MODERN METHODS
OF CONSTRUCTION

Rialtas na hÉireann
Government of Ireland

Tionscadal Éireann
Project Ireland
2040

This report was produced in support of Project Ireland 2040 and the work of the CSG Innovation and Digital Adoption Sub Group

December 2021

ACKNOWLEDGEMENTS

We would like to acknowledge the work and contributions of the members of the Construction Sector Group (CSG) Innovation & Digital Adoption Subgroup, Martin Searson and his team, the C4.0 Working Group, including Chair Tim Ferris, Secretary Sean Downey, and CIF Executive Aine McGinity, and those who gave their time for the one-one stakeholder interviews.

The CIF would also like to acknowledge the valued contributions and support during the development of this report from Enterprise Ireland, members of the CSG subgroup and representatives of the Department of Housing.

Image courtesy of
Framespace Solutions

CONTENTS

EXECUTIVE SUMMARY

A Modern Methods of Construction (MMC) Working Group was established by CIF in 2016 consisting of member companies from the Housing, Specialist M&E, Civil Engineering, Modular Manufacturers and General Contracting companies. Using the UK's MMOC Definition Framework document as a baseline, this working group interviewed key industry stakeholders and subject matter experts (SME's) involved in modularisation. Following the approach taken in the Phase 1 Report of analysing the present state of MMC adoption and what organisations are applying this within the Irish construction sector, this report looked at what issues are present and what the key market requirements are to drive further adoption and implementation, on a wider scale for both domestic and export markets.

A total of 29Nr. participants took part in over 40 hours of one-to-one MMC/OSM (Offsite Manufacturing) stakeholder interviews, conducted from February 2021 to the end of May 2021. All the responses given were in relation to current MMC and modular construction in Ireland, and from the interviewee's experience and knowledge. The data also captured the one key element that each stakeholder would like to see in a MMC Demonstration Park, further strengthening the need for a single entity to lead the delivery of this project.

The key themes and responses that were determined after analysing the data point to the following key market requirements:

1. A national infrastructure of testing facilities, providing durability, acoustic, thermal, structural, fire and moisture.
2. Building physics technical advisory service - an independent expert unit that can be called upon to answer technical queries or provide guidance for public and private stakeholders.
3. Living laboratory demonstrating multiple typologies - a demonstration of physical building types or specific uses to allow modelling and an examination of operational characteristics in a living environment.
4. Industry focused advanced education and training facilities to deliver human capital - meeting the current and future needs of MMC.
5. Support the 'golden thread' concept by urgently resourcing standards and building regulations agencies - considering the full life cycle of product development and manufacturing through to design, installation, use and reuse with standards, accountability, and traceability at the heart of the process.
6. Maximising waste reduction and drive circularity to support a decarbonisation, climate resilience, social and community wellbeing agenda.
7. Establish and maintain an open-source knowledge bank - a library of digitally held technical content that can be accessed free of charge and is interoperable with digital data platforms.
8. The voice of the customer and consumer must be at the core of the centre including the 10 major spending government departments and private clients.
9. Develop 'Technology Readiness Level 4-7' – to focus on technology that has gone beyond high level concept analysis and is close to being developed and/or commercialised for practical application in industry (see Figure 1).
10. Interact, support, subcontract to and align with the Construction Technology Innovation Centre (CTIC) and Build Digital Project - an MMC Demonstration Park must co-exist with the Build Digital Project under Action 7, and the Construction Technology Innovation Centre (CTIC) being advanced by Enterprise Ireland under Action 4.
11. Develop certification systems for standardised typologies across sectors, i.e. housing, education, medical - actively drive national standards to support standard typologies to enable scalability, repetition and growth in supply chains.
12. Support the requirements of insurance, funding, security, and investment decision makers - address concerns by providing regulatory, audit, inspection, and certification systems to alleviate client and building user concerns.

13. Construction leadership and management must evolve to bring Supply Chain Optimized (SCO) logistics and a lean approach to 'right first time' delivery - provide a platform for an industrial leadership academy.
14. Support design for manufacture, installation and management of follow-on trades and build the necessary skills in sufficient number to meet national construction demands.
15. Public sector to lead by example to facilitate the development of a pipeline.

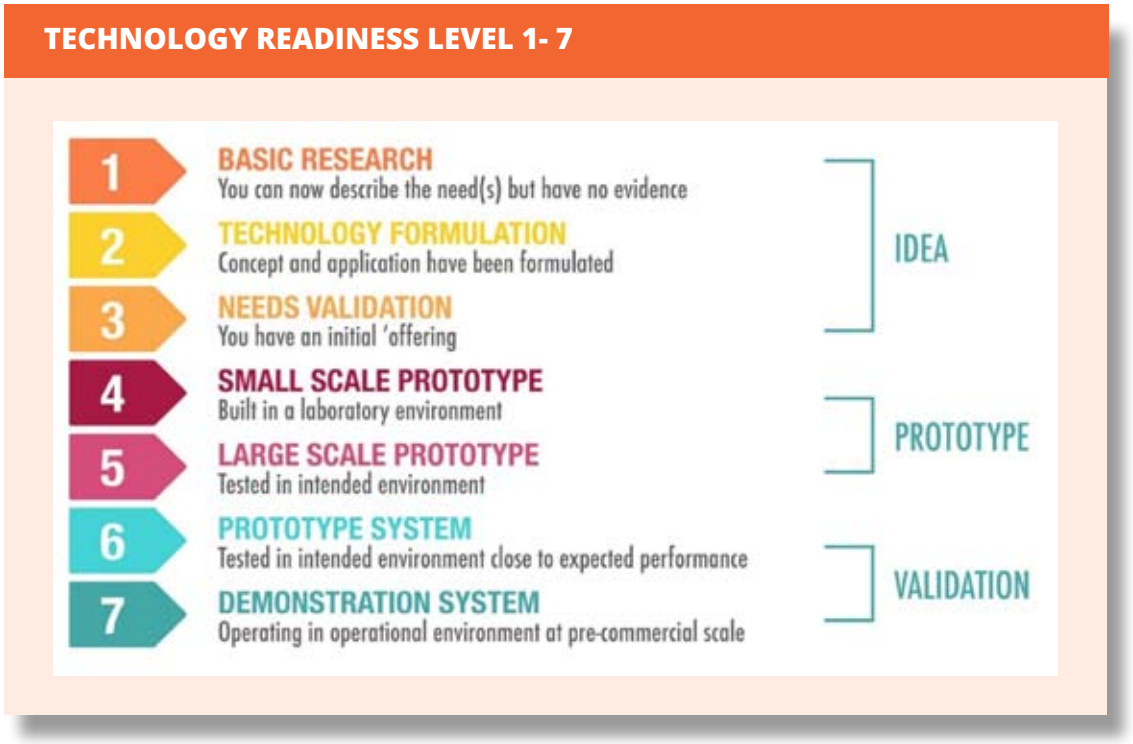


Figure 1: Technology Readiness Level 1- 7 (source: Enterprise Ireland)

Following the introduction to Modern Methods of Construction (MMC), Chapter 3 explored the logistics of how a MMC Demonstration Park and a Construction Technology Innovation Centre (CTIC) could align with the commitments in Project Ireland 2040, most notably the Housing For All strategy, Climate Action Plan 2021, and National Development Plan, with actions centred on analysis, innovation, research, and productivity through a whole-of-government approach in collaboration with industry. Further analysis of the Housing For All mandate and the key definitions of MMC highlighted the synergy that exists and the opportunity to further drive continuous improvement and adoption of Modern Methods of Construction in Ireland.

Chapters 4 to 7 outline the MMC definition framework, the purpose and mandate of the report, followed by the data gathered and an analysis of the interviews carried out with industry stakeholders. The key findings are outlined in Chapter 8 and recommendations and next steps are detailed in Chapter 11.

Section 2

MCC INTRODUCTION AND BACKGROUND

Image courtesy of
Framespace Solutions

The Construction Sector Group (CSG) was established in 2018 to ensure regular and open dialogue between government and industry on how best to achieve and maintain a sustainable and innovative construction sector positioned to successfully deliver on the commitments in Project Ireland 2040. It is made up of representatives of key industry bodies as well as senior representatives of relevant government departments and agencies with responsibilities for policy and for the delivery of infrastructure and is chaired by the Secretary General of the Department of Public Expenditure and Reform (DPER). The group reports to the Minister for Public Expenditure and Reform.

The Innovation & Digital Adoption Subgroup of the CSG was established in September 2020 with the appointment of PJ Rudden as Chair.

In preparation for the development of Ireland's National Development Plan (NDP), the Department of Public Expenditure and Reform (DPER) asked KPMG and Future Analytics to undertake a report on the **Economic analysis of productivity in the Irish construction sector report** – published in May 2020. The CIF set-up a Working Group on Modern Methods of Construction (MMC), as part of the recommended Action No. 6.4 of this report.

The mandate and remit of this MMC Working Group is: ***"To Guide the development of Modern Methods of Construction (MMC), to support the Construction Sector Group (CSG) and Subgroup on Digital Adoption and Innovation."***

This report on Modern Methods of Construction (MMC) was undertaken by CSG Action 3 led by Martin Searson and a team of industry representatives. It stands side by side with the work undertaken by CSG Action 4 which was reported on by Ernst & Young in 2021.

These two reports and the Housing for All policy are the best current thinking inputs being provided to the main funding departments to assist with the establishment of a MMC Demonstration Park and Construction Technology Innovation Centre, and the alignment of these two actions with Action 7 Build Digital.

A flexing structure was developed to drive the seven Actions, develop critical thinking and ensure alignment as each action developed.

The structure has evolved over the last 14 months to meet the business needs of the project. Most notably following the publication of the DHLGH "Housing for All" policy document in September 2021. The current organogram is shown below (Figure 2).

The Key Action items from this DPER commissioned report, around further adoption and implementation of MMC for Ireland were as follows:

- Consideration should also be given to including new skills within traditional apprenticeships to enhance their appeal to a broader range of potential applicants, including skills related to growth areas such as deep retrofit and MMC.
- Industry to liaise with education and training providers on initiatives to ensure the recent uptake of certain apprenticeships is sustained and to strengthen registrations for areas experiencing shortages i.e., wet trades, and for growth areas such as MMC.
- Develop an anonymised Competitions Programme that encourages innovation in design, construction, technology and MMC.

Furthermore, the following Actions mention the requirement for MMC to be integrated into:

- Public contracts to support, value, and reward innovation through use of BIM, ISO 19650, Lean processes and Modern Methods of Construction and circular economy initiatives in public procurement contracts.
- Joint Working Group to be established to guide the development of off-site construction and other Modern Methods of Construction.
- Industry to work with education and training bodies on upskilling the sector on modern construction methods and digital innovations and ensuring that education and training programmes are equipped with the best technology and resources to attract fresh talent to the market.
- Consideration of new skills within traditional apprenticeships e.g., deep retrofit and Modern Methods of Construction (MMC).
- Industry to work with educational partners to promote built environment options within primary and post-primary curricula.

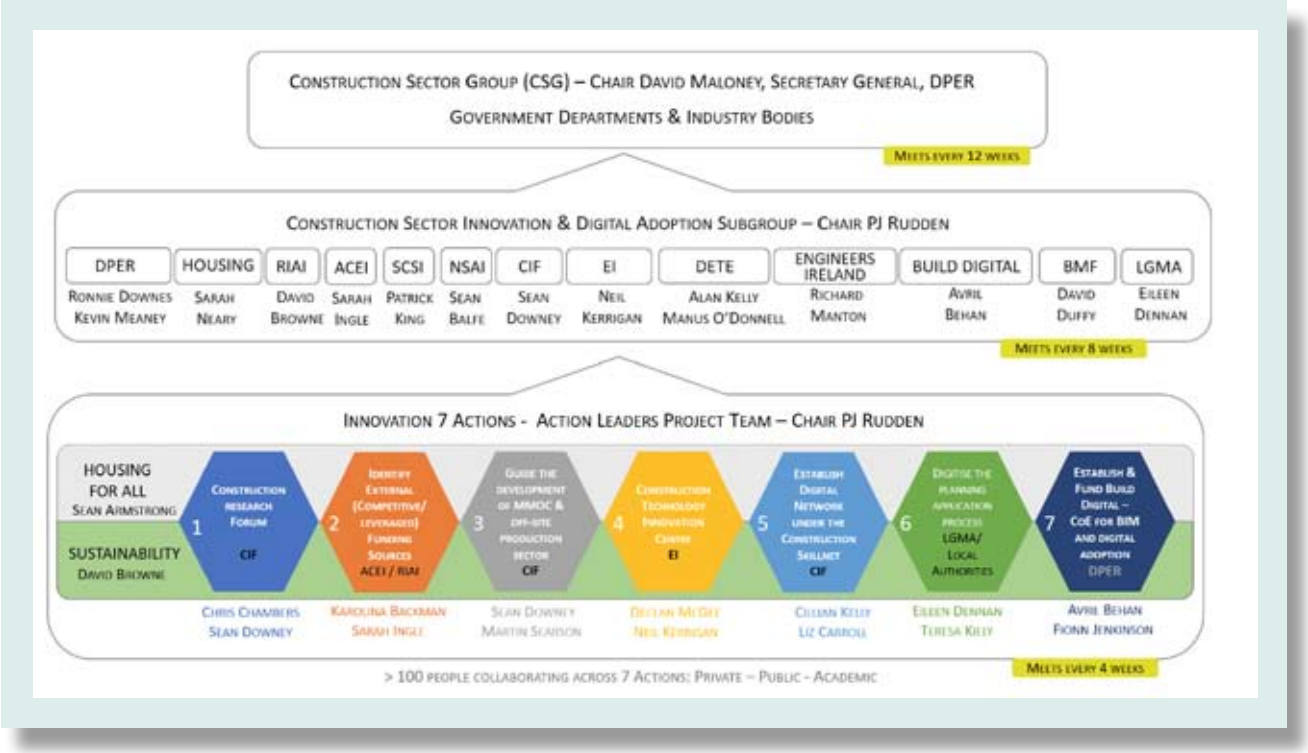


Figure 2: Overview of Construction Sector Group and Construction Sector Innovation & Digital Adoption Subgroup

There are 29Nr. Working Group members, who have a common interest and involvement in MMC/modular construction in Ireland. The current MMC Working Group membership are listed in Appendix 2.

2.1 MODERN METHODS OF CONSTRUCTION

MMC is the future and will increase modular and offsite manufacturing to higher standards of design, fabrication, testing, and certification. The cost benefits of a centralised MMC and Demonstration Park supported by a research and innovation centre (Construction Technology Innovation Centre) to the state will also significantly contribute to the regional dispersal of employment opportunities and the financial viability of a diverse ecosystem of supply and manufacturing enterprises, for Offsite Fabrication (OSM)/modular construction solutions.

Companies no longer need to be located within a certain commuting distance but can support the objectives of the **National Development Plan (NDP) – Project 2040**, the **National Planning Framework (NPF)** and drive employment growth in other urban and rural settings whilst utilising the telecommunications, road, and rail network for connectivity to project delivery locations. MMC will enable early engagement and collaborative approaches with clients and design teams whilst ensuring that the optimum procurement models are applied to realise greatest value and cycle-time costs. Cost benefits of a MMC and Demonstration Park supported by a research and innovation centre (CTIC) will further support modular construction in tandem with BIM, Remote Inspection, Robotics and Data Analytics. MMC will also have a focus on sustainability, climate action and the circular economy to minimise waste.

Modern Methods of Construction (MMC) is used to describe a range of offsite manufacturing and onsite techniques that provide alternatives to traditional house building. Typical MMC systems include timber frame, steel frame, and precast concrete. Timber frame currently makes up approximately 25% of the Irish market

There is a good regional distribution of OSM providers across Ireland, with dedicated offsite fabrication facilities located here in this country (Appendix 6). This helps support the National Development Plan (NDP) around regional employment and towards meeting sustainability requirements, in reduced transportation and accessibility costs on projects dispersed across the country.

The largest concentration of Offsite Manufacturing facilities (≥5Nr.) are located in the following counties: **Cavan, Cork, Dublin, Galway, Kildare, Limerick, Meath, Tipperary.** It is not surprising that the OSM firms are generally located close to the larger cities of Dublin, Cork, Galway and Limerick but also in counties close to the motorway network.

Image courtesy of Framespace Solutions

NO. OF IRISH OSM SUPPLIERS / PROVIDERS *Sept 2021 by County*

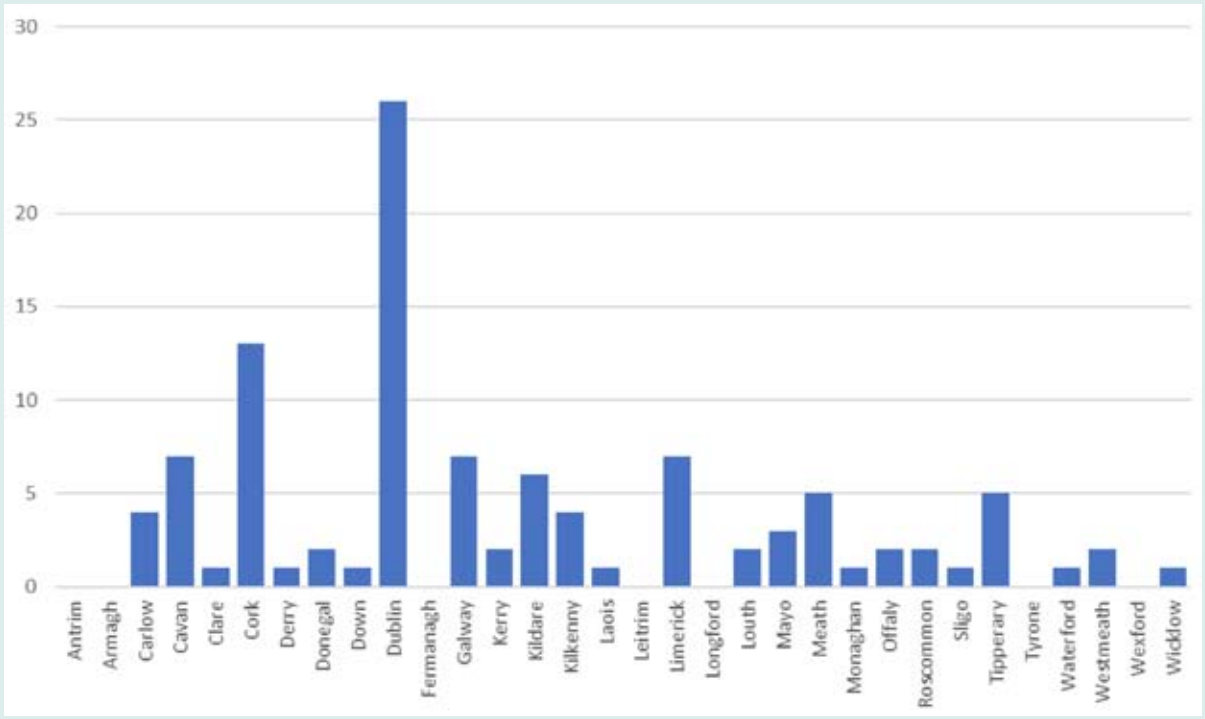


Figure 3: Number of Irish OSM Suppliers/Provider Firms by County – September 2021

A further research exercise may require a National Database be set-up for all OSM facilities and workshops here in Ireland to be established and hosted online for both private and public sector clients to avail of and for greater awareness and evaluation of the OSM eco-system and solutions available, to meet growing demand and sectoral needs i.e., Housing, Student Accommodation, Data Centres, etc.

Government departments rely on the construction industry to deliver their capital projects, based on the Strategic Investment Priorities in the National Development Plan (NDP) and the National Planning Framework.
(See Figure 4 on page 16, overleaf).

Furthermore, PJ Rudden has stated on 7th July 2021, under Modern Methods of Construction in Housing, that:

> ***"The Construction Sector Group Innovation and Digital Adoption project has a critical role to play in modernising our approach to housing in Ireland"***

Figure 4: National Planning Framework, Project Ireland 2040
**The National Development Plan 2031 - 2030 increased the allocated expenditure of the original 2018 NDP from €116 billion to €165 billion*

"This project of Seven Priority Actions is promoting Modern Methods of Construction (MMC) to include digital design, modular and offsite construction, deep retrofit and onsite process improvements like the greater use of cross-laminated timber.

These new methods will form part of the new MMC and Construction Technology Centre which is currently in planning and designs will be finalised in Autumn 2021 with construction proceeding in 2022/2023. The many benefits of MMC include a significant reduction in programme time as construction of modular units can be prefabricated off site and indoors, external factors such as inclement weather avoided with increased productivity, creating greater efficiencies and reduced labour hours.

The project will also embed sustainability which clients/ investors are progressively seeing as a key metric with public awareness and focus on climate action. Sustainability will minimise waste through mass production. Modular construction should result in at least 45% reduction in material use and over 50% in waste generation. Materials used in modular systems generally have a lower carbon footprint and can be more readily reused in comparison to traditional construction as brick and concrete.

Off-site manufacture (OSM) minimises environmental impact and disruption on site and products can be more easily tested to the relevant standards which significantly increases product improvements including sustainability and energy efficiency.

The principal reason why the Irish construction industry has been relatively slow to choose the MMC option is that the sector is set up to operate in traditional site-based processes. The overwhelming ask, from both investors and those in the offsite manufacturing sub-supply chain, is certainty. From the top down, investors and clients need certainty of integrity, performance, and capacity. From the bottom up, the supply chain wants certainty of demand and a delivery model that supports the design, procurement, coordination, and funding for a manufacturing led approach. Furthermore, the vast majority of firms (over 95%) are SMEs. They therefore would require significant support to utilise and implement MMC, given the associated retraining costs and labour shortages currently being experienced. However, with the new Construction Technology Centre, industry will soon have the opportunity to reboot construction to overcome recent delays to construction activity, and with investment, to avail of the time and cost advantages which a significant shift to MMC can offer.

