Off-site Manufacturing & Modular Construction

Transforming Construction

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Contents

What is Offsite Manufacturing / Modular Construction?

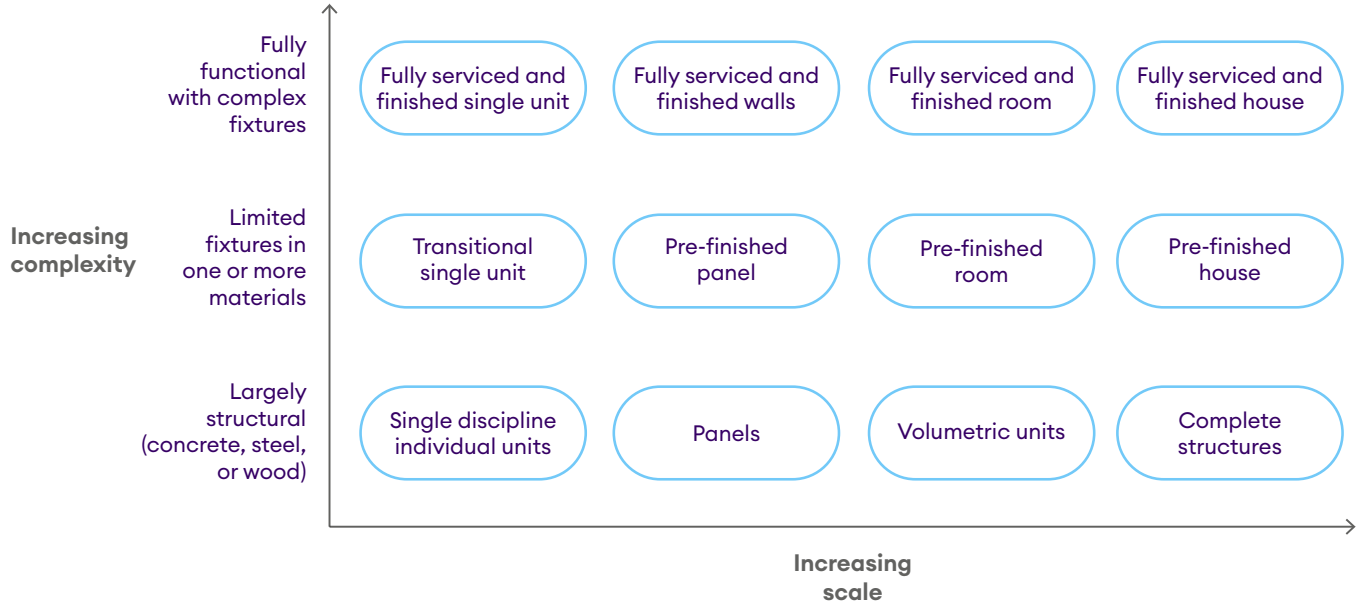
Offsite manufacturing or modular construction is increasingly being seen as an opportunity to drive change across the construction industry. Whether that be general contractors, specialty contractors, infrastructure developers, residential constructors or construction designers/consultancies.

In this paper, Chris Knight, Global Industry Director of Construction & Engineering at IFS, considers what this is, the challenges faced today, and sets out the opportunities for real change and what that could look like for the industry.

To start with let's explain what the terms offsite manufacturing or modular construction mean. In its broadest terms they're the practice of manufacturing components, assemblies or entire modules, typically in a factory environment, away from the traditional construction site, and then shipping them to site for assembly as part of the construction process.

Some governments and research organisations have tried to categorize what the terms cover, for instance, in the USA a view based on complexity and scale by components is used as shown below.

