunities and risks. MMC may also be adopted by existing housebuilders as an alternative to traditional building techniques. They may buy in the MMC products from suppliers, or set up their own manufacturing divisions and aim for full vertical integration. Nevertheless, the Callcutt Review¹⁰, referring to evidence that at least two major housebuilders have recently closed their in-house divisions, viewed the business models as distinct and not easily merged provided. Integrated supply chains may address the conflict. As the MMC market matures, housebuilders may feel more confident about outsourcing production of MMC components from independent manufacturers.

There has recently been significant growth in MMC housebuilding in some parts of the market. The Housing Corporation has actively promoted its use: 48% of all grant funded work in the 2004-2006 national affordable housing programme involved one of the prescribed MMC techniques. This reflects a difference in business models: RSLs have a constant supply of tenants, and want their new homes ready for occupation as soon as possible.

However, the majority of housebuilding is still based on a traditional, well-proven approach: on-site construction using traditional materials, construction techniques and trades. Offsite construction is gaining ground but it is still only used for a small number of developments, is thought of as innovative, and there is little experience of the systems and how to use them. The 2005 DfM (Design for Manufacture) Competition has begun to address the barriers by engaging and supporting volume housebuilders. Key actions recommended from the DfM Competition²⁵ include:

- education of the public and planners;
- continuing and long term testing, information gathering and dissemination of performance;
- training and development of housebuilders and suppliers; and
- agreement with warranty providers, insurers, mortgage lenders, policy makers and regulators on how to address issues.

There is nothing to stop housebuilders from adopting MMC if they feel it is a cost-effective alternative to traditional methods. Enough new homes, particularly for RSLs, are now being built using MMC to offer solid experience of the advantages and limitations, in construction and in use. It is possible that MMC's competitive position may strengthen with the zero carbon agenda: MMC homes are capable of achieving high standards of energy efficiency, and further experience may show this to be a worthwhile competitive advantage.

Other than in multi-storey developments where innovation is more acceptable (partly due to their more repetitive style or design), prefabrication therefore remains a minor feature, but this is likely to adjust in the years ahead. One factor that will drive the move towards prefabrication will be the need to achieve higher environmental standards, which are likely to be harder to achieve using traditional methods of construction on site. With the move towards

zero carbon, quality of build and tolerances will become more critical; achieving the necessary standards of installation with the existing subcontractor base may well become less cost effective, especially in a more rigorous regulatory environment¹⁰.

6 THE NEED FOR ADAPTABLE HOMES AND AN ADAPTABLE INDUSTRY

It is a popular conception that there is a lack of choice for home buyers on a number of issues (e.g. housing design, finish, quality, functions) and that many current ways of working in the housing and construction sectors are overly traditional and outdated⁶. In terms of the actual buildings themselves, the vast majority of the future housing stock in the next few decades is already in place now. Whilst advances in technology will mean that ‘smart-homes’ are commonplace, the nature of the individual households is forecast to continue changing. Together with the more diverse modes of living, working and leisure, it is evident that our future housing needs to be more flexible and adaptable than it is today^{32, 33}. Construction systems and techniques, as well as policy and regulation will need to acknowledge and enable this increasing flexibility, whilst the suitability (and adaptability) of the existing housing stock will also become an increasing factor. ‘Lifetime homes’, originally promoted by the Joseph Rowntree Foundation as an approach to intergenerational and adaptable design, are also important, although the focus and attention has partly been diverted due to the government emphasis on zero carbon homes⁹. Homes could become more adaptable, expanding and contracting in response to our domestic needs. Walls, rooms and even floors could be added or taken away to accommodate three generations as we live longer and land becomes an even more premium commodity. In addition, the pervasive and ubiquitous nature of technology in our lives and homes over the last two decades has produced a “anywhere, anyhow, anytime” attitude, especially amongst young people and in business. Over the past 20 years we have seen exponential growth in the use of microwaves, home PCs and other electrical appliances in the home, to the extent that almost everyone has them. More recent technologies in the home such as plasma screens, wi-fi, and smart metering are likely follow a similar path over the coming decade or so. Offsite buildings are inherently adaptable and flexible, and can hence have a substantial impact in this area in the future, as well on the refurbishment market.

If the UK housebuilding industry does not keep up with these developments and challenges, it will face increased competition from overseas suppliers already experienced in delivering innovative new housing to high technical standards. In comparison to manufacturing, the housing sector is traditionally not seen to be as severely impacted by the shift to low cost economy because the workforce has to be where the building is erected. Even this is changing however, with now complete building systems such as Verbus being manufactured abroad and brought over to the UK in shipping containers⁴.

7 CONCLUDING THOUGHTS

Notwithstanding the complexity of wide-ranging factors affecting the housebuilding industry, the future of housebuilding is likely to be driven by the combination of government policy on sustainability and fast evolution of innovative technology in a short and medium term. The current policy is markedly focused on the introduction and implementation of the

Code for Sustainable Homes and achieving Zero Carbon Homes in a few years time (whether this is actually 2016 remains to be seen). The innovative technology is multi-faceted, including offsite production. MMC housebuilding is likely to be driven by a more complicated profile of forces including demographic shifts, policy evolutions and climate change. Some issues such as global competition, in particular the consequent foreign entries, and aspects of sustainability other than energy such as water, waste and ecology will possibly become increasingly dominate.

We see a less likelihood of changes in the future to the dominant nature of new home completions by private housebuilders in the UK. The structure of the industry however, may become more diverse, with more specialist firms on sustainability, zero carbon and innovative renewable technologies. It is very likely to see, again in the future, the coupling and decoupling of housebuilding and manufacturing, as has appeared previously in its history. The benefits of the increased industrialisation of housebuilding will become more recognized and accepted by consumers, builders, regulators, lenders and policy-makers. Land use planning, unless with dramatic changes, will again act as a determinant force, driving housebuilding organizations in relation to their house type designs and technology and innovation take-ups.

Technological innovations are under evolving that will help improve the design, construction, and efficiency of new homes. Offsite production and fabrication of components, rooms and buildings is increasingly common and continues to grow. In the longer term, new building materials, including those derived from nanotechnology and biomimetics, promise improvements in strength, durability, weight, energy performance and sustainability unavailable to the designers and engineers of today^{34, 4}. Advances in ICT have already revolutionised the design and communication processes used in the construction of new homes in the past decade, and significant developments will also be seen in the area of smart and intelligent buildings.

The way we purchase homes in the future could also change. Prefabricated offsite houses might never be actually repaired or renovated on site, but instead form part of a disposable sealed unit that is removed and replaced as a stock item, and designed for a pre-determined lifespan. Already, suppliers such as Toyota in Japan allow home-buyers to customise a pre-fabricated house online before they order it. This will have subsequent follow-on implications for many trades and small businesses, which currently rely heavily on ongoing home maintenance requirements for employment. Factory produced homes are also likely to be increasingly imported and exported in accordance with international standards.

Take-up of these innovative technologies will depend significantly on market factors, in particular the scale of the increased costs and the willingness of occupiers and home owners to pay rents and prices to cover them³⁴. New technologies however, will continue to fall in cost and become increasingly accessible and acceptable over the next few decades. There is potential for more the more innovative methods of building, both offsite and MMC, to move from niche, high value applications into more mainstream housebuilding, much as concrete and steel revolutionised construction a century or so ago. In addition, there is a need to ensure that new housing developments are robust against a range of possible changes – in social values, occupiers' demands, security expectations, energy supply and climate change – which in turn are likely to increase the up-front costs of housebuilding.

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