In summary, MMC describes an approach to constructing buildings more quickly, reliably, and sustainably by methods such as off-site manufacturing, modular construction panels or light steel framing, structural insulated panels or cross-laminated timber."

PJ Rudden
Chairperson
CSG Subgroup on Digital Adoption and Innovation

7th July 2021

Section 3

A MODERN INDUSTRY RESPONSE TO FUTURE POLICY AND SOCIETAL NEEDS

Image courtesy of
Framespace Solutions

3.1 HOUSING FOR ALL

Ireland's national 'Housing for All' strategy states that 'everyone in the State should have access to a home to purchase or rent at an affordable price, built to a high standard and in the right place, offering a high quality of life' yet that the current system is not meeting the needs of the people of Ireland.

Reducing residential construction costs is a key theme within Housing for All, with actions centred on analysis, innovation, research, and productivity through a whole-of-government approach in collaboration with industry.

Housing for All identifies that the new Construction Technology Innovation Centre (CTIC) will prioritise residential construction - supporting innovation, modern methods of construction (MMC), digital and manufacturing technology. In this regard, the Government will enhance the intended role of the new Construction Technology Innovation Centre (CTIC), which is under development, beyond the standard remit of Technology Centres in general for its first three years of operation in order to prioritise residential construction, in particular by incorporating:

- structures and funding to enable innovation in residential construction prior to the National Standards Authority of Ireland (NSAI) compliance processes, including demonstration, certification, standardisation and commercialisation as well as research and development;
- a proactive role in strengthening the residential construction value chain;
- promotion, development and support for innovation / modern methods of construction (MMCs) using digital and manufacturing technology;
- support for SMEs to develop scale and to adopt MMCs and Building Information Modelling (BIM) techniques for residential construction; and
- support for digitisation in the manufacturing sector for residential construction e.g. digitally controlled manufacturing equipment.

This will be complemented by an increased focus for the Department of Public Expenditure and Reform-led Construction Sector Group (CSG) on the residential construction sector. This will include the introduction and full implementation of a pipeline of cost reducing innovations and productivity measures, in line with its established remit to improve productivity and efficiency, and to control price inflation.

Enterprise development agencies, including Enterprise Ireland, will support these initiatives, which will be coordinated through the Department of the Taoiseach.

As well as the state taking a leading role in innovation and productivity, DETE, supported by the DHLGH, will promote a culture of innovation in residential construction. This will be achieved by;

- development of Modern Methods of Construction (MMC);
- establishment of a Construction Technology Innovation Centre (CTIC) within the same governance structure as a MMC Demonstration Park;
- publication of exemplar case studies of MMC developments;
- development of design for manufacture guidance for industry so that dwellings are suitable for MMC; and
- creation of a government construction website to promote initiatives in construction.

This work will be underpinned by the development of Key Performance Indicators for MMC and Cost of Construction, which will be reported on quarterly. The public sector will continue to provide exemplar projects to help with the capacity building process through public tenders for innovations such as rapid delivery housing, and design and development of low-carbon buildings, and will support enterprises to reduce cost of materials in construction. Initiatives such as standardised design to better facilitate MMC at scale and lean construction management education will be rolled out.

Figure 5: Offsite fabricated Goldsmith, UK Residential units (fabricated in Ireland) – 11th November 2020 (Source – Cygnum)

3.2 PUBLIC SECTOR LEADING BY EXAMPLE

The public sector will continue to provide exemplar projects to help with the capacity building process through public tenders for innovations such as rapid delivery housing and design and development of low-carbon buildings and will support enterprises to reduce cost of materials in construction. Initiatives such as standardised design to better facilitate MMC at scale and lean construction management education will be rolled out.

To date, local authorities have completed 752 dwellings across 30 projects, with a further 627 dwellings across 15 projects under construction and a further 756 dwellings across 22 projects in the design / planning phase.

The Department of Housing is working closely with all local Government and Heritage authorities in relation to increasing and accelerating the delivery of a range of social housing programmes and supports, including through the use of design-build rapid delivery methodologies (including prefabricated and modular build units). Local authorities have been advised that design-build rapid delivery approaches should be adopted where appropriate to deliver social housing projects on local authority-owned land.

To support delivery, the Office of Government Procurement (OGP) put in place a framework of design-build contractors in 2017. This framework, which expired in February 2021, was available for all local authorities and Approved Housing Bodies (AHBs) to use in the interest of accelerated delivery. While some local authorities have progressed projects using the framework, the scope of works was generally limited to certain development sizes and unit types. On this basis, other local authorities have implemented their own frameworks, while some have tendered on individual projects for design-build contractors, on a case-by-case basis.

The Housing Delivery and Co-ordination Office and DHLGH are currently working with the local government sector on replacement frameworks which will operate on a regional basis and cater to a variety of development sizes and unit types, including apartments. In addition, Dublin City Council has developed a framework of design-build contractors for the delivery of a volumetric programme of houses and apartments which is available to all local authorities and AHBs to use on larger projects. It is envisaged that over 1,000 fast-track homes will be built using the Dublin City framework, and while the majority of these will be in Dublin, there will also likely be schemes in other large centres.

Many of the issues around delivery that non-prefabricated social housing construction projects face, are also faced by design-build projects, such as preparing sites, services/access to the site, community consultation, planning, etc. There can, however, be savings in terms of programme and construction time, with these advantages growing as more use is made of these frameworks and as contractors gain more experience in implementing these methods. Under this mechanism, acceleration is delivered both by the use of the design-build services of specialist contractors, and reduced construction time periods due to considerable off-site fabrication. As well as off-site construction providing many benefits in terms of delivery and affordability, the new frameworks will provide sustainable and durable quality housing. All new dwellings (including prefabricated and modular build units) must comply with the building regulations and building control requirements and for social housing achieve a 60-year durability for all key elements.

DHLGH will continue to work with local authorities to maximise delivery and harness appropriate opportunities to deliver on additional build units, including through design-build schemes.

Figure 6: Cork Street, Dublin (Source: Dublin City Council)

3.3 COMPLIANCE AND CERTIFICATION OF INNOVATIVE CONSTRUCTION PRODUCTS AND SYSTEMS

The design and construction of buildings is regulated under the Building Control Acts 1990 to 2020. The Act provides for the making of Building Regulations and Building Control Regulations.

The Building Regulations set out the minimum legal performance requirements for the construction of new buildings and certain works to existing buildings. They do not prescribe materials or methods of construction to be used. The purpose of the Building Regulations is primarily to protect the health, safety and welfare of people in and around buildings.

Technical Guidance Documents (TGDs) are published for Parts A - M of the Second Schedule to the Building Regulations. Where works are carried out in accordance with the relevant TGD, such works are considered to be prima facie, in compliance with that Part of the Regulations. However, the adoption of an approach other than that outlined in the guidance is not precluded provided that the relevant requirements of the Regulations are complied with.

Part D of the Building Regulations sets out the legal requirements for materials and workmanship. It requires that all works must be carried out

- using "proper materials" which are fit for the use for which they are intended and for the conditions in which they are to be used, and
- in a workmanlike manner

to ensure compliance with the Building Regulations.

The process of Agrément certification applies to those products and processes which do not fall within the scope of existing construction standards, either because they are innovative or because they deviate from established norms. NSAI Agrément assesses, specifies testing, and where appropriate, issues Agrément certificates confirming that new building products, materials, techniques and equipment are safe and fit for purpose in accordance with the Irish Building Regulations and with the terms of the certificate. Such certificates may be in addition to, but not conflict with CE marking.

All new dwellings (including prefabricated and modular build units) must comply with the building regulations and building control requirements and for social housing achieve a 60-year durability for all key elements.

3.4 CLIMATE ACTION PLAN AND CIRCULAR ECONOMY

The transition to climate-neutrality will require changes across our society and economy, including in the built environment, energy, transport, waste, and agriculture. This will require a collaborative effort by government, business, communities, and individuals to implement new and ambitious policies, technological innovations, systems, and infrastructures. Within the construction sector, greater resource efficiency and re-use could avoid the need for millions of tonnes of virgin raw materials per annum, as well as reducing the carbon intensity of our built environment. Reducing the volume, and associated costs, of construction and demolition waste could also contribute to greater affordability, particularly in relation to the high-density residential sector.

Potential areas where construction initiatives could focus to support the circular economy include:

Sector	Potential Actions
Construction	Increased use of offsite design and manufacture
	Modular building design
	Refurbishment and retrofitting of existing stock
	Tackling dereliction and bringing stock back into occupancy
	Increase use of Construction & Demolition Waste as a secondary construction material

The development of a Construction Technology Innovation Centre (CTIC) and a Modern Methods of Construction (MMC) Demonstration Park, which includes a mandate to promote circular construction in its term of reference would be a significant support to the overall aims of the Circular Economy Strategy. All the potential actions listed above would benefit from the availability of demonstration-level projects, which could allow for the development, testing and certification of new techniques and materials. The dissemination of knowledge and skills regarding circular construction across the sector would also be enhanced.

3.5 CONCEPT FOR HOUSING FOR ALL DEMONSTRATION PARK AND CENTRE OF EXCELLENCE

3.5.1 HOUSING FOR ALL DEMONSTRATION PARK- SCOPE

The objective of the Housing for All Demonstration Park is to showcase exemplar activities that would assist the construction of future housing and to help build public awareness and awareness across the full residential construction and development sector of what the next generation of future affordable and sustainable housing construction would resemble. The purpose of the Demonstration Park is to demonstrate new and innovative approaches to delivering a more economically and environmentally sustainable built environment through physical buildings, development and commercialisation, on a single campus. The activities and areas which the Demonstration Park will develop are listed below in section 3.5.6.

The Construction Scotland Innovation Centre follows a similar model to that being proposed for the Construction Technology Innovation Centre in Ireland. It is proposed that the MMC centre and Demonstration Park should share a campus with the possibility to deliver training and other services such as testing at the same site. The Construction Technology Innovation Centre should reside within the same governance structure as the MMC and Demonstration Park. Further synergies could be achieved if the CTIC were to share the same campus as the MMC and DP however this would be subject to site selection and governance structures. Synergies and exchange of ideas and approaches should be actively supported and should be measured and reported on through outcome focused indicators related to the adoption in the domestic residential construction market of new technologies.

Case study:
Construction Scotland Innovation Centre

The Scottish Funding Council launched the Innovation Centre programme in 2012 to support transformational collaboration between universities and businesses and working in partnership with Scottish Enterprise and Highlands and Islands Enterprise. The Centres aim to enhance innovation and entrepreneurship across Scotland's key economic sectors, create jobs and grow the economy.

Innovation Centres have backing from industry and will draw on all of Scotland's research expertise in the relevant sector to work on problems and opportunities identified by industry. They will add value through secondments, industrial studentships, spaces for collaborative work and shared access to equipment.

Innovation Centres also support skills and training to develop the next generation of researchers and knowledge exchange practitioners through masters and post-doctoral level provision.

The Building Research Establishment in the UK operate similar innovation parks as those in Scotland - here: ***https://www.cs-ic.org/*** and in England here: ***https://www.bregroup.com/ipark/***

3.5.2 DEVELOPMENT OF LOW EMBODIED CARBON CONSTRUCTION MATERIALS

Climate Action Plan 2021 states that the approach to develop low embodied carbon construction materials will include distinct steps for demonstration, certification, standardisation, and commercialisation of construction products. This will include the research and development of alternatives to traditional building materials and the increased use of low carbon materials in construction. It will also allow for the decarbonisation and re-certification of existing construction products, when lower-carbon manufacturing processes are implemented. In line with its leadership role for the public sector, the OPW (Office of Public Works) is currently developing a roadmap to promote the use of low carbon building alternatives in construction, and we will identify opportunities to locate and build an exemplar public building using best available sustainable materials and, in particular, buildings using wood. These Actions set out in Section 13.3.7 of Climate Action Plan 2021 can be supported through the MMC Demonstration Park.

3.5.3 LOCATION/FACILITIES

Co-location with existing training and development facilities is the most desired approach.

Facilities should provide for training, demonstration, and test facilities with the potential for future expansion.

Any facility should include a state-of-the-art Modern Method of Construction training centre constructed from low embodied carbon materials as the development of this building will act as a flagship for the Demonstration Park.

It is proposed that the facility is supported by existing public bodies or consortiums of public and private bodies. In order to maximise synergies it is proposed that the Demonstration Park (DP) is co-located with the MMC centre.

3.5.4 RESOURCES

The management of the MMC/DP will require a CEO and an Industry Development/Built Environment Development Training, Research & Dissemination team. The MMC/DP will be established to prioritise the deliverables for the Construction Sector Group and Housing for All. It is envisaged that the Construction Technology Innovation Centre (CTIC) would bid for research projects from calls by SEAI RDD Fund, EPA Fund, and research projects required by Industry.

3.5.5 IMPLEMENTATION

The governance structure for the demonstration park and training facilities could also be integrated into that for the MMC centre, and enable delivery of actions from Housing for All, Climate Action Plan 2021, National Development Plan and Project Ireland 2040 priorities. The primary focus of the Demonstration Park will be on the delivery of residential construction in an economic, environmental, and socially sustainable way. Given the breadth of the residential construction sector this will require a collaborative approach between Government Departments, state bodies, third level education bodies, industry and professional bodies.

It is proposed that the Demonstration Park will provide serviced sites for manufacturers to construct innovative dwellings which then can be used for showcasing to industry specifiers and for training and development.

3.5.6 SCOPE OF WORK FOR THE MMC AND DEMONSTRATION PARK CENTRE OF EXCELLENCE

HFA commitments for the MMC and Demonstration Park Centre of Excellence

- a proactive role in strengthening the residential construction value chain
- promotion, development and support for innovation / modern methods of construction (MMCs) using digital and manufacturing technology;
- support for SMEs to develop scale and to adopt MMCs and Building Information Modelling (BIM) techniques for residential construction; and
- support for digitisation in the manufacturing sector for residential construction e.g. digitally controlled manufacturing equipment.
- Development of Modern Methods of Construction (MMC);
- Establishment of a 'Centre of Excellence' Demonstration Park for MMC;
- Publication of exemplar case studies of MMC developments;
- Development of design for manufacture guidance for industry so that dwellings are suitable for MMC; and
- Creation of a Government construction website to promote initiatives in construction
- Enhance holistic construction product assessment processes for the residential sector to facilitate certification of modern methods of construction and the introduction of sustainable construction products and oversight of onsite installation, including through expanding the successful National Standards Authority of Ireland (NSAI) Agrément approach
- development of Key Performance Indicators for MMC and Cost of Construction
- standardised design to better facilitate MMC at scale
- lean construction management education
- an analysis and value engineering exercise for each component of cost of construction (including cost of compliance) of house and apartment development, with a view to reducing cost (including cost of compliance) and increasing standardisation

Image courtesy of Framespace Solutions

Detailed Requirements for the MMC and Demonstration Park

- **Modern Methods of Construction**
  - Modern Methods of Construction (MMC) demonstration
  - MMC –Design and Procurement
  - MMC – Certification, Standardisation, Commercialisation
  - MMC-Creating a pipeline
  - MMC Key Performance Indicators
  - MMC –Robotics and Automation
  - Modern methods of construction-Retrofit
  - Design for Manufacture
  - Design for procurement
  - Building Regulations Compliance
  - Innovation dissemination, networking and awareness
  - Training, Education and Skills

- **Design and procurement of housing and apartments**
  - Design, Procurement,
  - Apartment Design and Specification
  - Apartment procurement
  - Automation of Building Regulations Compliance
  - Innovation dissemination, networking and awareness
  - Cost effective design and building regulations compliance
  - Social Housing Design and Specification
  - Social housing procurement
  - Training, Education and Skills
  - Rented property standards
  - Value engineering of design specifications

- **Climate Action and Resilience**
  - Ageing, health and wellbeing (designing for an aging population)
  - Low carbon buildings and materials
  - Planning & Designing for Compact Urban Growth
  - Designing for district heating
  - Integrating Transport (EVs) and Built Environment and Energy Systems
  - Renewable energy design for housing and Apartments
  - Use of ICT to integrate with user of housing (Smart meters, Heating Systems, EV, integration with ICT systems)
  - Adaptation

- **Digitisation**
  - BIM
  - Onsite –Robotics and automation, surveying,
  - Lean/Agile/Total Quality Management

- **Heritage**
  - Bringing Back Homes/reuse of existing buildings
  - Change of use of existing buildings
  - Designing for compliance

WHAT IS THE MMC DEFINITION FRAMEWORK?

4.1 MMC DEFINITION FRAMEWORK

The MMC definition framework is a new seven category definition framework that enables a full and future-proofed range of "Modern Methods of Construction" used in homebuilding, to be better understood with regularised terminology.

The definition framework spans all types of pre-manufacturing, site-based materials, and process innovation.

This definition framework is an output of the CIF's Modern Methods of Construction Working Group based on the UK's MMOC Definition Framework document below (see also link https://www.gov.uk/government/publications/modern-methods-of-construction-working-group-developing-a-definition-framework)

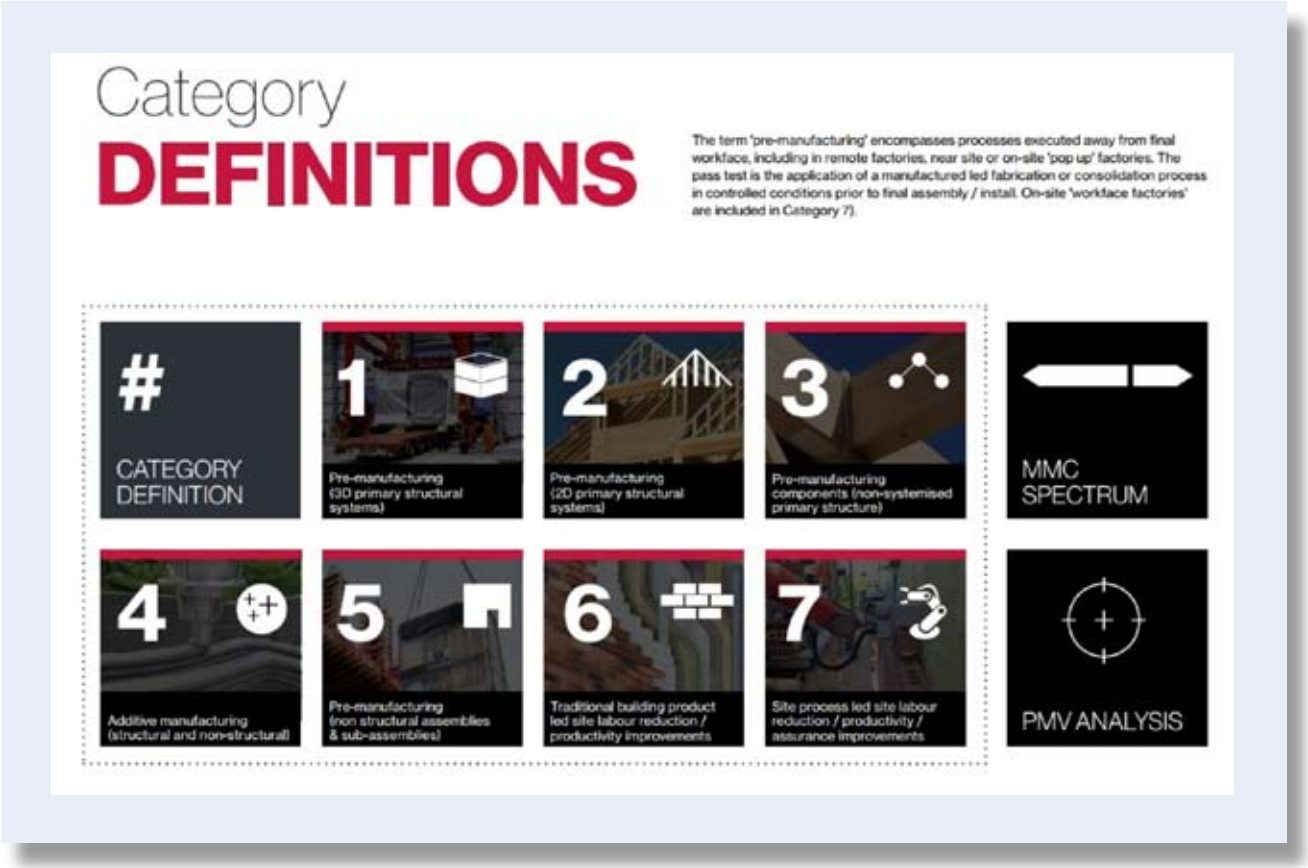


Figure 7: UK MOMC (Modern Methods of Construction) Category Definition

Modern Methods of Construction encapsulates:

- Modern Materials
- Modular Construction
- Modular Assemblies and Sub-assemblies
- Design for Manufacturing Assembly (DfMA)
- Offsite Manufacturing (OSM)
- Offsite Fabrication

Delivering Pre-Manufactured Value (PMV) to clients, stakeholders, end users and the architectural, engineering and construction supply-chain.