Complexity and scale of modular construction – comparison of approaches



Source: Case studies; interviews; McKinsey Capital Projects & Infrastructure

In the UK, local government setup a working group to define the different types of offsite manufacturing and construction in order for them to be able to measure how much they were being used in practice. The broad definitions are shown here:

#
Category definition

1
Pre-manufacturing (3D primary structural systems)

2
Pre-manufacturing (2D primary structural systems)

3
Pre-manufacturing components (non-system-ized primary structure)

4
Additive manufacturing (structural and non-structural)

5
Pre-manufacturing (non-structural assemblies and sub-assemblies)

6
Traditional building product led site labour reduction / productivity improvements

7
Site process led site labour reduction / productivity / assurance improvements

These studies have been completed in different parts of the world to not only create a definition, but to also to measure its effect on time when used on a project. For instance, one study looked the use of 3D volumetric pre-manufactured modules on a apartment construction project and the result was measured to be between 20%-50% compression in time when compared to traditional construction processes, as shown below.

[1]Over-runs of 25-50% of projected construction duration are common.
[2]Mechanical, electrical, plumbing.
Source: Case studies; interviews; McKinsey Capital Projects & Infrastrucutre

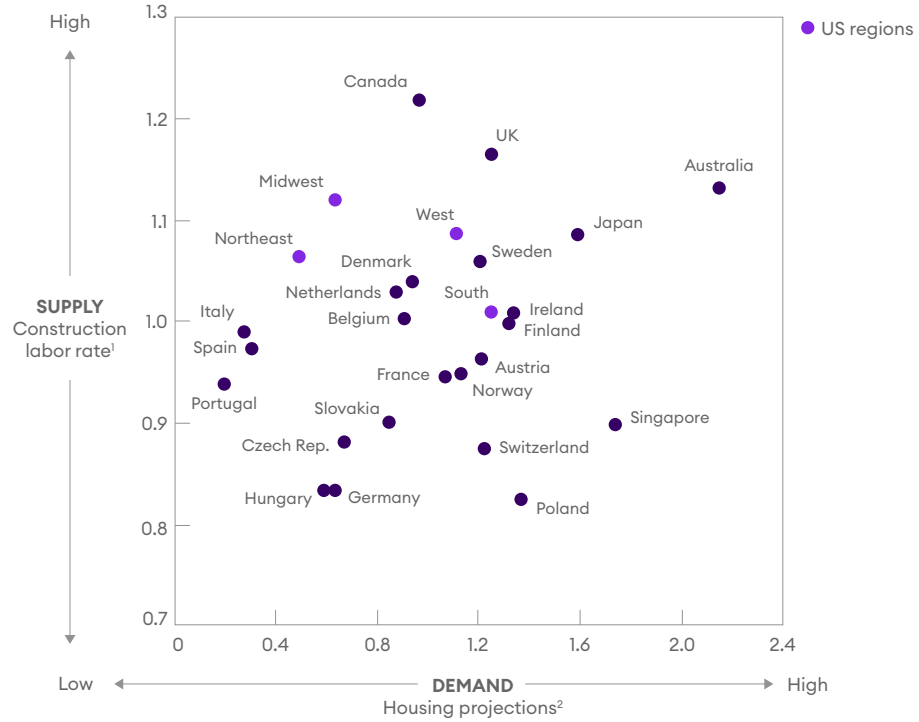
Why do we need it?

Productivity in construction globally has hardly improved in the last twenty years and when combined with other challenges in construction like sustainability targets, build volume targets set by the market and government, supply chain issues, a lack of skilled labor, an ageing workforce and the poor quality of traditional construction, these are powerful reasons for change.

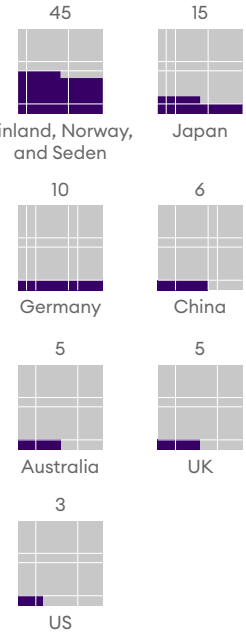
There are several drivers for change to using offsite manufacturing and modular construction which come from different directions but combine around the following key requirements:

- **Established target market** with a value for new real estate construction alone in Europe & the USA has been estimated to be $130billion by 2030. Ref1
- **Costs savings in construction** estimated at 20%. Ref1
- **Build timescales reduced** by up to 50%. Ref2
- Speed for construction
- **Less waste produced on site.** Traditional construction as 30% average wate on site but this is reduced to 5% when using offsite manufacturing and modular construction practices
- **Provide more affordable housing.** A survey carried out by the Lincoln Institute of Land Policy (LILP) in 2019 found that 90 percent of the 200 cities around the globe that were polled were unaffordable to live in, based on average house price in relation to median income. Ref3
- **Average house** price in 200 cities in the USA is over $1million. Ref3
- Hong Kong is the least affordable city to live in for 11 years running. Ref3
- Increase in global house prices. Ref4

Near-term demand for new housing vs construction labor supply



Current offsite share of housing, %



[1]Construction wage divided by national median wage.
[2]2027-20 average housing projection as a % of national housing stock.
Source: 5 in 5 Modular Growth Initiative (Ryan Smith); ABS. Stat; CMCH; curbed.com; Euroconstruct; HIA Australia; ILOSTAT; interviews; Ministry of International Trade and Industry (Japan); Mitsui Fudosan; Natural Resources Canada; OECD; Prefab Housing (Matthew Aitchison); Roland Berger; UK Minisry of Housing; Urban Redevelopment Authority; US Census Bureau; McKinsey Capital Projects & Infrastructure

Who's driving the changes?

History

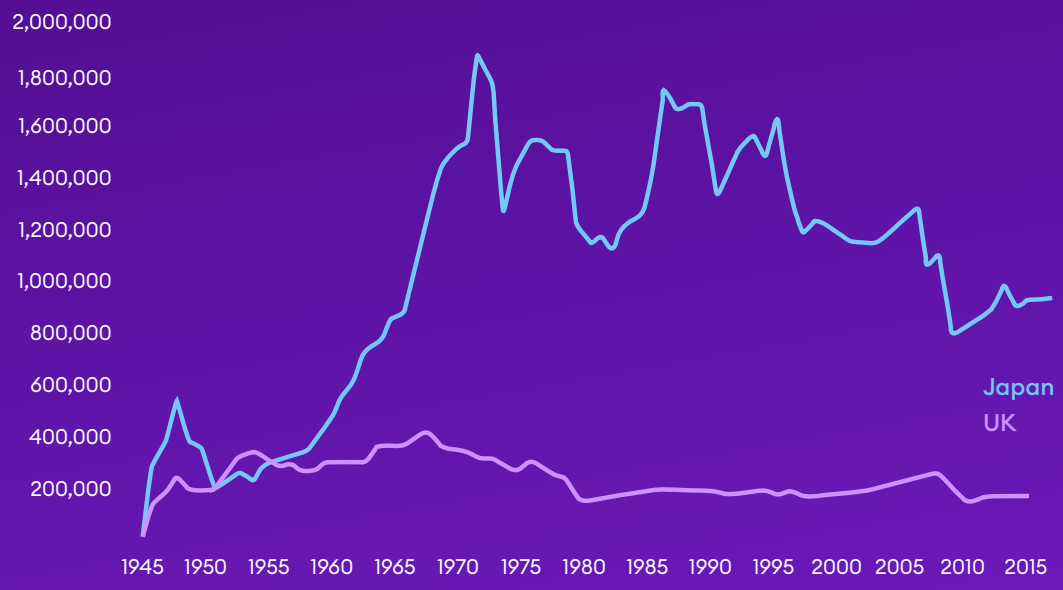
The use of off-site/modular construction is a wide-ranging term and vary in its application greatly its scope. It's worth noting that off-site & modular construction has been in use for over 10,000 years dating back to the Mesolithic period and archaeologists have found examples of the same style timber framing structure still used across the developed world today.

Much like the Romans who used to prefabricate parts of their forts, they also used moulds to create blocks and they obviously did it well as many of their structures can still be seen across large parts of the Europe and beyond.

In the 1840s modular construction was required to support the housing needs of the gold rush workers in the USA. Ref 15. Through the industrial revolution many buildings saw the use of different types of fabrication with steel being a prime example. Across the world there are steel framed structures that manufactured off-site and assembled on-site as required.