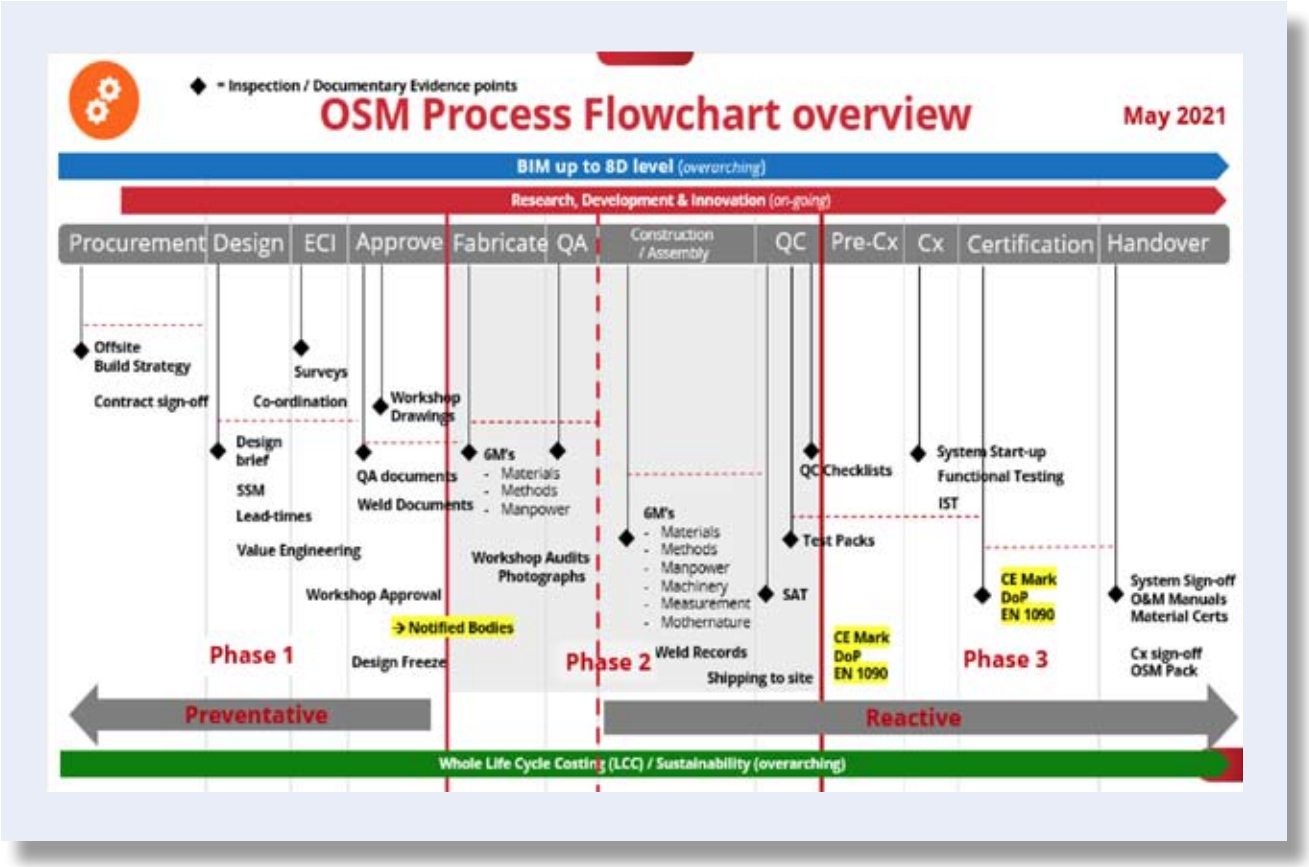


Figure 8: Offsite Manufacturing (OSM) Process flow diagram© Courtesy of Kyron Innovative Technologies Limited – May 2021 (Copyrighted – though reproduced with kind permission)

4.2 EARLY STAGE CONCEPT PROPOSAL

The following early-stage concept proposal shows the components of an MMC Centre incorporating a Demonstration Park facility.

Key Components include:

A.	Head Quarters, Reception, 100 pax lecture theatre	15,000sq.ft €8m	
B.	New Product Development	30,000sq.ft €4.5m	€25.75m total
C.	Digital Living Laboratory	10,000sq.ft €3.25m	
D.	Collaboration space/Education & Training	30,000sq.ft €10m	
E.	Inner apron (Heavy Plant/Equipment)		
F.	Outer apron (Construction Demonstration)		

The figure below represents a combined ecosystem that may be co-located on a single site of public land. Initial scale may be five acres with the ability to scale up to approximately 50 by 2040. The spatial requirements and the land available through public stakeholders/sponsors may determine preferred geographical location and the format i.e., single site versus multiple cooperative facilities.

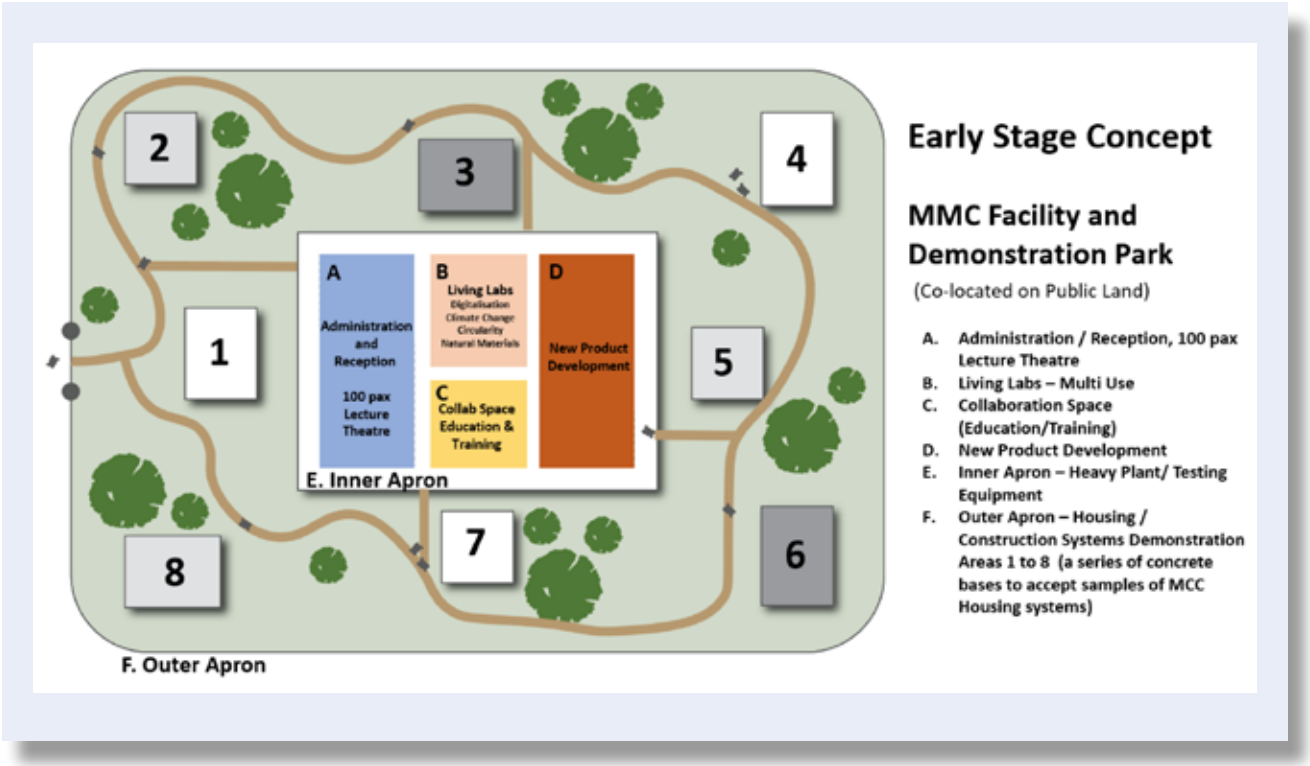


Figure 9: Early Stage Concept of MMC and Demonstration Park

PURPOSE AND MANDATE

Initially, a 'Present State' analysis was completed for Modern Methods of Construction (MMC) and a Phase 1 report issued back in December 2020. This is the Phase 2 report generated from a series of MMC stakeholder 'one-to-one' interview findings completed from February 2021 to June 2021 and the interview metrics summarised in detail below, form these anonymous interviews.

The purpose of this report is to assess the quantitative data gathered and analysed in Q4 2020 and to validate this information on MMC with Offsite Manufacturing (OSM) stakeholders, both public and private sector representatives, and from across the supply-chain spectrum. A total of twenty-nine stakeholder interviews were conducted over a five-month period, to gather empirical and qualitative data on OSM. The key findings are outlined in Chapter 8 and recommendations and next steps are detailed in Chapter 11.

The MMC Working Group mandate from the CIF Executive Body is to:

1. To consider all policy developments / matters in the area of MMC, including modular, offsite fabrication, system building and pre-fabrication.

2. To advise the Construction 4.0 sub-committee on MMC policy in this area.

3. To oversee and guide the MMC/modular construction relations with relevant national and local bodies including government departments and state agencies on MMC policy matters.

4. To develop the OSM/modular construction strategy with regard to its evolving relationship with client organisations in both public and private sectors covering MMC.

5. To establish an industry led Working Group that engages with other relevant stakeholders.

6. To examine best practice domestically, at EU level, and internationally to ascertain the best approach in developing MMC/modular construction policy for Ireland.

PRE-INTERVIEW DOCUMENTS

The following seven pre-interview structured questions were issued to the participant stakeholders in advance to help frame their responses. This was followed by a more informal interview, with the aim of validating the original quantitative analysis and to better understand the current and potential OSM sectorial market and challenges / opportunities.

The questions looked to further understand:

- Three key asks to transform the OSM sector
- One element that a Construction Technology Innovation Centre (CTIC) to support MMC must contain

The key questions that were asked of the MMC / OSM Subject Matter Experts (SME's), who have previously and currently procure, fabricate, and implement Modularisation / OSM solutions for the Irish Engineering & Construction sector, (and based on their project experiences), were as follows:

1. When did you first employ Modular Construction on an Irish construction project and for how many years have you employed this Build Strategy?

2. What worked for you on previous projects where Modular Construction/ Offsite Manufacturing techniques were employed?

3. What didn't work and how do you mitigate this in the future?

4. If you had the chance to re-start that previous project(s), what would you do differently?

5. What, in your opinion, are the current restraints / issues that are preventing further adoption of MMC on Irish construction projects?

6. What suggested recommendations or solutions would you employ for further increased implementation of Modular Construction, Sustainable Materials and/or Offsite Manufacturing (OSM) for clients.

7. Is a new procurement route / contract required to increase greater facilitation of Modular Construction, Sustainable Materials and/or Offsite Manufacturing (OSM) for clients?

Each 'one-to-one' stakeholder interview was scheduled for 30-45minutes, though due to the richness of the information provided was consistently covered over 50-60 minutes for each participant. The following people attended each Interview:

- MMC / OSM Stakeholder participant(s)
- CIF Director of Specialist Contracting/Secretary C4.0 Working Group
- CSG Activity Leader 3 – MMC

A total of 29Nr. participants took part in over 40 hours of one-to-one MMC / OSM stakeholder interviews, conducted from February 2021 to June 2021. All the responses given and summarised below, were in relation to current MMC (Modern Methods of Construction) and modular construction.

The rich data gathered from these one-to-one interviews is outlined in Appendix 3, which have been anonymised as previously agreed with the participants, due to the information being provided and the strategic and commercial sensitivity of the data discussed.

DATA GATHERED AND ANALYSIS

The following data was gathered, based on the seven interview questions asked and of the key needs for a MMC Demonstration Park and a Construction Technology Innovation Centre:

Total	74	%
Completed	29	39.19%
No response	45	60.81%

Type	Breakdown	%
Client	6	21%
OSM Supplier	9	31%
Consultant	7	24%
Main Contractor	2	7%
M&E Specialist	3	10%
Certification	2	7%
Total	29	100%

BREAKDOWN OF STAKEHOLDER TYPE

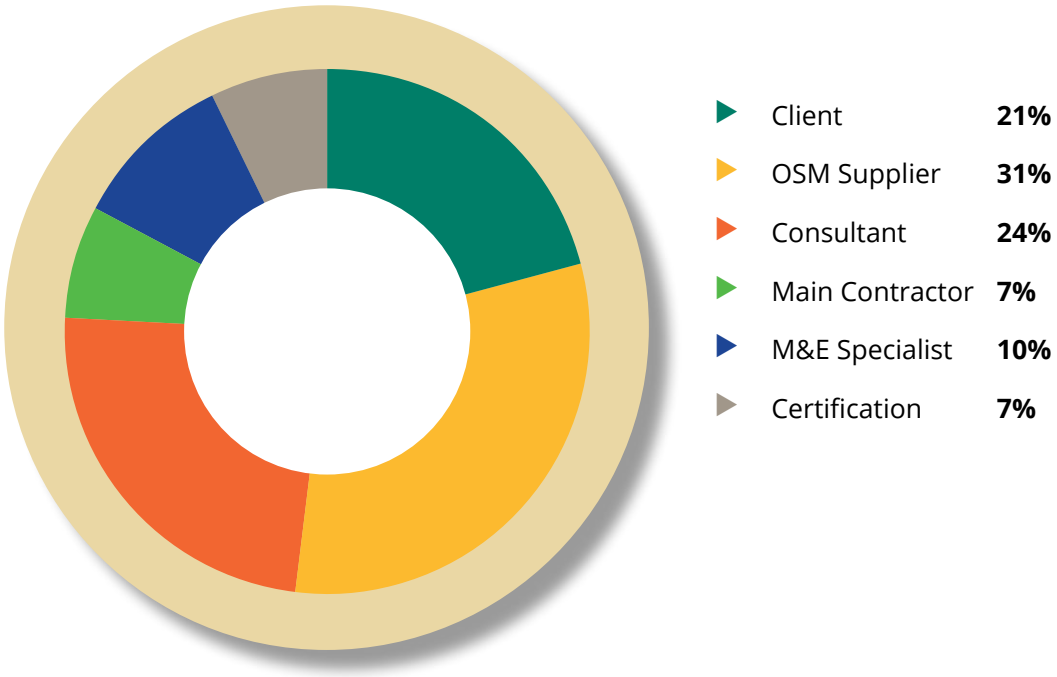


Figure 7: Breakdown of Stakeholder Type

7.1 BREAKDOWN OF KEY REQUIREMENTS FOR MMC DEMONSTRATION PARK AND CTIC:

BREAKDOWN OF KEY REQUIREMENTS FOR A MMC DEMONSTRATION PARK AND CONSTRUCTION TECHNOLOGY INNOVATION CENTRE

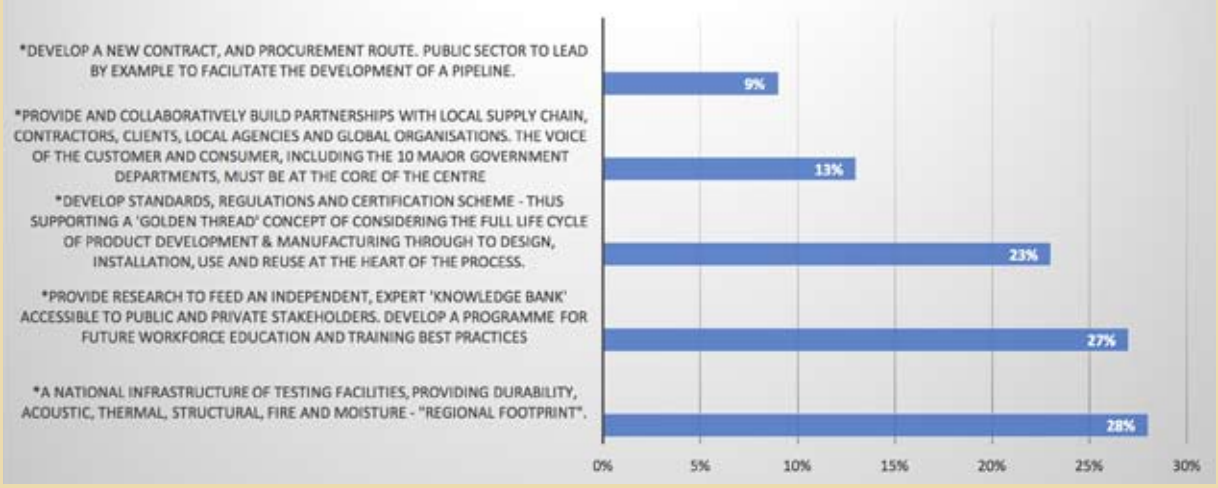


Figure 8: Breakdown of key requirements for a MMC Demonstration Park and a Construction Technology Innovation Centre

The graph above highlights the key requirements for a MMC Demonstration Park and a Construction Technology Innovation Centre (CTIC). Twenty-eight percent of those interviewed were keen to see some form of testing facility, particularly for fire, acoustic, structural, and thermal. Twenty-seven percent felt that education and training facilities were important to ensure Ireland stayed up to date on industry best practices. Developing and supporting a 'golden thread' concept in standards, regulations and certifications was a high priority, with 23% of stakeholders stressing that this is a key requirement. While 13% and 9% spoke about building collaborative partnerships and developing a new procurement route and contract respectively.

KEY OUTPUTS FROM THE STAKEHOLDER INTERVIEWS

The key responses and outputs from the one-to-one stakeholder interviews are outlined as follows:

1. A National Infrastructure of Testing Facilities, providing acoustic, thermal, structural, fire and moisture.

2. Building physics technical advisory service - an independent expert unit that can be called upon to answer technical queries or provide guidance for public and private stakeholders.

3. Living laboratory demonstrating multiple typologies - a demonstration of physical building types or specific uses to allow modelling and an examination of operational characteristics in a living environment.

4. Industry focused advanced education and training facilities to deliver human capital - meeting the current and future needs of MMC.

5. Support the 'golden thread' concept by urgently resourcing standards and building regulations agencies - consider the full life cycle of product development and manufacturing through to design, installation, use and reuse with standards, accountability and traceability at the heart of the process.

6. Maximising waste reduction and drive circularity to support a decarbonisation, climate resilience, social and community wellbeing agenda.

7. Establish and maintain an open-source knowledge bank - a library of digitally held technical content that can be accessed free of charge and is interoperable with digital data platforms.

8. The voice of the customer must be at the core of the centre including the 10 major spending government departments and private clients.

9. Develop 'Technology Readiness Level 4-7' - focus analysis and is close to being developed and or commercialised for practical application in industry (see Figure 1).

10. Interact, support, subcontract to and align with the Construction Technology Innovation Centre (CITC) and Build Digital Project - an MMC Demonstration Park must co-exist with the Build Digital Project under Action 7, and the Technology Centre being advanced by Enterprise Ireland under Action 4.

11. Develop certification systems for standardized typologies across sectors, i.e. housing, education, medical - actively drive national standards to support standard typologies to enable scalable, repetition and growth in supply chains.

12. Support the requirements of insurance, funding, security, and investment decision makers - address concerns by providing regulatory, audit, inspection and certification systems to alleviate client and building user concerns.

13. Construction leadership and management must evolve to bring Supple Chain Optimized (SCO) logistics and a lean approach to 'right first time' delivery - provide a platform for an industrial leadership academy.

14. Support design for manufacture, installation and management of follow-on trades and build the necessary skills in sufficient number to meet national construction demands.

15. Public sector to lead by example to facilitate the development of a pipeline.

EMERGING THEMES, CHALLENGES & BENEFITS

Image courtesy of
Framespace Solutions

The following key themes and responses came back from the majority of the MMC / OSM industry stakeholders interviewed, as follows:

- Volumetric pipelines are needed to make MMC commercially and sustainably viable – with clear Design Frameworks produced to tender for.
- Must have an Offsite Build Strategy in place, from the start – as can go from an offsite build strategy approach to a traditional onsite construction, but not vice versa.
- Clients are looking to more and more modularisation solutions – they are not seeing this from the existing design teams, main contractors and less so from the OSM supply-chain. They are not being made aware of possible solutions for design consideration.
- The predominant demand from construction industry is certainty – especially with more mature clients, as they are very clear on where the value lies on the OSM Value Chain Process; through their own research, lessons learnt and analysis of what has worked in the past.
- Clients seeking more innovation and solutions from the OSM supply-chain and market.
- Fire, Acoustic and Structural Testing & Certification facility is needed in Ireland – none here. There is currently only one facility available in Belfast, Efectis (https://efectis.com/en/) and (https://efectis.com/en/services-by-solutions/)
- OSM ecosystem / supply-chain is not fully known by clients, and the modular solutions and offerings they can provide, for further consideration.
- The industry will utilise a Construction Technology Innovation Centre if built, and particularly if it has a focus on awareness, understanding and education of MMC / Modular Solutions and Material Technology.
- Greater understanding, education and training is needed to implement Offsite Manufacturing (OSM) / Modular Construction, with previously applied examples from an Irish and International context for students, as it is not a dedicated subject or module taught in Universities or Colleges.
- Lack of understanding of what constitutes OSM / Modular Construction / MMC and what is possible with modular solutions and their limitations.

9.1 BENEFITS OF USING PRE-FABRICATION / MODULAR CONSTRUCTION

The following benefits of MMC / OSM were provided by the 'one-to-one' stakeholder participants as based on their knowledge and experience. These have been documented and evidenced as accruing from adopting a build offsite strategy and having early design and engagement for such an approach from the outset of the project:

9.1.1 SPEED

Quicker turnaround times for organisations and construction projects. Modular Construction removes days from the system lost to postage and data entry.

9.1.2 ACCURACY

The accuracy of data input early into a modular construction system will be significantly improved as interpretation of handwritten / 2D Project Specifications and Drawings will be removed from the system. The BIM format of the Project Specifications and Drawings will ensure that all necessary fields will be completed, removing the burden on offsite fabrication personnel to return incomplete modular solutions (unless the design has changed, after offsite fabrication has already commenced).

9.1.3 AUTOMATED VALIDATION

Automated validation is built into the pre-fabrication / modular construction approach. This will further ensure that modular solutions / assemblies are completed fully and accurately.

Confirmation of receipt of a modular construction requirement / solution

An email from the Offsite Manufacturing (OSM) / modular construction provider will issue to the design team and the relevant Project Stakeholder Organisations confirming that they have received a complete modular construction application, to fabricate to.

"Consistency is key in Modular Construction, particularly around time and cost certainty."

9.1.4 METRICS

A suite of pre-fabrication / modular construction metrics will be available to the design team on re-fabrication / modular construction applications such as how many are at invitation stage, for review, with OSM provider, in progress, completed, shipped, rejected, cancelled, etc. The design team will also be able to gauge how many modular construction applications are being processed by the OSM provider.

9.1.5 TRACEABILITY

Using a unique pre-fabrication / modular construction identifier the offsite fabrication personnel will be able to isolate and trace the progress of any offsite fabrication personnel application.

A design team member will be able to trace the progress of their own offsite fabrication personnel application, removing the need for them to contact the OSM)/ modular construction provider with a query regarding their progress status.

9.2 BENCHMARKING EXAMPLES OF INTERNATIONAL CONSTRUCTION RESEARCH INITIATIVES

Construction Innovation Hub (UK)
Value in design, delivery, and operation – targeting value and whole life performance. The CIH is developing a Value Toolkit – a suite of tools to support faster, value-based decision-making across the investment lifecycle for its clients.
Manufacturing – developing a platform construction system, which consists of a standardised 'kit of parts' that can be deployed across multiple building types and sectors and offer significant benefits.
Assurance – achieving standardised products and processes across the supply chain, to deliver safe and resilient buildings that are built to deliver long-term societal outcomes.

Advance Dudley II (UK)
Training for apprenticeships at advanced and higher levels in a range of new and traditional trades.
A four-storey high 'hangar' where students are taught the practical know-how required for fabricating and assembling buildings using the latest available technologies.
A 'carbon-friendly technology centre' where students acquire skills in the installation of air source heat pumps and photo-voltaic technologies.
A 'construction manufacturing and fabrication centre' to develop building engineering skills

Construction City Cluster (Norway)
Has its own coworking space (CoLab) where members work, host events and test business models with the objective of scaling solutions and defining the future of construction. State-of-the-art facilities demonstrate solutions, tools, and services that are transforming the construction and real estate industry – presently hosting a VR lab, the latest in loT sensors and a makerspace with a 3D printer.

Construction Scotland Innovation Centre
CSIC offers a range of product development, manufacturing, robotics and visualization equipment, including: the gantry crane, forklift & hand tools, robotics, 3D technology, virtual and augmented reality equipment.
Business innovation and alternative business models.
Technical support to develop new systems, products, components, and solutions.
Process innovation (e.g. offsite methods) to improve construction and production processes, increase productivity and minimise waste
Service innovation to access new market opportunities

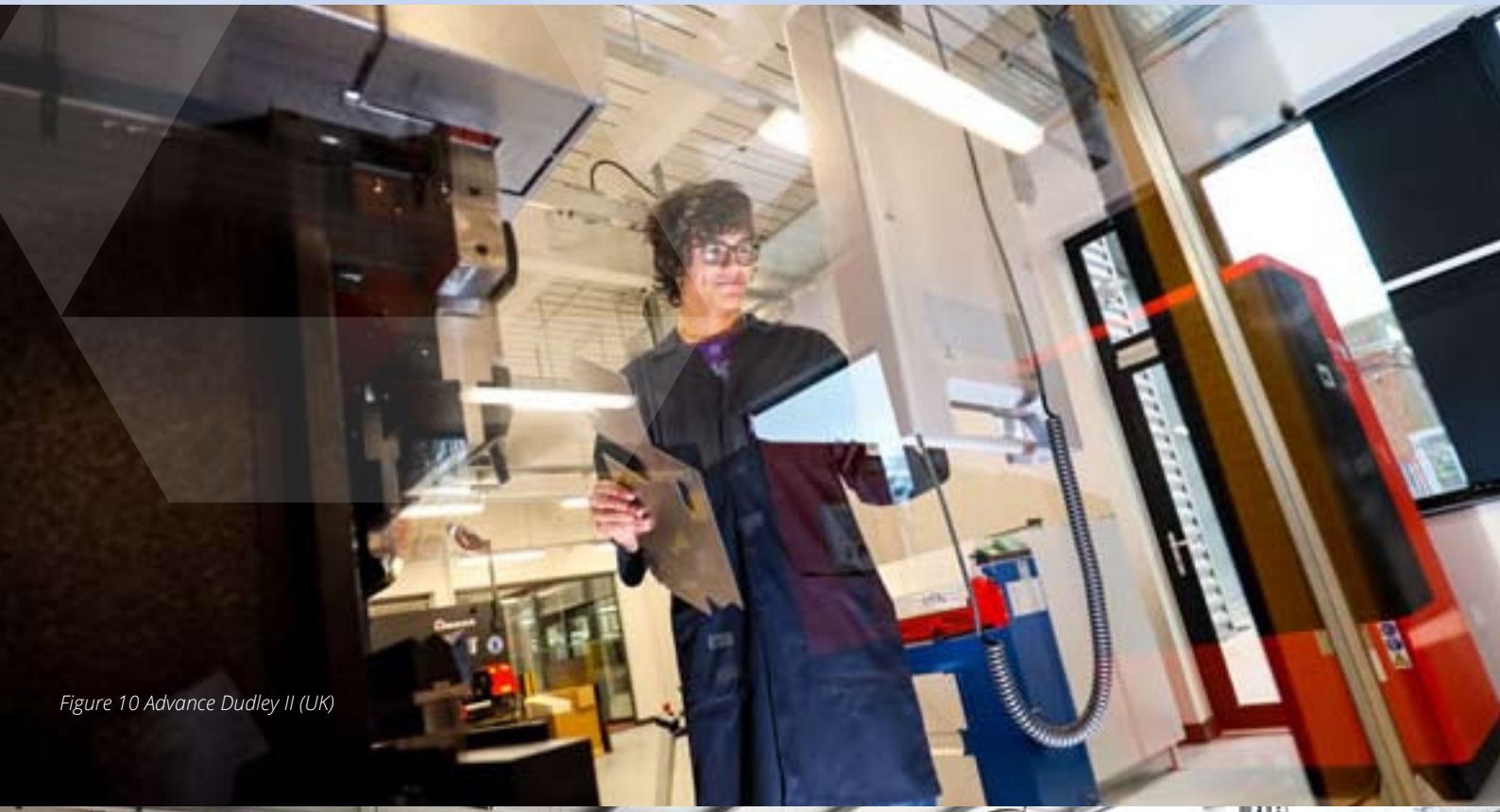


Figure 10 Advance Dudley II (UK)

Figure 11 Construction Scotland Innovation Centre

SUSTAINABILITY CONSIDERATIONS FOR MMC

Regarding the generation of sustainable construction material / product matrix for Modern Methods of Construction (MMC), there was a poor response rate to this exercise under Phase 2. This was possibly due to lack of sufficient awareness of sustainability issues and their likely significant impact on the future of MMC.

The tools and roadmaps related to sustainable materials are already published by the many stakeholders in the construction sector, and they are all linked (Appendix 4).

Furthermore, The Construction Sector Group Innovation and Digital Adoption Subgroup set up to implement 7 Priority Actions including productivity, digitisation and sustainability. The Subgroup set up a Sustainability Consultative Group to outline key research areas for disruptive and scalable innovation in sustainability, carbon reduction and climate action in the Irish Construction Industry, required to achieve the objectives of the National Development Plan, Housing for All and the 2021 Climate Action Plan. This Report is contained in Appendix 5 of this MMC Report and refers to the November 2021 Report on Towards a Net Zero Whole Life Carbon Build Environment by the Irish Green Building Council. Appendix 5 summarises four specific themes that were considered by the Group with respect to decarbonisation, the circular built environment including resource and material efficiencies, climate change resilience and finally social value and community wellbeing.

Specifically, the recently published Climate Action Plan in November 2021, with regard to cement and construction sector evolution it states:

'Construction of new homes, offices and infrastructure has significant environmental impacts and in particular the production of clinker to make cement – used in concrete – is extremely carbon-intensive. Nevertheless, our society needs this activity to deliver on our housing, health, education, transport and economic needs. An evolution in both cement and construction sectors is, therefore, required as we decarbonise our economy and society.'

10.1 KEY POINTS ON CONSTRUCTION MATERIALS:

12.3 MtCO2eq was attributable to all Built Environment activity in 2019, including commercial, public and residential projects. This amounts to 39% of the overall 59.9 million tonnes total emissions for Ireland.

Cement is responsible for 4% of total national emissions so is a high priority target area and requires an adaptation plan as part of the Climate Bill to decarbonise this source of construction material.

Focusing on just embodied carbon from the materials sector the GHG emissions are 4.1MtCO2eq and is the largest single contribution in Built Environment sectoral emissions. Taking into consideration the amount of construction required to deliver the National Development Plan and resolve the housing crisis, this 4.1MtCO2 is likely to increase in the 'Business as Usual' scenario.

In order to meet the 2030 targets of the Climate Action and Low Carbon Development (Amendment) Act 2021 there will need to be a 50% reduction in the embodied carbon for all buildings.

Total estimated embodied carbon for all buildings in Business as Usual = 4.2MtCO2eq

50% reduction in embodied carbon for all buildings in Business as Usual = 2.1 MtCO2eq

To deliver this 50% reduction in materials carbon and meet all our building needs using 'Business as Usual' will result in a failure to achieve the targets of the Climate Action Plan.

While a move to Modern Methods of Construction like offsite, modularisation and precast concrete will lower some of the emissions from the embodied carbon, the methodology for selecting, combining and delivering materials requires immediate change. This must be led at client level to ensure consistency with specification and project deliverables.

10.2 CIRCULAR ECONOMY AND WASTE REDUCTION

Apart from agriculture, construction and demolition wastes are the largest component of wastes generated in Europe, and Ireland is no exception. Construction and demolition waste is waste from any building works, demolition and development. Excavated soil and stone is the largest element of construction and demolition waste at approximately 80%. The remainder includes concrete, brick, tiles, metal, glass, plastics and metal. According to Housing for All, this represents a huge cost and loss of value to the construction sector as well as resulting in significant volumes of avoidable waste.

The Waste Action Plan for a Circular Economy published in 2020 by Department of the Environment, Climate Action and Communications commits to the introduction of a recovery levy of €5 per tonne of waste to recovery activity such as incineration in Ireland or elsewhere. However the bulk of construction waste is exempt as it is used as cover material on landfills and then therefore is part of landfill engineering and thus exempt from the recovery level.

In parallel with these waste soils achieving End-of-Waste designation, this will reduce the demand for virgin soils and support re-use and cost reduction by keeping material out of waste streams through streamlined End-of-Waste and By-Product designations for specified C&D waste streams.

In addition to the foregoing, the adoption of circular economy principles is to 'design out waste' in the planning of housing and infrastructure. To support this, waste prevention, avoidance and minimisation are key through robust project planning prior to construction.

RECOMMENDATIONS & NEXT STEPS

This qualitative research is based on the required inputs for the Detailed Description of Needs (DDN) process and research being carried out by Ernst & Young consultancy for the proposed Construction Technology Innovation Centre, under the remit of Enterprise Ireland. It is being funded with support from the Irish Government and Irish Engineering & Construction sector to future proof the industry. These key themes and emerging technological advancements that will impact in the medium to long-term are identified as including the required skillsets and materials needed to meet these requirements. Enterprise Ireland are providing leadership in this regard for the research, feasibility study and industry needs for the proposed MMC Demonstration Park and a Construction Technology Innovation Centre, with inputs from the seven Action Groups under the Construction Sector Group (CSG).

Collaboration is needed and the following next steps and actions are important in order to progress and develop a MMC framework.

11.1 NEXT STEPS IN MODERN METHODS OF CONSTRUCTION:

No.	Task	Partners	Timeline
1	Complete a 'cross-referencing' exercise on the Offsite Manufacturing (OSM) supply-chain database of companies based / fabricating, here in Ireland.	Enterprise Ireland.	This has been completed by Enterprise Ireland construction sector and the database is up to date.
2	Development of a Master Online database of Offsite Manufacturers (OSM) Providers, as a national search location for both private and public sector clients, by MMC / Modular Construction solution(s) and sectors served.	CSG Innovation & Digital Adoption Subgroup Action 3	In Appendix 6 of this report and updated quarterly
3	Recommend a scoping and costing exercise is carried out to prepare a detailed specification for the MMC Facility and Demonstration Park. It has been agreed that the co-located facility will be situated on public lands in the optimum location to support the national requirements. Further details and a concept drawing of the facility and Demonstration Park can be found in Chapter 4.2 on page 24. Some activities for the national facility will involve: • MMC Culture development • MMC Standards for Housing • MMC practices for housing • MMC Supply chain development for housing and infrastructure • MMC procurement practice & administration for housing and infrastructure • Dissemination of know how & case stories • Teaching MMC best practice methods • Informing policy makers on the economic benefits to develop a MMC supply chain • Show, Tell, Do, Train.	DETE, DHLGH & CSG Innovation & Digital Adoption Subgroup to set up a delivery team to progress action on this item This item is listed as an Action under the Housing for All section 23.9 and is deemed very urgent for delivery	Set up team and report monthly to the CSG Innovation & Digital Adoption Subgroup

No.	Task	Partners	Timeline
4	Engage further with CSG Sub-Group - Action Group 2 on sustainable materials and technology solutions, required for further adoption and sustainability outcomes for MMC.	CSG Innovation & Digital Adoption Subgroup	Baseline report was completed and published in November 2021. Engagement with Government Departments is critical
5	Research on MMC Skills and 3rd level educational courses needed for the new Value Chain model for the sector (as part of the Future Skills Needs analysis).	As part of the MMC Phase 3 research – by Quality Positive Limited	Due for completion in Q1, 2022
6	Review the EY - DDN report on the International Benchmarking exercise of MMC, globally versus Irelands current status and industry needs.	CSG Action Team 3	Review to be completed by end Jan 2022
7	Material science and material technology solutions need to be explored further, within the Construction Technology Information Centre and the MMC Demonstration Park, as part of research and further support to offsite manufacturing / MMC.	CSG Innovation & Digital Adoption Subgroup	TBC
8	Recommend the establishment and certification of a dedicated test bed facility for structural, fire, acoustic, thermal and modular assemblies, including prototypes, based in Ireland, to meet current and future needs	For discussion with DHLGH, DETE and CSG Innovation & Digital Adoption Subgroup	Monthly update
9	Recommend the establishment of a dedicated Irish Standard, under the auspices of NSAI and, for MMC / Modular Construction and OSM and incorporating updates to BC(A)R 2014 for interfaces and sub-assemblies.	NSAI & CSG Innovation & Digital Adoption Subgroup	Set up preparatory meeting with the NSAI in Jan 2022.
10	A detailed review to be carried out on the re-use and repurposing of construction material streams and M&E materials, to ensure great support of a circular economy for MMC/Modular Construction, with recommendations of current industry standards that require change/updating or need to be created specifically for an Irish legal framework context.	For discussion with the DHLGH, DETE and the CSG Innovation & Digital Adoption Subgroup	Monthly updates
11	Recommend a workshop with relevant operational stakeholders to discuss how the sector will bring forward these actions in order to establish a collaborative approach to further drive MMC.	CSG Innovation & Digital Adoption Subgroup	January 2022

11.2 POTENTIAL FUNDING OPTIONS

The MMC Demonstration Park would require a significant initial investment from the state to support major capital programmes such as Housing For All and the NDP 2030. The centre would grow from an initial scale of €10M to possibly €50M in Year 5. Whilst the funding matrix demands a proportion of investment from the private sector, a primary larger investment from the state at commencement and a more sophisticated approach to sourcing EU funding by Year 5 would be required.

It is very clear from the above stakeholder interviews, their rich responses and the data analysis that each MMC client, whether a private or public stakeholder and the offsite manufacturer require 'time and cost certainty' in the value stream supply-chain route. This is what MMC/modular construction can bring to the sector; helping reduce design, pre-construction and construction cycle-times and giving great assurance that current and future sustainability and quality requirements can be met, through supporting technology and outputs developed around;

- Lean fabrication and operational processes;
- Production supply-chain methods and mindsets, incl. Logistics Management;
- Funding and tax credits to support SME and micro enterprise transformation and upskilling.
- Supply chain optimisation together with technology and smart management transferred from other industries.
- Further application of digitalisation incl. BIM, QR Codes, Bar-coding, GS1 standards, Equipment and Material traceability and tagging, EPD certificates, RFID, Remote Auditing, AR / VR, Common Data Environments, etc.
- Creation and application of a national Irish MMC / Modular standard and certification scheme, equally resourced
- Assessment of current material and waste streams in construction, to identify where reuse and repurposing of construction materials, coupled with material science and material technology research and innovation, can further support and be applied in MMC/modular construction i.e. Eco cement, etc.
- 3rd Level, Apprenticeship and Skillnet™ courses developed on MMC / Modular Construction, to improve understanding and education on MMC / Modular Construction methodologies and applications.
- Increase regional employment opportunities through MMC/modular construction methodologies and upskilling.
- Development of a suite of standardised modular housing and school building designs, through a tender award framework for OSM providers to meet as a performance specification.
- Strategic engagement – establishing an industry led Governance Board and Project Advisory Group, with industry, representative bodies and public sector organisations.

All of the above, will further drive continuous improvement and adoption of Modern Methods of Construction.

APPENDICES

APPENDIX 1: **GLOSSARY OF TERMS**

Acronym	Term	Acronym	Term
AAR	After Action Review	DNCLG	Dept. of Housing, Communities and Local Govt. (UK)
AB/IAB	Irish Agrement Board	ECI	Early Contractor Involvement
APAC	Asia Pacific region	EMEA	Europe, Middle East, Africa region
APD	UK Green certification scheme	EN	European Norm (standard)
AR	Augmented Reality	EPA	Environmental Protection Agency
BCAR	Building Control (Amendment) Regulations	EPCM	Engineer, Procure, Construct, Manage
BCSA	British Construction Steel Association	EWI	External Wall Insulation
BIM	Building Information Modelling	FAC	Framework Alliance Contract (UK)
BMS	Building Management System	FDI	Foreign Direct Investment
BOPAS	Build Offsite Property Assurance Scheme (UK)	GC	General Contractor
BRE	Building Research establishment (UK)	GCCC	Government Committee for Construction Contracts
BREEAM	Building Research Establishment Environmental Assessment Method	GGBS	Ground Granulated Blastfurnace Slag
BTR	Build To Rent	GSK	Glaxo Smith Kline
CE	Certificate European	HAS	Health and Safety Authority
CIP Skid	Clean In Place Skid	HSE	Health Service Executive
CITB	Construction Industry Training Board (UK)	HVAC	Heating Ventilation and Air Conditioning
CLT	Cross Laminated Timber	IP	Intellectual Property
CNC Machinery	Computer Numerical Control Machinery	IPD	Integrated Project Delivery
CSA	Civil, Structural, Architectural	ISO	International Standards Organisation
DFMA	Design For Manufacture and Assembly	JCT	Joint Contracts Tribunal (UK)
LAMS	Laminated Section	NZEB	Near Zero Energy Building
LCI	Lean Construction Ireland	OGP	Office of Government Procurement
LDA	Land Development Agency	OPW	Office of Public Works
LEED	Leadership in Energy and Environmental Design	OSM	Offsite Manufacturer
LGS	Light Gauge Steel	PI	Professional Indemnity (Insurance)
LOD	Level of Detail	PIR	Polyisocyanurate Insulation
M&E	Mechanical and Electrical	PMV	Pre-Manufactured Value
MEP	Mechanical, Electrical Process	PRS	Private Rented Sector
MVHR	Mechanical Ventilation and Heat Recovery	QA	Quality Assurance
MVP	Minimum Viable Product	QC	Quality Control
NDA	Non-Disclosure Agreement	RCU	Recirculation Air Unit
NEC	New Engineering Contract	RECI	Register of Electrical Contractors Ireland
NHBC	National House Building Council (UK)	RIAI	Royal Institute of the Architects of Ireland
NPD	National Product Development	RIBA	Royal Institute of British Architects
NSAI	National Standards Authority of Ireland	SFS	Structural Framing Systems

APPENDIX 2: **MMC WORKING GROUP MEMBERS – DECEMBER 2021**

Sean Downey	Director Specialist Contracting, CIF (Secretary, C4.0 Working Group)
Tim Ferris	Director, Jones Engineering (Chair, C 4.0 Working Group)
Jennifer Nesbit-Daly	CIF Administrator, Specialist Contracting – to August 2021
Aine McGinity	CIF Executive, Specialist Contracting – from October 2021
Trish Flanagan	CIF Executive, Education & Skills – from November 2021
Martin Searson	Quality & Lean Specialist, CJK Engineering (Working Group Chair)
Frank Murphy	Operations Manager, Cygnum
Gary Plunkett	Construction Manager, Carroll Estates
Michael Murphy	Digital Manager, BAM Ireland
Daragh Keran	Design & BIM Manager, CPAC Modular
Brian Kennedy	Director, Vision-Built Limited
Justin Keane	Director of Digital Delivery, Offsite Manufacturing and Quality at Mercury
Peter Browne	Business Development Manager, Mac Group
William Power	Director, C+W O'Brien Architects
Declan Wallace	Technical Director, Evolusion
David Browne	Director, RKD Architects
Joe Kennedy	Managing Director, Smith & Kennedy Architects
Martin Lydon	Managing Director, LMC Group
Stephen Ashe	Director, Linesight
James Clifford	Associate Director, Cogent Associates
Susan McGarry	Managing Director, Ecocem Ireland
Pat Kirwan	Associate, HJ Lyons
Derbhile McDonagh	Director, O'Mahony Pike Architects
Rory O'Connor	Design Manager, Actavo Building Solutions
Michael Burke	Business Development Manager, Actavo Building Solutions
Sean Sheridan	Electrical Project Manager, Tritech Engineering
John Whyte	General Manager, BRE Group (Ireland)
Claire Lane	BIM Manager, Associate Director, LMC Group
Viviane Leuchtenberg Esposito	Quality and Operations Manager, Quality Positive Ltd
Micheál Keohane	Director, Modern Homes Ireland
Lee Murphy	Director, G-Frame Structures Ltd

APPENDIX 3: **STAKEHOLDER INTERVIEWS**

These notes are a direct transcription of 29 one to one conversations between the interviewees and the reports' authors team. They are a direct record and as such may reflect personal views. Where personal company details have been referenced the authors have tried to anonymise those details. A significant amount of the information provided had commercial sensitivity and was provided on the basis of confidentiality being maintained throughout the drafting and finalisation of this report.