Probably the most recognisable use of prefabrication came after the 2nd World War, with a solution devised by the UK government to temporarily house people made homeless during war. Between 1945-1951 over 1.5 million prefabricated homes were delivered. Many of these are testament to build quality that could be achieved as they are still being lived in today. But there is also a cultural stigma attached to 'prefabs' as they were never seen by most people as 'proper' houses, and that still holds true today.

There are parallels to this story in Japan, but a primary difference was that Japan maintained its level of production of modular housing for far longer than the UK. Ref 15



The following graphic shows the housing completion in Japan and the UK from 1945 to 2015, where it is seen that Japan has produces significantly more houses (diagram by the author).

Government Targets

Increasing there is a drive to use established manufacturing techniques to assemble components offsite and the range and types of these assemblies make it hard to categorize and consequently measure the true impact on market even at a regional level alone globally. But given the powerful drivers behind this movement, governments are increasing the pressure for change, for instance in Singapore the government requires developers to use prefinished modules for housing projects. In September 2020 the UK government, under Homes England, announced that housing associations must commit to building 25% of accommodation using off-site manufacturing and modular in order to secure funding. They stated the off-site/modular construction is 'central' to governments affordable homes programme. Ref 5

The UK government has committed £2.3 billion to a Housing Infrastructure Fund back in 2017 and has also defined how modular construction can be categorised. Ref 13

Another example was published in September 2020, when Homes England announced that housing associations must commit to building 25% of accommodation using the process in order to secure funding. They stated that offsite manufacturing and modular is 'central' to governments affordable homes programme. Ref 9

Also, way back in 1974 the National Manufactured Housing Construction and Safety Standards Act of 1974 was introduced by The Office of Manufactured Housing Programs (OMHP) to establish federal standards for the design and construction of manufactured homes to assure quality, durability, safety, and affordability. Ref 12

Staying with the USA, they have created a new regulatory code (CC/MBI 1205 – 202) which sets the standard for off-site construction that is being implemented in a number of states. It's intended to provide minimum requirements to safeguard the public health, safety, general welfare and address societal and industry challenges for the inspection and regulatory compliance of off-site and modular construction. Ref 11

The Canadian Minister of Families and other members of parliament announced another investment into the Rapid Housing Initiative, which is building affordable homes for at risk and vulnerable people in Canada. Ref

There are many other examples of markets and government pushing to use more off-site manufacturing and modular construction.

Age old problems

The two primary drivers most many others in the construction industry globally are **historic low productivity and the demand for housing.**

When thinking about productivity not just in housing but more generally across all types of construction the numbers are eye watering. A recent report examined this and produced the following schematic. Ref 8

There are clear and consistent challenges mentioned across Europe as well, and in a recent report

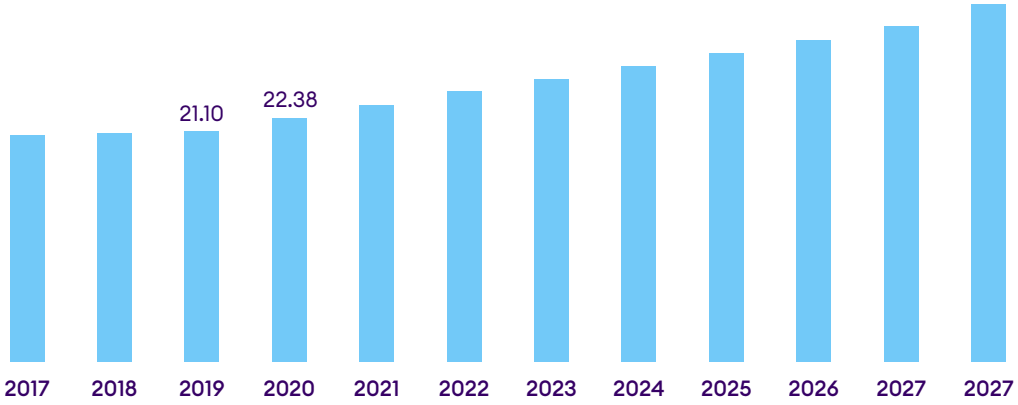
'Housing Europe', which represents 46 regional and national federations across 25 countries. They found that **population growth combined with insufficient supply**, were noted across the union. Ref7