Direct discourse from the one-to-one interviews

OSM # 1

Q. Have you considered what suggested recommendations or solutions would you employ for further increased implementation of Modular Construction, Sustainable Materials and/or Offsite Manufacturing (OSM) for clients?

A. The school framework has looked at a number of different types of schemes and have drawn down from scheme one, scheme three etc., this means that you have repetition across multiple sites. This is a movement in the right direction, straight away, not having a lot of different school types in every site.

There is still a belief within the industry that modular construction equals rapid construction. We need to have the design stage at the start and then we need the procurement, construction and then moving to the site. There was a misunderstanding that the saving is on the time and space. The saving is not the design or the procurement. The design is just at the start and it's leading from there.

Q. Is there a confusion between modular and temporary buildings?

A. We are now building schools that are completely compliant with all building regulations, yet there is a perception that modular equals temporary. The government must push forward the use of modular for permanent buildings and as a way to improve productivity, decrease time on-site, and increase the specification of floors, walls, roofs etc.

Q. Do you think that they might be influenced by the demographics, or that they consider building at national school level to be valuable for a short period only? Would there be a benefit in making the buildings adaptable to go from national school to secondary school use?

A. Yes, that would be beneficial, although there are some slight differences between the two i.e. room layouts. We need to look at standardising modular construction, where each company can have their solution for a modular building, and they can have that certified & proceed with fire testing etc.

A centre of excellence is where standard details and a technical guidance document for modular construction in Ireland, should be developed.

Q. What is the capacity of your factory?

A. In our factory, we have 24 modular units on the floor at any one time. We currently have a project which produces 8-10 units a week, with a three-week bill period on the eight units.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Q. When you describe the test and certification do you go as far as your primary structure, secondary steel etc, or do you have fire testing & acoustic testing for integrating different types of facade systems?

A. We are currently looking at NSAI (National Standards Authority of Ireland) certification for a 10-storey residential product and we are developing details for fire testing for all of our external and internal walls.

Q. What is your primary system?

A. Our current system is hot rolled columns with cold rolled beams and cold rolled joists, for both floor and ceiling.

Q. I'm interested in your journey on the certification side, what have you done so far and what to you need to do?

A. We had started work on this aspect & were derailed by the pandemic. We have come back to the process this year and we are currently developing the details.

Q. It's a performance standard as opposed to from a particular product. Is that a challenge when it comes to facade systems or do you go as far back as the external skin?

A. We are going as far back as the external skin. We only get certification for the outside of our box. Our primary market is currently education and some medical.

The current building regulations do not allow for modular buildings at all. We have gone through the process of bringing an existing building through BCAR (Building Control (Amendment) Regulations), upgrading where we need to and putting the building through the BCAR process to be certified again, recertifying the new work.

If it is a permanent structure, i.e. a house, you do not retrospectively apply building regulations to the existing structure. In this case, there is an existing structure which has to be moved. You will be applying current building regulations to a structure that was built 5 - 10 years previously.

There should be to cut off points in place, where works will be required, especially with Part L, the performance of a current building compared with a 10 – 15 year old building will be a completely different standard.

Your three key points for the centre are:

1. Limiting the typology - if you can standardise the approach to a point where everyone involved understands the main parameters of what the building should have, that will allow the market to respond, set up systems/factories and begin production.

2. Educating the client to understand the difference between modular, rapid and temporary.
   And also the difference between modular and what is considered standard construction.

3. The re-use of structures and putting a process around carrying out an assessment on an existing structure that will be reused somewhere else.

Your key ask of the MMC centre is:

A Technical Guidance Document for MMC in Ireland, and training for same.

One of the biggest problems I have is that the clients don't understand the need for a design freeze and want to alter the plan midway through production. We have had instances where the production stops until you can redesign and come back to it.

Q. What about traditional procurement routes?

A. This involves a lot of certification as clients want to know where the materials are purchased. Many clients are reluctant to pay until they see something on-site, therefore an upfront deposit is needed, as the main spend is at the beginning of the project, on the structural steel.

Q. Do clients visit the site? Or do you use cameras in the factory for them to view progress.

A. They come and visit the factory, and we will provide reports with details of all the material.

We have also developed an app in-house which is linked with BCAR for inspections so that the client's team and our own team can inspect as many modules as they wish. We also have photographic evidence of every single stage, which is date stamped, timestamped and geo-stamped, and goes into a report for the client. The eventual goal is that the end user will add the information to their own manual in the cloud, with a QR code attached. When repairs are required, the QR code is scanned and links directly to all of the information in that particular module, removing the need for paper manuals.

Q. We previously spoke about traditional procurement. You were saying that the traditional model doesn't work. There is a need for a new model, a new approach and a new payment system?

A. Yes. Payment is needed up front for the structure and the initial spend.

Q. In terms of sustainability, have you started measuring the benefits of the current embodied carbon or logistics or transport or any of the opportunities around off-site versus traditional?

A. We haven't explored that. We are looking into ways to make our own factory more efficient and more "green" but that is not related to the modules themselves.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

GC # 1

We first became involved in off-site manufacturing approximately 16 years ago, around modular plantrooms in Beaumont Hospital. What I have seen in recent years is a holistic solution, in each of the different disciplines coming together. When dealing with a consultancy-based design team especially those which are more traditionally based, the design for manufacturing and assembly (DFMA) mindset is not incorporated into the project early enough. If the project goes down a traditional design route, it can reduce the opportunity for offsite assembly & offsite manufacture.

Q. If they had that mindset, where would you see them working?

A. The reality of it is that the entire industry will not change to modular offsite. Most of the work carried out will take a more traditional approach. Modular will be suited to certain types of projects only.

Q. What is stopping more projects using modular?

A. There is a sense that there are limitations and constraints to modular, certainly from an aesthetic point of view, perhaps building shapes probably tend to be a little bit more standard. There should be a distinction between construction under a roof versus actual OSM. The ideal would be the automation of the process offsite. If there is a client-side team or consultancy/architecture firm, they must have a good understanding and an appreciation of what is required from the brief for developing the initial concept.

We have developed standard forms and a standard process workflow which is akin to a design contract where you are brought at concept stage then start to develop the design. At this point you have a basis of design and a pack of information on a modular solution, with a budget. At this point you would go to tender, or the client may negotiate to keep you on at stage two, where you will develop a detailed design and progress to a fixed price range. This practice is more prevalent in the UK.

Q. Are you seeing this in any sectors in particular?

A. We are seeing this more and more in the pharmaceutical industry, specific to modular projects.

Q. In your opinion, what is the one thing that needs change for clients to accept modular methods on a build?

A. The client brief - a schedule of accommodation with adjacency. The client knows their own process flow, so they should be capable of advising you of the different spaces they will need, in the form of a performance specification, and the modular brief can be developed from there.

Q. Regarding sustainability, have you been asked by any clients to provide information on the sustainability of your materials?

A. No, although we were involved in a modular project for an insurance company which required LEED (Leadership in Energy & Environmental Design) Silver accreditation, which we achieved. One of our main areas of operating is around Lean, and we are actively involved with LCI (Lean Construction Ireland).

Q. In terms of interfacing with the other specialist trades, be it mechanical or electrical, you are essentially the main contractors, or you are leading the module. How have you applied lessons learned to these situations?

A. We have developed solutions in-house, including a RCU (Recirculation Air Unit) concept developed for HVAC solutions, which is used on suitable projects.

Q. For the MMC Centre are you seeking something that discovers innovative product, or looks for the next generation of ductwork, electrical wiring systems etc?

A. We have established our own Innovation & NPD (National Product Development) Working Group, led by a senior architecture technician, which is aimed at researching modular systems which are currently available in the industry.

Q. Have you experienced any challenges with putting modules through the standards process?

A. It has been a challenge, particularly with energy modelling, new values, condensation risk assessments and fire complaints. Planning applications for modular building are subject to more scrutiny than a traditional build. The need for standardisation in this area is very apparent. I was previously involved with a company who performed independent fire testing on their older buildings.

Your three key points for the centre are:

1. Standardisation - efficiency in manufacturing and procurement, commercial advantage, continuous repetition, continuous improvement, Lean ethos.

2. Early contractor involvement.

3. The model for engagement, procurement, and contractual engagement.

Q. If offsite manufacturing was to increase by 20 - 30%, would there be sufficient subcontractors/specialists to meet this demand?

A. In terms of measuring the metrics, the capacity of the factory will determine the output. Regarding suppliers, steel is currently difficult to procure.

Q. Regarding the secondary school education market, if you secured a tender for a secondary school build, are you confident that your company could find the capacity, or the skillsets to fill the factory?

A. Yes, the delivery skills required are tradesmen skills, which are the same as required on a traditional build. It is not that different at that delivery level.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Public Client # 1

Q. From your perspective, what are the three issues or challenges that, if they were addressed, would transform the ability of the sector to deliver MMC or offsite manufacturing? Secondly, the state is going to invest in a Construction Technology Innovation Centre that will have three parts, encompassing BIM, RDI and a centre for modern methods of construction. What is the one key component you would hope to see in this centre?

A. In terms of MMC, it is important to note is that there is a public sector and a private sector. the public sector is governed by procurement, which is a significant barrier. Often when the public sector goes out to tender, your preferred manufacturer will not be the most cost-effective choice.

Q. Do the proposed new EPA (Environmental Protection Agency) lifecycle guidelines offer hope in terms of having qualitative standards around the future adaptability of a building?

A. Yes.

Q. Is there a challenge around manufacturers meeting the requirements on paper, but perhaps not being as structurally sound as you would like?

A. The challenge lies in not having the opportunity to meet with the manufacturer from the beginning and collaborate on the specification.

Q. Have you considered using alternative forms of contract?

A. In terms of public sector contracts, we have not sought early contractor involvement. Our approach is more traditional. Our client organisations do not want take risks. BIM and modular construction tend to "trickle down" to the end of the market that we operate in. For our organisation, a big project is 50 houses.

To a certain extent, we find that many traditional consultants do not want the process to be disrupted, as this will reduce their scope of services. Regarding the SMEs which generally engage in small housing projects of up to 50 units. This is where you need to percolate down to, the innovation.

The percolation will come from the bigger organisations. Government policy in terms of BIM, does not prioritise housing.

Q. Regarding the MMC centre, what changes are needed for your organisation to move forward with MMC?

A. One, that it has pragmatic expertise, particularly around lessons learned. Lifecycle management can be a challenge, resulting in the use of simpler finishes which are easier to replace. Training and support is needed in terms of MMC, as well as explainer videos. It is important for the centre to influence the design side. Our architects and consultants do not design for MMC. In comparison, in Sweden, there is standardisation around design for modular buildings & funds are spent on the outdoor recreational areas of the project. In Ireland, the cheapest solution normally wins the tender, which doesn't lend itself to modern methods of construction.

Q. What are your thoughts on the UK and some of those models being adopted in Ireland?

A. In my opinion, the scale of the UK operations is neither welcomed nor possible in Ireland. There is a reluctance on the part of planners to roll out large scale developments and our local authorities have capacity issues. I don't particularly look at the U.K. as the model. We have made several attempts at the rapid build programmes and the volumetric housing driven by the OGP and Dublin City Council, and I don't believe that these frameworks have been meeting any of the targets that they were established to deliver. Regarding the MMC Centre, it is important to understand what makes sense for Ireland, and to encourage those technologies and approaches.

Standardisation is key. On the social housing side, we must standardise the plans rather than constantly redesigning. This should not be limited to the entire building, but should include the individual elements also.

Q. In terms of material streams, with the carbon action plan bill now being a been published, are you driving towards greater sustainability? Is this high on your agenda, or medium term?

A. In terms of the public sector and housing, the buildings themselves, where they are located and the biodiversity issue, are not high on the agenda. The current focus is on building regulations and part L. Particularly energy use and recyclables. In terms of embodied carbon, this is not covered in Part L, currently. The design teams, are more focused on using materials with less embodied carbon, i.e. timber frame, or other lightweight forms of construction.

Q. What is your feeling on the eco system, you being a client site? Do you feel that there is a sufficient number of providers in the market?

A. Yes, but as I said, that's not the end of the market that we are operating in. There are certainly more contractors in the market who are capable of delivering a full service all the way through.

There are other providers, that given significant demand, could expand their capacity.

Q. Is there a particular procurement route that you prefer, that will remove that barriers preventing you from expanding further into MMC?

A. In procurement, there is an obligation for transparency, competition and visibility. If you are engaged in a competitive dialogue, some transparency is lost.

Your three main issues are:

- The rigidity around procurement and the contract forms and what that permits, how that can dovetail or meet an innovative system and how to marry those together.
- Client experience and understanding your needs and translating that into a project brief through the design stage process and obtaining early contractor or early offsite manufacturing involvement.
- Ensuring that innovation initiatives are accessible for SMEs.
- Quality and ease of maintenance of the build.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

For the MMC Centre, the need for pragmatic expertise which represents all levels of MMC including modern materials, material streams and modern installation systems.

In Ireland, we are used to on-site inspections, and with off-site manufacturing, we will have inspections in the factories. This was an issue with some Dublin City Council projects, where components were manufactured in Northern Ireland. Dublin City Council inspectors were conducting inspections in the factory, and this was not welcomed by the manufacturer. Factory inspections must become standard.

OSM # 2

We first worked in the modular realm on a GSK project, which involved external racks with a large amount of steel structure and transferring utilities from an existing pipe rack into a new building extension. This was a new venture for us, and our involvement with MMC has developed from there. 90% of our current works are pharmaceutical-based, with hot-work being one of the key risks involved, when dealing with a live plant environment.

Regarding OSM, the smaller components i.e. complex manifolds, dropdown stations with less metreage of pipe have a greater cost benefit.

We have tried to maximise what we can do off-site in relation to testing, insulation of piping, cladding and labels. The approval of items such as insulation labels and tags must happen up front. This requires early engagement.

Q. Do clients visit the facility, or can they view progress through a camera setup?

A. Initially, clients were visiting the facility on a daily basis and were very much involved in the overall tracking of the welds and the associated NDT (non-destructive testing). Once we had built up a relationship & trust with the client, there was less hands-on involvement.

It began as a daily visit, then a weekly visit and eventually progressed to sharing our database with them, where they could inspect our progress & quality on a daily basis. It has been a learning curve for us.

Q. In terms of lessons learned, how have you banked this knowledge and applied it to the next project team?

A. One of the early engagement activities is to align yourself with the structural steel contractor and identify the drillings that they should do in the overall building structure, to accept your rack afterwards. Therefore, when you size with your rack, you can use the pre-drills as a guide. This significantly speeds up the entire process. We conduct visual inspections on all aspects of the project, which are signed off in-house or by a third party, nominated by the client. Initially, we had someone living on-site, who would visually inspect every weld.

Your three main points are:

1. Early involvement – introducing modular from the very concept stage.

2. Identifying the value of modular & viewing things from an operational perspective as opposed to taking the metrics point of view.

3. Understanding the best methodology for offsite installation before taking activities offsite and the integration of same into onsite activities.

Q. What is your key ask for the MMC Centre?

A. Training and education in relation to the available software systems & to understand those across all the disciplines. Facilities to allow fire testing, particularly electrical testing.

Q. When you look at integrating across other kinds of trades, are you investigating the potential of other trades which might add value?

A. Yes, we have worked with sprinkler systems on a few occasions where their piping was designed local to our racks, and certain elements, i.e. headers, would have went on our racks. This links back to early engagement again, identifying not only your scope for modularisation, but maximizing scope across all disciplines.

Q. Do you have any issues around structural testing?

A. Yes, you must go through all of the temporary works which are associated with that, and identify lifting points. There is a lot of work involved in identifying the overall best process of this.

Q. How is this interpreted by the other project management companies? Do they view you as encroaching on their value? Is that a challenge?

A. This is being driven by the client. They are driving this on particular projects right through the design house and back to the contractors.

Q. In terms of sustainability, have you been asked by the clients to look at the components of the materials or the sourcing of materials?

A. We must track all of those items in relation to our carbon footprint. Some vendor components which would usually be free issue to the contractor, or in our case, bought by the client or the design house, are now being shipped to our offsite facility and must be reshipped as part of a module, to site. We are also finding ourselves more involved in procurement and expediting in the last two years, than on previous projects. The client will provide you with the specifications & the manufacturer, but you will manage all of the procurement and the expediting on those components. These clients should establish their own global procurement system, with their own warehouse for storing these items. Oftentimes, specifications will vary across different sites, and may contradict each other. A broader conversation is needed around the overall procurement process.

In relation to the various apprentice schemes, this is something that we need to go back and delve into in more detail. We must look at that closely in-house to make sure we can support the demand that is there.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

OSM #3

I was first employed in modular with a company that extensively provides these services in the UK. In 2002 we worked with a timber frame structure in South Dublin. There were very few competitors. It was low value, low cost. It was a temporary product. There were essentially prefab classrooms. There were lots of work for a small number this type of contractor at that stage in the market. Now we can see it moving more towards extensive work in pharmaceutical sectors grade A office accommodation and volumetric steel frame.

Education and health healthcare need to understand how it works for them. When you get investment houses and clients driving the demand for a higher quality product. Including system such as light gauge steel then that can be a game changer. The key components that we need to have fixed or addressed are building control, and the regulations for testing including fire, sound and structure.

The greatest catalyst for change I have seen would be the Department of Education in the UK. They created a national framework and created a huge level of demand from the public client side. The government is leading the demand side. Demand and the need for value for money. And also demand to develop short term capacity.

Health is also driving demand, due to COVID requirements in the past 18 months. Most suppliers' manufacturers in the off-site market are using light gauge cold rolled steel frame. This doesn't lend itself to multi-storey residential. That needs hot rolled steel solutions.

Installation is an issue. Standards can be addressed. Carbon will be a key performance indicator. It will be legislated for, and OSM offers best data and the best chance for the market to be able to respond.
Key providers in this area include, McEvoy, Cabinpak, Extraspace and Caledonian Building systems.

Mac Skystone are focused on a build to rent market. Their main competitor would be Vision Built and they would be targeting the likes of Greystar in the BTR (Build to Rent), residential section sector. There is an opportunity due to skills shortage and demographics are against us. Capacity simply will not be there. Market demand will be for a particular type of residential product.

From a public perspective, Dublin City Council's framework for 2D and 3D construction was insightful. The framework called up 2D offsite solutions. Vision Built have won a 200-unit contract there. One of the key issues is there's no standardised product.

Standardisation is key for me, and that's number one. There can be 300 apartment units with five or six different types of modules. We don't need 16 different department types. Just because of the fact that people feel the need to offer a wide variety. Do you get that with the Department of Education? And contractors such as McAvoy, Warnock's, Elliotts, must be able to compete on an interchangeable, standardised basis that allows them to scale up and respond to their clients' requirements and to ensure that they have capacity for standardised units.

They can be supplied to any school across the UK on that framework. There is a cultural issue to overcome to a certain extent as we have homogeneous housing design. TCC's Rapid Build project was not necessarily a success. The demand needs to be driven by clients. We need established demand and to signal that to the industry.

Phase one should be to ask people to come up with an interchangeable light gauge steel frame system. Phase two would involve managing the sub elements such as mechanical and electrical systems, and the integration of facade systems. Try sampling and using labs tests of all this to check what didn't work. And don't bite off more than you can chew.

Some examples of real innovation include three story schools in London where there's multi use games, facilities being placed on the roof that allow the schools to have quite a nice outdoor space in a really tight urban site. Cold rolled and hot rolled steel are key issues to be addressed when we're talking about scale density, structure, and in particular the height of the buildings as mentioned previously.

For constraints, the market offers significant barriers to entry. The cost of setting up an office and a fabrication facility. It also requires a new finance model, and that's my second key point. You need a new finance model or a strategic partnership. Market feasibility analysis showed that there are quite a number of operators in the space already. But to a certain extent, some of them have existing partnerships or strategic alliances with either general contractors or developer.

We could say what failure looks like. We don't want a standard looking product. We want balance to still retain their unique aesthetics, to look like they fit in their place, but we need volume to provide viability.

We need 1000 units a year to sustain profits in each offsite manufacturing facility. Some interesting comparatives could be Tide or Vision, in the UK. They have a frame and a volumetric symbiotic system.

Where OSM providers target will depend completely on the sector that they're segmented to provide. Facility number one can be portacabins, which are temporary, and number two could be moving into health and education which is slightly more sophisticated. Number three could be residential.

Separately, companies will seek to operate as possibly the main contractor in the first instance, possibly as a modular provider or possibly even the agency who hire a temporary product for a specified purpose and for a specified period.

My third big ask would be to get providers to segment the market and answer exactly what they need. Target temporary, multistorey or develop your skills as an OSM provider to make those specialist niche products.

There are two completely different parts of the equation. The first one is the factory manufacturing process and the first fix elements contained therein. The second, under a completely different process, is site installation, which requires sophisticated logistics and supply chain optimization. It also requires really good project management for just in time delivery and just in time installation.

In summary, I'd say contractors need certainty of demand, and clients would like certainty that the supply chain can respond, provide the capacity, and can meet the level of regulation standards that projects demand.

In an MMC center, I would like to see facade systems being tested. I'd like to see external integration with PODS. NSAI needs to step up and take it so far by supporting those tests.

I would ask the question whether the MMC center can do type approval so that we have a typical one bed, typical 2 bed, typical 3 bed unit that can be replicated and simply used as a platform for other companies then to manufacture from that base approval.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

That also allows you then to use step change and move on to bespoke approval for perhaps some unique systems or ancillary products that might be married together to meet that standard unit.

We need to provide accredited approved courses for modular and for offsite. That's the training and upskilling of existing staff. It's not the same process and it requires different skills. BIM and digital delivery of projects is part of the key to successful delivery.

The pain of the social housing model is very difficult and can be another barrier to the off-site manufacturing sector. You can get the site. You can get planning and the AHB will buy them at the end. Certain models in the UK are supported by better demographics in the market, and UK providers don't seem to see Ireland as a big enough market due to it being so fragmented. There are too many different subsets and fragmented clients.

Private Client #1

Our experience in Ireland is still very low. And such companies here don't seem to have the financial capacity to be able to move into an off-site manufacturing mode of delivery. For us as a developer, the frame can be 50% of the contract.

Our choice at the moment, particularly when we go above a certain number of floors, is precast for the primary structure. There's better definition in the fire codes. There's a multitude of existing standards and codes that we can rely on. Look at the volumetric solutions for multiple storey frames.

It's much more sensible, and we can standardize our units based on a known capacity and own strength. In terms of modular providers, we have already spoken to some of the incumbents here in Ireland and also to some providers in the Baltics as well as European modular suppliers. We would have concern about their M&E systems being able to comply with the Irish standards and in particular meeting RECI requirements but also certification under the national electrical standards here.

Over a certain height, such as 30 meters from the ground is challenging. We do get certain restrictions that can cause problems. The fire separation requirements between units, between safe corridors, between means of access. These can cause challenges and lead us to have requirements for sprinkler systems. In London, structural requirements really demand a rising frame but the industry there has adapted to provide standard rising frame systems. In Ireland, there really isn't that level of sophistication in the sub supply chain for a concrete frame. It is too fragmented.

The industry just doesn't have the stock of formwork systems to be able to manage the scale of projects that we would like to develop here.

Harmonization on electrical circuits is something that we would like to see. We believe an Irish based electrician should be able to operate and install a system that has been perhaps premanufactured elsewhere.

For example, we can install prefabricated kitchens, but perhaps there's an element of work at first fix that's been done in a factory. We'd like those electricians, plumbers, fitters to be able to complete that work in Ireland that might have been commenced elsewhere.

We have experience of prefabricated plant rooms. NZEB (Near Zero Energy Building) is driving new requirements for us in terms of the level of specification and the energy requirements for units. We've tended to move away from traditional gas boilers. We have experimented with the concept of an MVHR system and heat interface units to create prefabricated services units so that we can actually prefabricate and preinstall quite a bit of the mechanical and electrical, the brains of the system.

One of our large-scale developments here in Dublin is planned for 22 stories. We've worked with a Dutch OSM provider, and they use facades as a structural element, and also pop in windows. But unitized facades in Ireland in terms of their design and their sophistication are quite weak. Unitised facades would be something that we would really like to see being developed and standardised here.

Insulation requirements can make a huge difference depending on what the requirements are in the envelope. We've also used some unique prefabrication systems for the balconies and their associated balustrades to provide a solution. That means that we don't need to scaffold out entire external elevations after the main structure is complete. We can drop scaffold a lot quicker which can be very significant savings.

We feel modular in Ireland at the moment is very immature. We don't necessarily want to be the first one to test out someone's capability. Latent defect insurance is something that perhaps a lot of clients would like to see, but that can include very significant costs. Such as a €1,000,000 premium for a concrete frame system and €1.5 million premium where you're talking about the main structural steel frame. That is not good value.

First thing I'd like to see is key facades unitization being used. It's interesting when we look at capacity, we compare Dublin and at the moment we believe that when we get past structure and first fix we can fit out eight units a week in Dublin whereas in London because the capacity and the systems that we have operating there, we can actually fit 25 units a week. Subcontractor performance, productivity and outputs are much more efficient in the London market. Second thing I'd like to see is door packs. I have an experience with an Italian supplier who had provided materials that had a Serbian manufactured core for the unit, so we'd like to see that the standards across European Union are actually harmonized properly. And Europeans product supply chains are recognized here in Ireland. So, when we're looking for declarations of performance or certification at completion stage for building control, approval for BCAR, that that's a much more straightforward process. We'd like to see homogenized approvals, and particularly fire standardization across product lines.

The third thing I would like to see is the BIM model being used much more effectively. We believe that certain products and programs can be quite good. We use BIM 360. Other programs can present serious challenges. They can have certain benefits, but everything needs to be open source. There needs to be integrated management. And it also needs to recognize the fact that at the end of day the BMS systems have to be updated and have to be able to talk to the data that you're providing them.

The PRS (Private Rental Market) is here to stay. Private sales to a certain extent have gone from multi-unit developments, particularly in the city.

We used the Dutch delivery system in London and would be quite happy to replicate that here if it was the most appropriate for the market. The model needs to be considered. We don't feel that we will go to a main contractor and a natural traditional design team and ask them to design and then procure that product or that project. We're looking for early contractor involvement right down at the OSM provider level.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

We want to engage with the people that are providing us value and to complete that phase of procurement early if possible. There are quite a number of concrete frame contractors in London and scaffold and companies that design and have digital management. They are systematically ready to support this type and scale of development here in Ireland. We've used lightweight balcony systems that can be cantilevered and installed without the need for ground supported access. The fire regs are proving a bit of a challenge as we consider what our developments might look like in Dublin and how we might meet those requirements. With an off-site solution, we have a really good design support team based in London. We have UK and Ireland self-certification but in a European system you're conscious that there's a separate civil law code applying to part of your sub-supply chain. This requires an understanding of the approach that's taken to certify and systems that are manufactured in those different jurisdictions. Fire engineering facades will be critically important for any Construction Center. We need to see harmonization and digitalization come in twin track together and the building management system should be able to harvest that data.

OSM #4

I work for an offsite manufacturing company, but we only operate in the temporary building space. We are 3/4 of the way through certification at the moment for a permanent building solution.

We've had inquiries and we work with some of the main contractors in the country in terms of providing them with both 2D and 3D volumetric solutions. We work currently with the Department of Education.

The issue with temporary buildings can be that when projects are sent out for tender, there's no understanding how modular works. There is a need for training and education, not just on the client side but also on the installation side and on the manufacturing side. We need more staff who need to be trained in.

Training is needed for our existing products, but also in the new products that we're looking to develop, which will be primarily 3D volumetric. Second big issue that we have at the moment is the program and the form of contract. None really exists and sometimes with certain public clients we see an amended version of a traditional public sector contract that's been changed to try and set the procurement that they're doing with us. This needs time and needs to be condensed so that the contract is fit for purpose.

In terms of the actual products themselves and how we operate, we could do with a testing and certification facility here in Ireland. We find we're repeating the exact same exercises as others, and that they've paid extensively up to €300,000 for an AGREMENT certification.

And then we have to go and start ab initio with the exact same test and certification process ourselves. It should include structural analysis. And the intent has to be very clear. We primarily use a light gauge steel frame, hot rolled steel frame with four or six or eight posts depending on the length of the unit.

We tend to insert panels then, to complete the 3D unit. Our facade must be tested and certified to the NSAI or Agrement board standards. In terms of the framework for the Department of Education and temporary schools, that's €100 million that's out at the moment, it's live. And that is a certain amount of demand. There's also a lot of work with HSE, daycare centers, and COVID wards. Private clients are also seeking temporary solutions.

So, our current market is the health sector, education sector and temporary solutions including residential, nursing homes and student accommodation.

Sometimes clients feel we're not cheap enough. They want something that is much cheaper than traditional stick built, but that's not necessarily the solution that we offer. We can build up to 30 meters to finished floor level of the top floor, that is up to four stories. There is a big issue for PR combustible material following the Grenfell disaster in the UK. This is above 4 stories and up to 10. There's a different type of panel system that needs to be used. We operate as main contractors, primarily on a design and build approach. We use 2 consultants that we specifically like to work with that know how we work.

If we get into larger scale projects, we tend to hand over design and coordination to a Tier 1 subcontractor. Standardized guidance from the Department of Education would help. Education have a very good set of their own technical guidance documents. And they can to a certain extent allow you to select from a menu as to how you will comply.

The Department of Health tend to lump responsibility onto the main contractor, and they have no standard guidelines as to what their requirements are. Issues include how units can be bolted through floor beams to allow modules to be connected.

The key is getting early engagement of the offside manufacturer and the installation contract team, but primarily the OSM provider. Floor to ceiling heights can be constrained by transport. The industry is looking for 3.1 meters ceiling heights, but lorries can only be 4.7 meters high. This is also impacted by restricted routes to site based on bridge heights in certain locations in certain cities.

There is demand for fire testing. To our knowledge, there's only one location on the island, in Belfast. We've looked across at Warrington. We spoke to a few lecturers, and we brought in a new engineer. We intend to still use light gauge steel because that's where we feel the technology is at the moment.

The OPW's green procurement guidance will be something that we will track. We feel we need more visibility on that and how it is delivered in practice. Do we need to have greater transparency and a full video of the factory that would be useful to be able to track manufacturing?

You could assess what size is being installed at any point in time and allow a client to zoom in and do an order control on any part of our manufacturing process.

We have two factories, on the same site with five production lines. But they tend to have poor coordination, so we have huge capacity for improvement in our own manufacturing methodology.

We're made up of crafts and carpentry tradespeople.

I believe a center of excellence would need to be physical. It would also have to have a very significant amount of space for fire and acoustic testing. We've worked in the past with Evolusion who have a great team. But we also need to make sure that we're not paying for a test and certification process that has already been completed by someone else. They have a great project management for certification process.

We'd like to think that the state could step in and fill this gap. Perhaps using the right type of professional support such as technical building experts.

We like some of the standard details that manufacturers provide, such as Gyproc. We understand that the BRE have approached NSAI to try and support them and see if they could roll out the offsite modular standard that's been certified in the UK over here.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Public Client #2

I work for a government client, and we are currently looking at 3D modular as a particular solution to our needs.

We believe that we have quite a number of similar spaces and similar specifications that can be repetitively produced and installed across the country. Prefab can be a dirty word.

It can be a quality product but needs to meet the same regulations as stick built, traditional built.

We're currently in a tender process. We have a framework for modular buildings. We have demand, for a multi-story approach due to constraints and land values. The issue with multi-story is fire and structure is key.

There are legacy issues with some previous providers for certain public clients. First thing I demand is quality. Certainty of quality, certainty that the product meets the requirements of both the regulations, standards and the end users' needs.

Second thing we need is structure and fire. 3D modular is key. It's quick and can be quality controlled. Precast is being used a lot. There's a lack of future adaptability in those systems, and we've seen that in the past with certain modular products being provided where they are inaccessible. Then when you go to maintain them in the future, that can be a challenge. The cost of concrete can be excessive when you're looking at that as a potential material stream for a 3D volumetric build.

There are political challenges at the moment, in that certain people who are required to approve decisions for capital spend don't want to make difficult decisions.

With modular as the solution, we need to change the cultural perception about that. In the UK 2D steel systems have been developed in the past that were penalized and as it turned out, to be quite a poor product. We've seen evidence of that. To some extent, a hybrid steel and timber system could work, but it needs to be fit for purpose and needs to be able to adapt to the Irish climatic conditions. Questions I would have is how do you test those systems? What testing regime and what place do you test them in? It's a big job now and analyzing those systems for including part L, including NZEB compliance.

In 2008 there was a rapid build by public clients. They needed a rapid market response. Steel frame with a temporary fill was the solution provided by the industry. Now the Department of Education are undertaking a huge remediation program in that space. So that's created a major legacy for the offsite manufacturing sector before they even really get off the ground.

BCAR didn't help. The assigned certifier for us is only really a piece of paper. Modular providers can't self-certify so who is the design certifier? Who is their assigned certifier and what's the model? We're aware of carbon and sustainability but have immediate building needs now. We need to build units. We need to build space for our building users. We don't have time to wait and see if timber can provide us with a solution when we already have solutions from other material streams on the table. We like to develop a framework that seeks two-story buildings. The green agenda for

us is about fossil fuels and removing fossil fuel energy generation from our buildings. Industry can respond when it is regulated properly. We believe regulations, certifications are key. But we also need to create a level playing field where standardization helps people meet the minimum requirements and compete actively at that level. We want to improve the image of modular.

We'd like to see development of better external elevations to stop looking like a prefab. We would like to make them look like regular buildings. Our standard design and procurement process don't lend themselves to an off-site modular solution.

The pressure now for certain departments is serving the demographics of where the population change is going and what that means in terms of spatial requirements from building users. Covid also demands extra space.

The next two to three years will be very significant. The increase in the teenage population in particular. A question worth asking is would buildings that are provided from an offsite modular solution be mobile? How would we be able to reuse them in a different location? How does that work with the lifecycle of the building? The structural integrity of it, and the circular economy? We'd like to think that buildings could be taken apart and rebuilt, reinstalled in different locations and that when they are reinstalled, they are given a dispensation that they still meet the regulations, even if the regulations have changed because they were fit for purpose when they were built originally. My third big ask would be test and certification process, who certifies what?

I've seen models being developed in the factory with the modules that could help, but some issues with integration on site and the interfaces and protection could be key. We would be very happy with a pack of 10 standardised modular solutions and then to let the market innovate and meet those performance requirements.

A question would be, does this need a new procurement route? We don't have a standard form of contract publicly that we can use at the moment that's fit for purpose. Employer design works only so far by a project team. Again, we need early contractor involvement. We need an OSM provider to approach it on a design and build and install basis. At the moment, some departments are using the public works term maintenance contract to simply get around the requirements for public procurement and facilitate the type of procurement that they need.

It's a task order approach. The order is issued to start the design and then the second order is just to actually fabricate. Time pressure is a big thing for our department. We must be able to allocate enough time in advance to allow the offsite manufacturing team to get ahead and spend that time finalizing design before they go to fabrication. We'd like to do it once. And we like to develop a book, a cost. So that they, when the work is done, we can track the cost of it, and we actually know that we can replicate that project again in another part of the country, within a reasonably similar budget.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Consultant #1

I've been working in the modular industry since 2003. I have specialized in innovative products and moved to an offsite modular company then.

At that stage in 2003, I mainly worked on two-storey units to full panel systems. We got that approved as far as six stories. 80% of the company's work was completed for out of group developments.

We set up separately doing bathroom pods, and turnkey pilot structural pods. We worked with universities on volumetric but had to go to import panels to try and get the approval through. One of the challenges was the joist floor system with combustible material in a 3D product.

I was very enthusiastic about the way one Irish company branched out from 2007. We added a concrete floor and typically use a 600 millimeter square hollow section. It's made in China with a factory in the south of Ireland for assembly. In 2009 the company lost a lot of demand but they held on to their technology. That company now operates very successfully in the UK and they have completed developments up to 44 stories in their latest project.

Our company is one of the leading off-site consultants in Europe. With 40 staff we don't do much timber frame. We've carried out fire test and certification for all light gauge steel companies here in the country.

The problem is clients don't know enough. They don't know enough about modular by the time they think about, it's too late and we're brought on too late.

OSM manufacturing companies don't get paid for design. It's not seen as part of the value chain because people still have this mindset that there's a traditional designer somewhere else that's going to pick that up.

Of 120 live projects at the moment, we operate on a lean system. We pre con the work so we check that it can be modularized. Our engineering team assess it and we reframe it. We use software including Versus and Tekla. Our output is workshop drawings that you can roll steel from in the workshop.

We have relationships already with the NSAI, NHBC and BOPAS. Building physics is a big part of our daily role. We also work on product development. London can be very difficult to build them. The market there demands 35% better standards than the building regulations.

We're beating BREAAM as the best standard. Cold bridging and overheating are the key issues when you consider high density developments. The regulations have really developed in terms of thermal insulation, and they have then affected air tightness in buildings and as result humidity levels.

We have a quality department and carry out lots of site inspections. The building safety bill in the UK post Grenfell is going to be critical for buildings over 18 meters in height. We will have new challenges to meet in concrete, steel, and timber. With the primary materials you cannot go to stage two beyond the DPC before you get further approval. You need a structural fire review to pass thermal mechanical models. The challenge there is that they show very unrealistic fires during testing.

Apartments cost 1.7 to 1.8 times the cost of a house to build so sometimes you have to factor that in when you're considering the product that the client is actually going to be able to sell. When you start going mid-rise seven to 10 floors is really where it maxes out in terms of cost to value ratio. Hotels and student accommodation require much greater superstructure.

One UK company have a scale of 300 modules for a single project.

We need to understand why OSM companies have failed in the past and make sure that financial models are put in place to protect what they need, as otherwise you're simply risking your supply chain if you're not pre-funded properly. We need to do full scale testing including acoustic, thermal, structural etc. One ask is for all the frame companies to seek type approval. That is something that we could use in the future. We need to get like companies to seek a joined-up approach to fire testing in particular. This needs to be standardized. Acoustics is also critical.

OSM #5

The term modular and off-site shouldn't be lumped in with everything negative that's happened in the last 20 years,

MMC is not just about volumetric. Volume is key, but consistency of supply is more important.

Education around design is critical. Making sure that those who approve design understand offsite and modular need to be fit for both 2D and 3D requirements. There's limited expertise in this space. Manufacturers needs to vet the design, otherwise there's major cost implications.

We have an NSAI certificate up to 10 stories using light gauge steel and filled with a concrete floor system. Second point for me is there's no consistency with fire officers' approach. Dublin could be OK, but cork could say no to the exact same design and exact same type of scenario.

For example, in student accommodation a block design without sprinklers in certain counties will be accepted and in others not. The Knauff system Class A non-combustible floor in Galway was completely unacceptable. They demanded a concrete floor.

So, standardize construction. At six to seven tonnes per module, an 80 to 100 ton crane works. With a concrete floor, that's 21 ton per unit and a much larger crane. That's a very significant increase in the cost for the installation process.

It would be great if we had consistent order books from repeat clients. Building bathroom pods takes space and capacity output and is not the preferred option.

We really need two x 150 unit projects per year to be able to operate at the right type of capacity, to optimize our factory. And to pay for that factory. We've been operating for six years, 650 units of which completed. The problem is definitely inheriting poor design.

We've tried all types of completely finished units. The assigned certifier comes to visit and then can have challenges. What is their role and how do they fit into the BCAR system? If we're manufacturing in an off-site environment and they refused to go and inspect it there? We have identified a 48-step quality process in the factory.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

But we're still relying on traditional external skin and a traditional approval process. We've tried out weather and brick slips. They've been used in the UK very successfully. We have capacity for 500 houses or 1000 apartments a year. We are really in the 2D/3D framework for housing. We have orders on four small sites on live projects at the moment. The Mark Farmer report, I felt, was quite insightful in terms of where the market's going in the UK. And how they say that residential in particular is going to end up being mainly off site? We'd love to use cross laminated timber in the floor panels, but fire officers won't allow it.

Nursing homes and student accommodation is an area we need to break into. The Department of Education Framework in the UK is pretty successful, allowing up to five or six stories. But it's hot rolled frame. It's still intermediate structure.

Approval of products testing verification, such as things like brick slips will be critical. Robotics and automation offer opportunity. We need to be careful what we will automate or what we won't. There are certain experiences with large companies; Sekisui Toyota Homes, Kukai robotics that we might actually investigate further to see what benefits they could bring to our manufacturing floor.

Sustainability is a topic of conversation, but modeling the savings is tricky. What are the metrics? It can be hard to actually understand, and waste savings could be very extensive when you consider stick built versus factory manufacturing process. The cost of fire and acoustic testing is beyond ridiculous. We know other companies are testing the exact same type of systems and paying for the exact same type of system to be approved. If we need a 120-hour board passed, the industry should all stick together and test that consistently rather than paying for individual tests.

OSM #6

I work for an off-site manufacturing company. We have never been busier with inquiries both here and in the UK. There is a fairly big difference in how the two countries operate. Number one for me is procurement time and we need a two-stage bidding process with early contractor involvement.

With the OSM provider been involved at the very beginning, that has a major impact on how a factory and the manufacturing process will proceed and when they can proceed. Number two would be that forecasting is critical. Which job will stall and which job will be produced or procured. Downtime is a killer in terms of optimizing factory efficiency with peaks and troughs. We need to maximize the product flow.

A Pre-Construction Service Agreement is critical in the UK. The standardized agreement for this is very effective. We need to regularly review the design.

There are problems in securing finance. The traditional model is not something you should just adapt and move over to try and serve an offsite modular project. We're trying to shoehorn OSM into a traditional design model.

Bidding, with competitively the lowest price winning, can be a factor. We need more visibility and pipeline as OSM providers. Third big item for me is the issue around the review of certification. Irish building regulations are very robust. But it's a novel system. Some OSM systems are novel, and they need Agreement certs. Challenges exist as the regulations are changing so much, we need to align the regulations with MMC as opposed to the other way around.

Testing needs to be done in a collaborative way. A number of clients and providers should get together and get type approval as opposed to having to pick a particular product. We need open-source shared information for compliance and a shared database that we can compete on for standards and delivery ability.

We're primarily 2D with light gauge steel system. Some 3D, but the panels are primarily 2D.

We've got fully load bearing LGS system, providing for hotels, healthcare and education.

We use a manufactured particle board on outside sto insulation as the finished surface.

UK fire regs are moving away from PRI to Rockwool. Following Grenfell, they're moving towards a through wall solution. The system is flat packed. 1.5 units can fit on a lorry load.

Brick slips are the future for facades. EWI is going through NSAI certification. At the moment we're looking at more unitised facades as a key solution. There are lots of issues in related to tolerances. There's no documentation on OSM tolerances.