Country	Total present unmet housing need	Of which: total unmet social & affordable housing need	Average annual delivery (2017-2019) *New homes* ***New social housing***	Main issues driving unmet need
England	Around 3.5 million households have some form of unmet housing need	Around 1.6 million	*169,000* ***31,000***	• Insufficient supply • High volume of young people still living with their parents • Strong population growth
Germany	Roughly 1 million homes	At least 225,000 units	*288,000* ***26,280***	• Strong population growth • Insufficient supply • 'Secular shrinkage' of the social housing sector
Ireland	At least 165,000	At least 80,000	*17,800* ***7,500***	• Consistent shortfall in new construction compared to underlying need • High volume of young people still living with their parents • Insufficient supply of new social housing
Luxembourg	Difficult to estimate due to high volume of cross-border workers – 35,000 – unit shortfall in recent years	Difficult to estimate due to high volume of cross-border workers – c.6,000 on official waiting lists	*4,050* ***65***	• Strong population & economic growth • Insufficient new supply
Netherlands	331,000	At least 110,000	*67,000* ***20,135***	• Strong population growth • Insufficient supply
Slovenia	No reliable estimates available	Around 10,000	*3,165* ***75***	• Insufficient supply in urban areas • Internal migration related to economic pull factors (i.e. rural to urban)

Source: Housing Europe estimates, based on information obtained from 'The State of Housing in Europe' questionnaire, November 2020-January 2021.

The emerging markets are also driving change particularly with a focus on increased industrialization and urbanisation in developing economies like India, Vietnam and China where infrastructure projects are driving the modular construction market growth.

Asia Pacific Modular Construction Market Size, 2017-2028 (USD Billion)



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The benefits in of adopting modular construction in Europe and the United States could deliver $22 billion in savings annually. The figure below breaks down the size of construction expenditure across all types of buildings and then shows how much the sub-sectors could be impacted by moving to off-site/modular construction. This demonstrates very clearly the size of the opportunity to the industry. Ref 8

			Construction expenditure[2] $[8] bn, 2017	Additional addressable volume[3]	Market potential $ bn	Saving potential[4]	Savings volume $ bn	Rationale: High / Medium / Low — Repeatability[5]	Unit size[6]	Value density[7]
Buildings[1]	Residential	Single family	376		30		5			
		Multi-family	277		45		6			
	Commercial	Office building	77		10		2			
		Hotels	40		10		2			
		Retail	42		5		1			
		Logistics/ Warehouse	46		10		1			
	Public	Schools	59		15		3			
		Hospitals	41		5		1			
	Other buildings		70		5		1			
Building total			1,027		135		22			

[1]European countries included: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, UK.
[2]Includes only new building projects. Renovation/maintenance projects are less suitable for modular construction, but offer other productivity gain potential.
[3]Informed estimates. A full moon corresponds to a potential construction project value for (additional) modular construction of ~30%, a quarter moon thus to ~7,5% in 2030.
[4]Informed estimates. A full moon corresponds to savings potential of ~20%, a quarter moon thus to ~5%, for each € of addressed construction expenditure.
[5]No unique layout requirements (either from regulation, or design expectations).
[6]Small unit size allows standard transportation.
[7]High complexity of units, high share of wet rooms, etc.
[8]Used 2017 average annual exchange rate to convert to $ from Euroconstruct data in €.

Source: Euroconstruct; McGraw-Hill

Perfect Timing?

When researching this paper, I have found many articles talking about this being the best time ever for offsite manufacturing & modular building to become a recognised challenger to traditional construction practices, and in all types of construction. The themes are also global, not specifically regional, and that is being driven by challenges that we all face.