Affectus in France is used for fire testing. In 2019 we tested all the systems to EN.

We need to focus on compliance. We don't battle to be compliant. Certification standard would help everyone to compete on the process and the quality of our people. Test and research. Having dialogue about what is moving, what's changing, what's challenging sustainability. We'd like to be ahead of the game in terms of carbon footprint. We compare well against CLT (Cross Laminated Timber) because of the circularity of steel, and NZEB is not a challenge. We can bid for performance on the base of set criteria. U value and next generation of passive housing is a target. We would like to automate the process as much as possible. We think the standardized design components frameworks are a good idea because it gives visibility for OSM providers. We like to leverage more of an IPD (Integrated Project Delivery) model in terms of procurement and contract. It's not a bolt on to the current GCCC (Government Committee for Construction Contracts) or RIAI model where vested interests in those models are not necessarily going to allow the disruption that's required.

Consultant #2

We have applied modular construction for over a decade now; clients wanted to improve quality and delivery. We had an experience where we had materials that were sent from Europe to be installed in a factory in China and then exported back to Europe.

You can imagine the carbon footprint implications there for such long-distance delivery.

Hotels and office blocks offer the most demand for volume metric. There's more speed and certainty. Poland and Germany are moving into the OSM space. The British Isles is very innovative.

The very significant problem is that there's restrictions as to what can go inside the 40-foot unit.

You can lose all the time benefit of what is achieved in a factory if all the final connections have quality issues and tolerance issues.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

We try to go for lean. Want to prove the intent for the client as to what they want to achieve? Most issues seem to be about what can be containerized and trying to work around it.

Modularising MVP services again. I would ask the question whether Health and Safety rules in the manufacturing country are the same as the destination. So, do assembly staff understand the regulations in Ireland? Modular is assembly, not building.

We're still concerned about Health and Safety when it comes on site and slightly different assembly methods. My question would be what will be different this time? Our biggest single lesson? From our experience is the allocation of time. You must engage offsite manufacturing before the GC.

Get an understanding of the program and how it will be weatherproofed and be protected until it's safe. Is it bubble wrapped? What are the warranties and liabilities? When do they kick in when they land? When does a contractor who's responsible for manufacturing finish on site or when does he hand over to someone else on site? Who is responsible for the connections? Who's responsible for every element until such time as the client takes full possession?

We can see that sometimes a separate bond is required to be taken out on the entire process, which has joint and several liability.

IPD (Integrated Product Delivery) seems to be the model.

Structural loads and final build design can impact the structure of the pods. I'd say manufacturing includes a process of computational dynamics around how a unit would lift, move, and flex when it's lifted by the actual crane. This is where the structural engineer needs to be involved.

In terms of finance, it is 60% upfront payment to the offsite manufacturer. When the units are dropped on site that should be paid for 50% to the GC. Traditionally for installation and handling and then final payment minus 2.5% retention. This was the model when we would have started, all payments went through the GC. They were getting their main contractor discount.

The client changed that model completely and now pays the OSM provider directly. GC gets a payment only for their work on their attendances. We benchmark against APAC and the global Geo model by clients. There were some issues with their methods within the EMEA region that have been quite difficult, but also within the Arctic Circle.

We had new experiences in climatic conditions there, in particular associated with the protection of the units and the installation methodology phasing and removing the form of protection. How much of the building could be left open etc.

Marine environments also present particular challenges. MEP (Mechanical, Electrical Process) consultants are just as advanced as our structural engineers. They are the ones with the most sleepless nights, but they can often be used to working with factory operations such as structural steel manufacturers and fabricators. In Ireland we need to import everything. So that's the question, will there be enough demand on the island?

We need to make sure that international large clients as well as big public clients provide enough demand to support an ecosystem to be developed.

Bear in mind Georgian Windows would have had a standard form of catalog where you would have picked a unit and that unit is what you got. They didn't have bespoke windows and the key driver there was money and time.

Hungary and Poland have very skilled labor forces with much lower cost rates. We need to look deeper and consider the transport costs. Speed to market and time to deliver will be key. Logistics management again is critical. When we did a most recent project, we actually carried out auto tracks on the slab to show how pods could be moved into place. We use Revit and feel we looked at how the pods could be installed and then the impact of that installation on the critical path. We typically say that you need 6-8 months program time in advance of installation for the manufacturing stage. The main thing I would suggest is that IPD is the model considered. You need an open, honest, transparent, collaborative approach where everyone wants the best outcome for the project. Use last action planner with lean before you understand that process.

OSM #7

We have been producing bathroom pods for the last three years. We've been producing metal stud for the last 21 years for general contractors. We've been working for some of the main large contractors in the country. Volumetric is heavy. We've completed fire testing. We've completed structural testing. We're 80 to 90% complete in terms of our full certification system using Evolusion as our consultants.

We're seeking accreditation for multistorey on our system. We've built the single-story product that doesn't need certification for one private sector client. My first concern is about market confidence in the product, and scale and demand. My second concern is that the market is concerned about bonding security for a project. The traditional delivery model and traditional financing model are wrong for OSM. The industry is in its infancy, and is limited to just certain subsectors, including pharma and clean rooms. Our first project has pods. You need strong relationships or changing from traditional can be too challenging to convince them.

To go down the modular route, larger volume metric can be difficult to convince that first client. Financial certainty is a very difficult challenge. And I mean the model required. We are a very lean operator with high rate of in-house consultancy. Scaling requires direct hires and a full-service offering.

This includes delivery, and at key commissioning stages with a different level of care on sites. It's all down to experience and attitude. Pods are protected by shrink wrap. Volumetric will use full fireboard for temporary protection. Telemetrics can be very useful to monitor humidity within our pods. We give the general contractor trolleys and lifting cages to protect our structures.

Pods are generally hot rolled box sections currently, but we're manufacturing and use LGS. When the client's design team thinks they are educated on what OSM means, they don't fully understand various types of OSM construction, and the supply chain associated with it.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

If dealt with this could create security of supply around OSM manufacturers. There's nervousness in terms of finance, insurance, and accreditation for developers. They may want to consider OSM, but others in the sign-off stages are concerned about risk, such as lawyers and those providing warranties or insurance bonds.

We were sourcing the first three modules for a single-story product, but the client was nervous about certification. We are very supportive around strict fire codes and regulations. We would like to see that maintained and that standard being met by everyone. 90 minute internal external can be achieved. 120 minutes is preferable. We need support in achieving certification. We need a better contract with the NSAI. Everything is in place but a huge backlog in their system can have major impacts on whether or not you're able to offer clients the solution and guarantee you can deliver and certify on time. You can have provisional approval but can wait for months to actually get final certification. There's a six-month delay at the moment from NSAI and the AB. We're holding off on investment and staff and lifting equipment until such time as we get visibility on the certification process. We can achieve part L and part P without any further treatment. We can also provide a full envelope solution.

In the near future, we will have small one-story projects. Medical testing for certain logistics companies, working kitchens for catering companies and residential care homes.

We're talking to main project management companies about offering potential solutions into pharmaceutical and FDI sectors.

We are offering a new emergency department for a major hospital that is underway. We're working on a UK framework. We can license our design from a designer.

We can create a standardised modular design. A lot of manufacturers would be able to license it and let the market bid for the connection design and how systems meet each other is critical.

We need some answers there.

We need support from a National Center. A system for pre-qualification and tender to get on a framework signed with an NDA would be how we could see it working. A framework requires full design standards, a suite of designs, connection methods designed by the clients or their design team. We can then design in parallel, develop our own and innovate on our own system. We can be excluded sometimes because of a lack of developed products. We need to support emerging companies and we need to also make sure that the education system is ready to meet the requirements of this new manufacturing sector. A much quicker review process to control an OSM manufactured product is definitely required.

Private client #2

As a private client, we've had great success globally in terms of using offsite and modular. Most supply chain in Ireland is a great success for us from our point of view. Traditional Design Tender Award approaches is what we used to do.

But we're actively now working on a pilot project. We usually go out with about 60% design complete. We are now going out at concept stage to engage the supply chain.

In particular, it's the mechanical and electrical sector that we want to engage. We want to leverage off their ability to do design and build packages. That's where the expertise is. We're setting up to spend more time and more money on their designers.

Traditional design houses will not be in some of the same roles.

We were happy to previously pay the management contractors. But now fabrication firms are the ones that are growing the expertise and providing the actual value for the client. EPCM is a reimbursable format.

There's no incentive to innovate and drive down costs. We want to ask is the market ready to respond? Some are trusted, some are better poised than others, but we need to properly communicate that intent to those.

Some companies are comfortable, others need to confront the comfort of design at 80%. First issue for me is mobility and maturity to step up. Are there risks around that? Content has grown organically. Sprinklers have been standardized, designed and build installed and verified by contractors. BMS systems the same. Cold rooms remain as stick belt and the preserve of design houses. Submissions, approvals with huge amount of time and cost risk, are a waste.

There are less unknowns at later states if you can go to an OSM procedure. We see triple productivity versus current methods. Parameters need to change with earlier engagement based on less information. We are confident on modularization from concept level.

Our process would involve a tender with technical submission 50%, cost submission 50%. We see a four-to-six-week collaboration phase and then work with a traditional design house to potentially supervise on behalf of the client. We have competitive technical assessment, an assessment for cost and schedule savings. We then rank people based on that and hold a two-stage tender process. We would pay people for stage one. This requires collaborative involvement. The execution model is Design Assist as in an IPD type model. We have more control but less direct responsibility.

The new format will be two parts. One-part disruptive supply chain. One-part traditional design house. We need to have more competition. Must be a combined M&E led offer. Not all companies can offer it as specific to pharma. I'd ask how mature the sector is. Pipe racks on mechanical CIP skids are mature.
Other smaller companies who serviced the dairy sector in their distribution lines are mature.

We need to change transmission systems and to rely on more players and information flow. We want clean steam, Wi-Fi and purified water to be incorporated. We want to go as far as possible.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

The clean room is next to turn into a kit of parts.

We already have a full factory in operation delivered using significant OSM. It'll change in the next five years. A team of assemblers with enhanced digital capacity needs to enabled.

We need to get it together, build the factory virtually using project controls document with shift transferred from measurement in the fields. We need greater use of AR to verify the space. Measures evaluation space needs to be affectively managed, so there's no clash on site.

We need a more advanced BIM model. It needs to be designed and pre-conned. Proven so that it can be built in the required phasing. From a schedule side capacity and delivery piece, 6P is becoming a thing of the past.

Automated updates to make real time data with absolute scanning with Lider scan more frequently is good. A library of where things went wrong would help. One company we use, GagaMuller carried out a review over 6 months. Their plan loader software gave quite good geospatial management interfaces into the model and your last planner. You tilt your quality plans.

We have insight for up to six months. We are road testing in another country to enhance design flow and to inspect more interactive measures. Digital will enhance and set out the workflow. Only a few key people understand where the job is at. We need to broaden that oversight using BIM.

This project cannot be Dublin, Cork centralized. Need to evolve supply chains right across the entire island, that leverages regional companies to upscale them. It enhanced their offering in Ireland.

Radley in Waterford have a good fabrication system with super modules and structural models. Modubuild is someone that we've looked at. They have a large volume factory built. Perhaps we need a big-ticket international master supplier here in Ireland. Build it north, Southeast and West End.

Tier 1 M&E Contractor #1

I'm a chartered construction manager. The Project I'm working on topped out last week.

As a mechanical engineer with a Europe, UK and Russia background I have been providing OSM solutions in different environments and Geo locations for a number of years driven by a number of factors, good and bad.

I currently work on a large Semiconductor project here. The base build was driven by an OSM strategy from the client.

What happens here is very much at the forefront of technological advancements needed for our company to be active in OSM.

Prefabrication of small skids were being done since the 1960s. For example, the Shannon pipeline.

Our former experience has been quite successful in Sweden yet very unsuccessful in other areas such as Liverpool.

The level of BIM and investment in resources was only small and fragmented and no effort was put into how the parts as they get made add up. We looked at parts in isolation and needed to do it to LOD 400.

We can't do a hybrid version. The ability to sell to clients is key. Consultants are involved with the concept say at 30%. Then contractors get involved in the base engineering. There's a reliance on contractors.

If there is a fault, at full fabrication the blame is on the contractor. Consultants are reluctant to introduce contractors early. This does not give the client the value in their services. ECI is key for it to work, that equals cash savings.

Innovation with regards to bespoke development can be crucial. There is huge investment here in this project on BIM and digital. We can find problems before they materialize, we can invest in getting better solutions and I've seen a change in innovation for bespoke development delivery. The next level could focus on the integration of component manufacturers. Biggest cost is men and time. Assembly investment is paramount. Developing OSM is saving time on site. Contractors can struggle with onsite spend/earn ratio. If you maximize the efficiency in an off-site factory environment, that's a very significant saving for any project. The assembly line can give a good spend/earn ratio down as far as 25% of the site spend/earn ratio.

Good schedule, good safety, good record are foundations. Clients are driving the deliverables, including certainty and quality. Time requires early involvement. We also share with other global client manufacturing sites.

We need a centre to share in Ireland, push the limits.

The ability to transport OSM elements is a constraint, the road structure and the manufacturing limits transport. Councils are very different in terms of what they permit across the island. There are limits on nightly transport and constraints on infrastructure design that limits what can be moved. Whether it's head heights or bridge clearance.

In our supply chain we have standardization of certain elements, but we're open to innovation. Plug and play works well. They build it, integrate. Constraints on site lifting and safety onsite present challenges. If a client gets a consultant on board, it may not be best for the client.

Having developed solutions in OSM/modular for 20 years, I know exactly what they want, seek early engagement and whatever form saves money. OSM saves schedule time.

Some design houses are traditional and don't want to see that change been developed any further.

Some of them have realized they're not the experts in full fabrication but more want to embrace the change you demonstrate. After a project is completed, you must use AAR to ascertain where the value was lost and, what model should have been adopted? You need to give options. Value comes in many ways.

Involving QA support on OSM is also critical. There are big teams on an assembly line. We need to measure contentedness in those environments. If they know what they're doing and are comfortable with it and are interested things will be better. The environment is really critical as well. We must make sure that people actually enjoy working in a factory environment otherwise we will get poor inputs in and there will be a poor product out.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

There is less risk from external pressures and you can plan for that work. You can use lean, you're touching everything once. Employee satisfaction is something that would need to be monitored if we move towards a more off-site model.

The car park on this project would be an example. It is 10 years behind in term of applying existing methodologies, but we're trying to catch up driven by the client. Can you influence MMO, say, more towards modular? Yes, there are some specialist materials that are on a 14 to 20 week delivery. You can use certain procurement routes and a lot of collaboration with clients and suppliers that allows you to maybe move towards bespoke lightweight solutions. Lifecycles are very important. This demands very advanced assessment on how to measure.

Sustainability at the planning stage is critical. In Sweden it's embedded into the tender and you're offering that as you bid for a project. OSM is about avoiding rework. It should be very sustainable with a foundation of the QA process. Surveying and audit control is a very big positive. Tolerance is one of the biggest challenges.

It's a great industry for innovation. There's lots of young people coming into our industry, and it's very important to tell them the opportunities that await them if they harness the youth to bring in new skills. We rely on BIM accuracy. It was previously a cost and seen as a layer of bureaucracy.
Everything is going digital and that's a huge innovation in our sector.

Consultant #3

Some aspects of MMC are reasonably advanced. For example, Techrete with their brick slips, and unitised facades. This is something that needs to be developed but has not been done yet.

Bathroom pods have been in use since 1988. M&E is advancing well with larger companies, including Mercury and Jones. Move on to off-site fabrication facilities. Large skids off site can be plugged and played. We are seriously lacking in the area of modular construction.

Cross laminated timber is seriously lacking here. We don't have the infrastructure here to deliver these from the regulatory side, it's an issue. Systems can be tried and tested and understood. Non modular has no issues, so why, does it have an issue when it is simply turned into a modularised format. On a tender three years ago for a hotel group, the client was not interested. They foresaw problems. Replacing components, say the WC's and wash-hand basins.

If we are serving a project abroad, how do we set up an MMC sector here?

Payment is an issue. Design is an issue. Manufacturer investment is required, but they need to know that they will get scale of demand.

The LDA are working in this space as are Cluid, local authorities and approved housing bodies. We understand McEvoy made a €25 million investment in their UK factory.

It's not like a data center, with huge standardised racks. We don't have the well-established skills here to support a growth strategy but that must be encouraged.

Perhaps some foreign intervention is required to encourage them to lead. They could support growth. We need to instill a sense of urgency.

We must get developers to align client needs so we can define the centre. Client-led demand is critical. You must design for modular from the beginning. There are too many variations that kill the value of standardisation. Our company are applying a standard approach to apartments, layout detailing and sequencing. Modular demands standardisation. We need to be thinking about buildings being repurposed or recommissioned.

John Fleming had major success here in 2008. He created a new venture in the UK and that has been very successful over there. Facade was a major issue. We support the ecosystem. Austria has great experience in CLT. We shouldn't reinvent the wheel. We should simply try and apply technology transfer. In terms of procurement, the GCCC model will not work for modular off-site procurement. We need to move away from the RIAI and PwC forms. Modular seeks a completely different type of contract. Payment is back ended and needs to be front ended.

Systems in other countries should be considered. In an industrial setting you have a scheme design and detailed design. GE Healthcare's example that manufactures modules, all in a prefabricated format and links IP. We're working on projects that are cladding and prefabricated Truss systems. There should be the people that take on the role of research to show that CLT could be used and could work. They should have relatively quick turnaround. They should figure out where the best MMC is already and support developing that for our sector.

Consultant #4

I'm a specialist in construction quality and commissioning services. I act as a consultant and see it from design right through to client handover.

We're focused on the quality side sitting beside larger project management companies working as Commission managers on some of the larger projects in Ireland.

We are very concerned about how the project gets across the line to the client and how we get a smooth transition into operations.

Working with offsite manufacturers, we can see some inconsistencies at the moment. Design control is key. What's the starting point called in design?

We like to bring forward process and procedures that will support this. A lot of this is driven by schedule. Some clients will have nothing to do with OSM. Certain clients have a major requirement for OSM but don't understand yet how they procure it and also how they can manage it.

They have a completely different approach depending on what their culture is and also what the legacy of previous projects that have been delivered for them is.

Certain companies demand time to market constraints to be met. Others have a major demand for quality. In certain areas you can see how fabricators are the weak link, whereas in other sector designers are the weakest link. They tend to work on an hourly charge basis that uses the traditional model.

It's really about how it's done as opposed to companies dictating a model that suits their setup.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Some companies can have in-house design. Control can be very poor, can be incorrect, incomplete, or changed. In the meantime, documentation can be incorrect associated with blocks handed over to the client.

Really, what we're looking at is a model where we want to talk to the integrator as the integrator is key for us.

It's a new term that we use. And really, what they are is the person that can manage the BIM process and the facilitation or the interface with the OSM contractor. We've decided as a client to go with OSM. Stick built methodology still to a certain extent but there is a refusal to use technology that's already available. We need a control system based on an approach to delivery.

Clients are building projects to milestones, but systems are what get built so OSM must match that approach.

We need to build a way to leverage commissioning off site. Skids are sometimes too big and need to be broken down with new technology. Using a video link, we should be able to inspect remotely as often as we need to as we go in the factory. Documentation being issued on projects should be designed to be completed when the modules arrive on site.

There's a number of ways to check and inspect. It remains the same even if you go off site. Certain other major manufacturing companies have standard checklists which are repetitive and redundant but are provided simply because someone wants it. They don't even know what's on them.

There's a need for consistency across the supply chain. Quality can be seen as a cost, not an added value. The biggest thing for me is technology needs to be used. We need to scan barcodes and need to use a methodology for preinstall checks. BIM is the only way we're going to get to 80% off site for our client.

Our contract and key delivery strategy must be approached from a systems perspective. It is not the traditional discipline of M&E. There's a disconnect between building and operating. Need to move away from a dedicated EPCM to OSM contractors in a much stronger position.

Contractors with an ability to do modular build will have more market share as we do more joined up thinking. We're not there yet. Second big thing is we need a chain to show continuity of demand. The big FDI companies may have a five year demand span only. So, who will step in after that?

Maybe some companies will take on factories, but will they outsource more with more risk and carry less margin themselves? EIDA is a company that we use to assess this in terms of full understanding of the end game and track and documentation throughout the process. Information goes in, but it needs to be good quality data. Metadata will be important. The golden thread of information.

In an MMC center we want to see an integrated 3D model put into full lifecycle delivery that people can use, update and understand.

How do we measure customers improvement? Also training everybody in the industry. Whether you're in your 40s, fifties or just a new entrant. You're about to be obsolete unless you're up skilled and re skilled in the new method of working. We need master classes for younger new entrants now. We need to facilitate a cultural change and change in attitude.

State body #2

So, we have limited experience of working with off-site manufacturing companies. Some of us did work on them in the UK. They have a class system for modular driven by local authorities and supported by government. People tend to want to do things their own way.

Some of the standards that have been developed, for timber frame construction offer a potential model there for wider adoption. The industry can be a very fractured group with individual agendas, such as the Irish timber Frame Manufacturers Association. At present there is sufficient competency to build off site, but we need to produce a standard. One that meets the quality requirements using standards or common specifications.
OSM companies need competency but just want to do things their own way. There's no incentive for sharing and full-on best practice alignment of agendas.

Demand from main developers would be a big benefit. There's a fear that everything will be driven by cost and look the same. We have dealt extensively with some of these companies requiring certification. Dealing with IAB on LGS systems to BS 476 to cover their fire certs.

Try to get them to come together and commission shared tests, but they tend to refuse to do that.
There can be difficulty at junctions and thermal modeling for connection systems. There's a shortage of technical expertise to develop a testing regime.