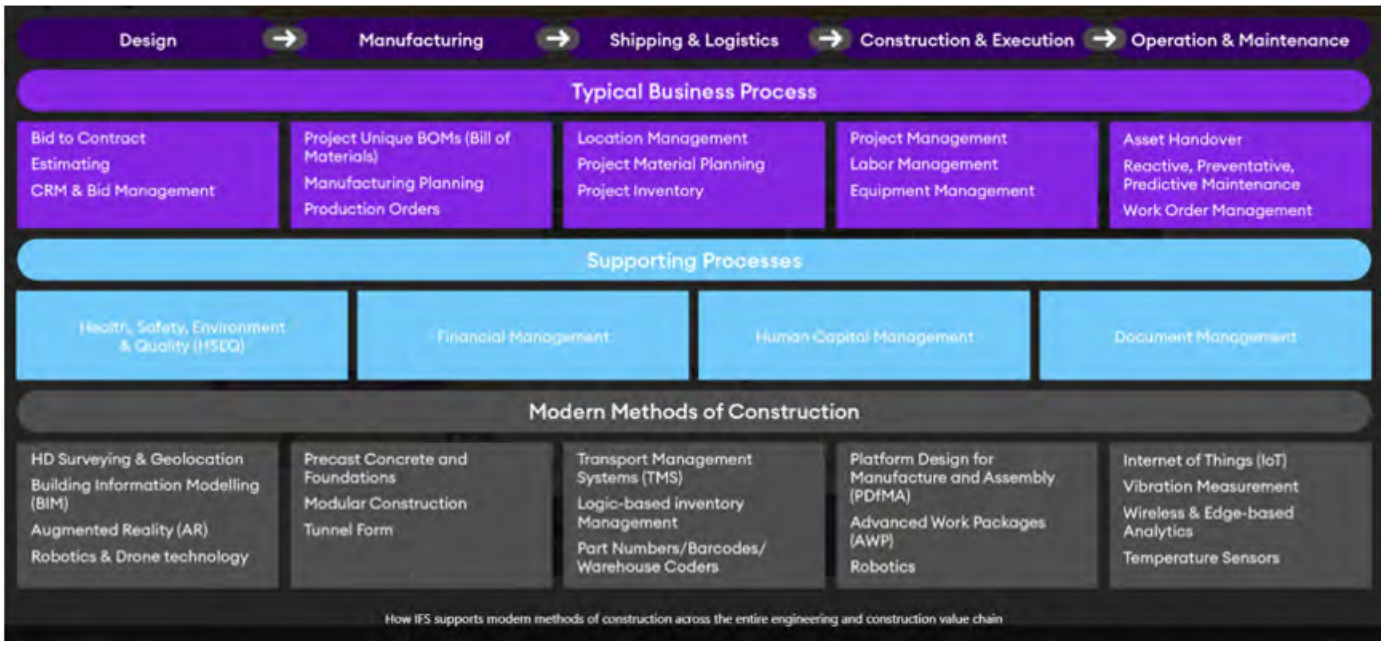
- Shortage of housing
- Age old low productivity
- Reduced build timescales
- Carbon Reduction Targets
- Emerging markets in Asia
- Unprecedented investment and an acceptance that culture must change
- Innovation in technology
- Shift in skills required on-site to off-site
- Manufacturing now viewed as part of the construction process

IFS – Beyond Traditional Construction ERP

IFS Cloud is a project & asset focussed ERP solution therefore designed to support the full project & asset lifecycle. To that end, IFS have customers that operate within different stages of this lifecycle. For example, organisations that design, that construct, that operate and maintain complex assets and facilities, as well as organisations that are responsible for multiple stages of this lifecycle and are able to manage the entire process within IFS. With this in mind IFS Cloud provides solutions for:

- General Contractors
- Speciality & Engineering Contractors
- Residential & Property Developers
- Modular & Prefabricated Manufacturers
- Facilities/Service Management Providers

An advantage of IFS Cloud is that it is deployed within one single product, providing seamless data flow between processes and a consistent user experience throughout the application.



How IFS supports modern methods of construction across the entire engineering and construction value chain

Check out how IFS can support your transition **here**

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