We previously visited Austria to look at how things were done there. It was ok. Some of their housing came to Ireland in 2016 that included a single leaf timber frame system, but our climate was too humid in winter.

There's lots of experts available and I would refer to the Timber frame construction report.

In 2002, there were international tests conducted on systems. We have a different frost cycle from other jurisdictions. You can get three cycles here.

In Austria they have competence and qualifications on site and factories.

Here there's some good knowledge, but gaps in references. Standards such as SO54 can support the sector developing is a good example.

Deep retrofit is also a new standard being developed. Digitalization will be supported.

I would ask the question: Are there enough people with technical competence and willpower to drive standards.

Building regulations for modular are required. BCSA has a good guide. BOPAS is a good gauge for the method of assessing competencies. NSAI have a criteria document to engage and manage. There's a need for a national trusted center. A go to confidential center. We can go and seek knowledge and support.

Enterprises do not really have a strong link to policy. The recession in the sector reduced the number of competitors. Lots of people are doing some things in a smaller format. Or a smaller number of people are doing scale right.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

It is important that all government departments know and appreciate that building systems need to be certified. Government departments can sometimes not appreciate the importance of recognizing that. State bodies are up to their eyes at the moment in terms of demand for services, and requirements to meet certain policy imperatives.

Startups can be involved at a very early stage. Use of innovative products can cause problems. For example, magnesium board sweats, possibly resulting in sulfuric acid mold growth.

Products can be very good and will continue to be, but need to be assessed for the Irish market.
There are absolutely limited test facilities here. Moisture isn't something that we've dealt with in the past. Weather and climatic chambers would be very useful. The Fraunhofer Institute in Germany lead the field in terms of certain testing and would be something that we should perhaps partner with here. IIRS under Enterprise Ireland was something that was very valuable. You could get your test and you could talk to the expert who was flexible and was an honest broker.

OSM #8

We are a leading offsite manufacturing company based in Ireland with extensive operations across Ireland and the UK.

We are providing market services right across UK and Ireland.

We have a structural research facility based in Portugal that provides education, research facilities for our team. The three big issues for us are education, the realism associated with the project program and certification.

One concern would be where industry currently sits. There are pockets of contractors who understand MMC. But we can't go backwards to influence design and the modulator to rationally designed a pre-procured project.

We work in major civils. We also work in Nursing Homes, schools, train stations. I get more phone calls looking for precast walls next week. It is not a typical process of designing a standardized product that you can simply send on the back of a lorry to someone 100 miles away.

Mechanical and electrical needs to be designed first. We've been working on a facility for a large state agency where everything needs to be cast into the precast walls. 1500 wall panels. For a particular education facility project, there's builders work. There're significant requirements, and if we don't have that design completed before we start fabricating well in advance, we simply don't press the button. We don't even allocate the space on the factory floor for those units to be made. We will also work in nursing homes where there's no M&E designed. And we have to just leave starter bars in place to catch different elements that will be done on site. That's where there's huge inefficiencies.

The procurement model and when parties are engaged is absolutely critical. Education architects and engineers is questionable. They do not really understand how the system goes together. Consultant designs are a waste if no OSM has been involved and yet you want to introduce an OSM solution.

Designers need to understand the new model and that they need early contractor involvement. They need early OSM involvement. On the installation side. You can find yourself in a situation where you have a team that don't really understand what's common and how they need to be ready logistically.

From an operations perspective on site, working on these different projects can put existing systems to test and put real strain on people that are not conversant with just in time ordering and really sophisticated logistics planning.

OSM companies don't always want to share data. Consultants may not understand the thermal mass of concrete and the requirements in terms of design outputs. Certification including BCAR is a key issue. What certificates are required from a statutory point of view and what is required to meet the sub-allocation of liability that is driven by the project design team.

There's a need at design phase, for a responsibility matrix, and design approval process. The consultant should be feeding our company, not the other way around. If it is to be the other way around, and that should be very clear in the appointment documents the payments should flow in the same manner.

The last 18 to 24 months have seen a huge change. We have our building. We have the skill set. We have a project in this country where we've had a major manufacturing slot already allocated for the project, but everyone else who's party to the project simply hasn't come on board to provide the detail required in the right manner to allow us to fabricate on time.

We see value further down the chain. We've had requests for certificates of compliance with certain project requirements and planning permission.

We're trying to create alliances and we're looking at strategic partnerships with local schools. Presents short to medium term we are looking at pharmaceutical.

The full model needs to be coordinated. We're looking at mature clients that can integrate. We're looking at UK based consultants. We're looking at the green requirements over there for concrete. And we've also done a lot of work on this for major data centers here in the greater Dublin area.

We have pre-certification for APD, that's green in the UK. It is a key issue. We've drilled into our design mix. We want to offer the client a choice. A building Carbon calculator is key for client to be able to see exactly what metrics are in each material stream.

Production is at net zero. It's the input materials that are the challenge. Material suppliers need to be sophisticated. Need to understand what the requirements are going to be? Those little pieces are key and we intend to build the platform, not just software tools in isolation.

Bridge beams that we use are technical manuals. These are free datasets we like to share. Put on 30 kilometer tunnels down power stations. Logistics have not been an issue. In terms of Brexit, the UK is 70% of our turnover. Export documentation can be difficult, automation of logistics and UK export system is something that we've developed over the last 18 months, which is quite sophisticated.

We're delivering a digital ecosystem, and we're bringing that forward together with our manufacturing system. We've checked Salesforce, we've tried Revit neither of them worked. We are closely aligned, mostly with Tekla software and that works in the structural elements end of the sector.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

OSM #9

So, I've looked at the three biggest things that affect our ability to operate as an offsite modular company. You can do your offsite. You can have your agreement, test and certification. Then you go to site, and you have to go through it all again. You're basically duplicating the system and removing all the value from the entire process.

BCAR consultants can establish a framework that can be very difficult because they're imposing standards way above what's required, either in Ireland or in ISO.

We have our certificate. It fits our model and the product's performance requirements.

Then site based BCAR with assigned certifier gets involved and demands something completely different. A different level or some other template that they use themselves.

We can offer full volumetric and we offer pods. We have double certification in place in those systems. The question is how design certifiers see their role moving forward? Or do they fall into the OSM journey?

When I compare the BIM journey to the OSM journey we are now in we cannot follow the same pathway. To a huge extent we pretend that BIM is working. We make it look like it is working and in the end as the client never uses the asset information it never gets flagged. You cannot approach OSM with the same approach. We are actually manufacturing the project in a factory, it needs to be right, otherwise you will have major problems and an expectation that significant elements can simply be changed upon installation. That's not how it works.

BIM had the potential to be a game changer for the construction industry, but it doesn't deliver.

Second big issue for me is that we must change, the way we operate. You need early contractor engagement. The hierarchy of the team has got to be completely redefined as a modern team. Design must be done prior to tender. That's the ethos behind BIM. The end user in mind.

Asset management in mind.

MMC will only work when design is frozen. We need a full concept design from a client or developer who then gets good cost control information and understands that they have certain elements of budget locked down in a modular solution.

Good example would be the pods for bathrooms or kitchens or utility rooms.

Construction clients need to grow up. Cost consultants have a big role. The traditional role of the quantity surveying company is changing. We can take design and get better market rates. You have to go down a trust route. You have to use open book. Schedules with variable finishes. Some general contractors want to get an understanding on costs, but some of them are trying to split apart your manufacturing process to see where they can save about money and offer alternative products in your supply stream just to try and carve a bit more value for themselves. And that's completely confrontational and completely counterproductive.

We are just about to go into a large volumetric project at the moment, but we need certainty of demand across the year to be able to justify the investment in our factory and our capacity. We've looked at a JV with large developer. We need that scale. The government framework needs to be guaranteed. There's risk for new entrants. We need to look at residential low-rise houses, Mid-rise apartments. We need a partner and then potentially will become our own client.

Volumetric is repetitive services. But how do the OSM companies make it work? How do they become versatile? Our primary system is hot rolled steel. Cold rolled and infill panel system. Our system has all the flexibility of temporary with permanent quality. If you can tighten up on design and repeat that design, you can preplan projects because you have a module that works.

The big issue of certification is not a problem as we have it but it takes time. Acoustic and fire must be in a National Center. We want to see factory acceptance tests. If it's completed in the factory, it is insane that you may have more certifiers looking at a traditional model to seek recertification on site. They should not be allowed to look at it again on site.

Everything should be verified that is completed and it's simply about the junctions, the application, the connections and making sure that things haven't shifted when they've been installed and lifted, and fully certified. A lot of it is based on opinion.

From a finance perspective, there are a number of models. We have an acre and a half of pods made in our factory. They are waiting to be installed, so there's a huge cost of storing them and a huge cost of pre manufacturing. Consultants need to have a better understanding.

Current payment structures are initially clients will pay for a product that is manufacture. Vesting certificates should be something that's considered going forward. Early completion is key. Retention should no longer be required. Sectional completion is something that should be considered. Defects liability certificates could be released as soon as elements are installed as opposed to waiting for someone else.

The form of contract is broken, and we need to standardize this, make sure that it's fit for purpose and meets the model that's required.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Consultant # 4

I currently work on the demand side for the client as a designer. First, is client demand needs to be lined up. We need to understand their needs and their demands.

Quality, speed of delivery, audit, and quality control.

The economic pull of a number of clients would be very influential in making offsite modular/off-site manufacturing work for construction. There are institutional investors. They like certainty they need control. They like guarantees and the ability to supervise.

There is a focus on client typologies and that needs to be properly engaged. They'll drive it first. UK manufacturers have no problem finding finance. There's a need to invest in large pilots. In the UK investment is piling in from China, Korea, Goldman Sachs, etc.

Second big issue is compliance and legislation. Government can ensure regulatory systems and structures are set up to respond. We have systems here in the UK where government agencies are not set up to do things and respond. We need to set the groundwork and prepare regulatory structures to be ready. There is a perception that the UK has cracked it but that is not the case. There are countless white papers and standards, but the industry still does not operate to the level of efficiency that can be made out sometimes. Ireland is quite advanced beyond the UK but only in serving certain subsectors.

Time is often the main driver. If you have to wait six months for a compliance officer to sign off on something that they have seen before that's a challenge on the customer side.

They don't care if it's made in a factory or on site. There are many issues with ensuring that they are primed and ready. Since Grenfell is a lot more interest in the specifics of what is being installed certified and what has been tested.

It's interesting the way insurance providers view risk. They see repetition as an opportunity for failure and improvement. Designers versus insurance is an issue.

We need a respect-based insurance model. It is talked about, but not used by many. We need an insurance product that is government backed. For the first six years of the product installation.

The MMC market is bobbling along, but now meeting, challenges and regulation in the UK

A lot of ability, but not delivery at scale just yet. You must have smart clients. Put in place a good financial flow. The investors tend to look with a cold eye, and they can get good finances to flow. The problems can be an unusual form of insurance or contract, but these can be overcome.

I looked at a 500-student room project one year at an early stage. I suggested traditional versus factory tracking to see what benefits were derived from the chosen model.

During the pandemic, traditional sites closed for a long time. Factories only closed for a week and reengaged very quickly.

Third biggest issue is skills and knowledge. Everybody having a go to experiment, but making disasters. The interface between traditional elements, contractors and manufacturers can be very risky.

The finance model, program on site and technical understanding are my biggest concerns.

OSM think about this in a different way. There are two different sectors merging together. It's important to realize that you do not need to do small pilots. That's too expensive and it doesn't deliver enough data. We need substantial projects with tight controls and a really good, sophisticated supply chain to be able to pilot whether or not something will work effectively. You need a big education framework here in as in the UK we have a £4.5 billion one from the Department of Education. It is aimed at MMC manufacturers and we have a focus on that as a national skills project. The manufacturing Technology center in BRE have a research hub that's built in to support their work.

CITB have been involved to a certain extent. But they're primarily tasked with delivering the traditional skills are not future skills orientated. There's a defined period of time to get them ready. We have got to get the private sector involved here. The procurement model, how to fund and bond are challenges.

People we work with are capable of doing manufacturing and construction. There's a lot of difference between manufactured and the traditional site-built design and build requirements from the contracting team.

FAC contract model is worth reviewing as well as versions of NEC I make reference to David Moseley and Kings College work in this area.

Also, Sekisui came into UK with its superior technology from Japan. LG from Korea, have also looked at the UK housing sector building typology. The choice above 7 stories should be concrete and steel
The Irish Center really needs expertise in subject matter. Warrington are good at doing a specific job, will test and give you an answer. That's what I learned. OSM needs to have testing capabilities for some major problem to bring confidence in the long term. There is too much reliance on desk studies. We need to make sure that we cannot allow OSM to be open to interpretation. Regulations are about performance and not prescription. For sustainability. What do green funds seek? What are they outcomes required and will they bother to measure it? The RIBA Modular Housing Handbook is a very useful guide.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Public client #3

I'm working for a public client where we have a €2 billion capital development program. Over the next couple of years we are responsible for procurement and design. It is continuous in a complex environment. We have a number of very technical projects with live working environments that need to be maintained including replacing full existing systems.

We found OSM to be a huge value and scan 2 BIM.

We build remotely, install scan to cloud. We use BIM 360, factory acceptance testing. We have full fat testing before it arrives. Pre-designed, pre-tested turn around design of each section of a new project.

It is much more efficient. The contract and procurement model is complex. We've got complex construction, complex installation, we design. manage, construct. It is being developed through management contracts. We have the right framework and contractor price is what they can see. But we retain provisional sums for a very limited number of unknowns.

We try to develop our design as far as possible to RIBA Stage 2. We need knowledge of the market, and we need to understand how to pay contractors for inputs at pre contract stage, what they're doing, what they deliver, and how much certainty they will get from that process.

Number one is getting the right contract. Two is extensive use of them when they are developed.

Then establish client awareness and get protocols set up so that the team can respond to your requirements. JCT is a formal contract we use. Then we design, manage construct based on. Theres a wholesale move towards also an NEC form. We have quantified cost risk assessments. We have quantified program risk assessments with shared risk registers.

We add value with maximum early risk analysis and management insurance and risk minimum disruption. To continue operations but absolute certainty right first time and the highest levels of safety. I've also looked at our peers in other international jurisdictions. Some of them wanted to set up seven different centers of excellence across international locations to have specialist technical delivery and expertise in each major sub-material stream.

We mapped the resources that are available on the island and some of them are clustered. Having better oversight on that would be much more helpful. If we had our way, we would have 100% offsite. Safety is paramount for our client with roughly a total so far of 1 1/2 million man hours worked with no reported incidents.

We don't see it as having to pay a premium, we're concerned that we're tapping into the same pool of labour and contractors as the traditional stick-built market, and we'd like to break away from that.

Knowledge of the pipeline for our suppliers can be key. We provide them with a certain amount of demand, but they need to understand all their clients would also have a demand for their services. That would be very powerful.

We have frameworks with tier one contractors, other clients in our space have frameworks with tier two and three. That gives the market certainty of demand. We use a management contractor model.

That allows us to choose our providers. OSM must be visible. We're providing tunnels here, so we need early contractor involvement.

Civil engineering projects require end user performance criteria. 95% is design and build.

Customer is very sensitive and has a certain number of touchpoints. We need to be more controlled when it pre agreed profits and overheads. The joint tender process that's mature.

We have tried to buy all our products from Irish sources, but that's not always possible. Sustainability demands are huge.

A reduction in our carbon footprint, particularly for new capital asset delivery is going to be more important. We'll be looking at the electrification of certain assets that we already have, and that poses big challenges as we try and choose the right product streams and methods of delivering those projects.

We're looking at major market disruption there. The new regulations have changed project requirements. We are 100% conversant with BIM 360. we use 4D Since 2006, 3D with time added that's linked to costs also.

CE Marks on products was a bit of a challenge. We've had European contractors who wanted to bring in a modular Civil structural element, but the components were not CE marked, and that was a challenge. Bringing those together can be very beneficial. We should really leverage sustainability for manufacturing on the island.

In terms of a BREEAM or LEED Gold, is 50% based on transportation. So, if you're able to offer a really sustainable product here, it will get a much better market response because of the lack of international logistics involved in delivering the site.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Public client #4

OSM has not been used widely within our public client.

We have program directories. We have access to site challenges. To get on our site is a nightmare.

In terms of projects, we are building there are plants for electric charging of vehicles. That is something that we're trying to focus on in our asset care team. They wanted to build it offsite, but you need to see it on site.

We've reviewed the Facebook project and their attempt as an example was to manufacture electrical units in Donegal using E&I.

A new major project in the UK is all off site. That requires a slightly different team. We've looked at Manchester and Heathrow as models to follow. We should be saving money, should get better effectiveness.

Clients want to see metrics on savings, design and that the build is better. The process could be much better.

One of our teams on Monday looked at this contractor who is the expert bringing ideas and initiative to the fore. The ECI process is where you want value. You don't design it so far that the contractor can't bring any further value.

We need to focus on procurement of the end-product, not how it's built. Large multinational contractors have been to visit us and explained how they are doing this in other jurisdictions.

They've got an offsite process. They wanted to explain lessons learned from FDI projects here and allow us to use them as a consultant.

When our investment program was being advertised, other companies didn't show live related projects.

Getting M&E teams to secure delivery is key.

We don't deal with them directly anymore and that's an internal capacity issue. This is the way we've done things.

Value efficiency and certainty. We work with those who really want to drive differentiation between tenders. Quality control and offsite is something that is really important. How far can you modulise and how far can you whilst still managing that process.

We had 2800 people on site at one stage, but with a fully modularized project we should never need those numbers again on site.

If there's a National Center being set up, I see it pushing the boundaries. How do we do this in the most efficient way? Consultants can be very influenced by in-house client-side teams and that needs to be challenged.

Consultant #5

As consultants we've used modular in healthcare, healthcare, construction since 2011.

We used modular for temporary schools with modules for health care and design and build contracts, but don't get as much detail from the manufacturers. The biggest issue we see is there needs to be more openness in terms of design details.

OSM has a bad image and lightweight options like timber and steel and schools' projects in particular.

We stick to tried and tested methods. We have a reluctance to use something totally innovative.

Designers need to see inside the OSM black box. We had a project involving reviews of pre-manufactured steel core, steel plates, fusion rods, and full concrete with a twin wall type construction. The stacking of modular pods worked effectively.

There is no open shared evidence about how buildings have been designed and tested. There are reservations about going over four or five stories. We must have test papers available on pilots. We need open-source documents that show how certain systems work and can be adopted again.

An MMC Center could support this type of evolution and provide proof of concept and replace what we had in the IIRS.

PI is the biggest issue for us at the moment. If it's not durable, robust, it simply will not be banked on.

Multinational factors also. There's little scope for innovation in a very risk averse, quite strict investment market. There's a fear over fire. The PIA challenge is blocking cross laminated timber. We've been asked to start looking at it in UK, Netherlands, and Canada. They are already using it extensively.

In terms of fire, Dublin Fire brigade can have a very subjective opinion.

We may want to look at cross laminated timber, but the fire consultants would say our PI doesn't cover it. It's a nonstarter.

They don't want the risk. Certain people we know are looking at sustainability types of material,
Concrete GGBS content using 70% GGBS and concrete elements for radiation shielding would be one example.

We need independent testing of materials?

The end user drives sustainability and if they don't care, who else is going to care and why should they? It's not just modular design for manufacture and assembly. SFS systems are still required for frame buildings with flexibility for future adaptability, and flexibility for future adaptation. The third issue is the procurement model. It is a big risk in healthcare with existing services and topography of the site.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Better visibility of who is able to do what would help. Contracts are too inflexible. There's no ECI, no innovation enabled. Little flexibility without a two-stage contract.

We have used intent management type contracts which work. The main contractor then send out standard packages. The biggest issue is the contractor comes in when design is complete. A Pre-Construction Services agreement is very valuable and used extensively in other jurisdictions. A design team is novated over to the main contractor. The market needs to see scale of demand to drive supply capacity.

Competition in terms of procurement should focus on differentiation and quality. What is their QA/ ISO process?

There's one big precast manufacturer that documents the QC process. Some don't care. We're really behind on Passivhaus large scale housing. Design responsibility is critical. The HSA code practice for anchors sets out some useful guidance and certain elements that could be adhered to.

The framework for each element of design and offsite technical capacity s well as supervision of installation are the critical items for us.

OSM # 10

For me the first key issue is early engagement. The contract and procurement model drives a traditional route. And if that's the way you're going to keep going, it's going to end in failure. You cannot move. You cannot deliver OSM in a traditional project.

You have to start with OSM in mind. This dictates different delivery on the finance model. It restricts our ability to broaden the scope of our premanufactured valley or PMV.

Second big issue is a very volatile industry and lack of stability, due to the boom bust cycle. You look at a five-year payback when you invest in a factory in the equipment, CNC machines and skills in the longer term.

But more development is required. We currently export to UK. We started in 2008. We are the first company to have a passive house system for the UK market. We created a niche for ourselves in terms of passive schools, residential housing.

We use 2D frame timber frame wall with service battens on the inside and insulation. Twinwall partitions fully slabbed.

Third issue is developers have too many unique wants. Subjective wants on internal finishes. We note that other providers are looking at the supply chain and the system is a major investment. There in automation and machinery. One CLT project in UK uses glue LAMS C16, graded mainly Scandinavian imports, material supply chains and the impact of price increases can also have a major impact on the stability of our model.

Other material streams need to be considered in terms of response to moisture. And a mixture of different types of trades is something that needs to be concerned. Carpenters in general operatives, machine operators, internal training system is what we've implemented. The product needs the ability to change between designers.

There's a lot of architectural technologists in our team completing certification tasks. We don't have issues. We buy timber that is certified. We have chain of custody certification. With particular wall type floor type, it's fire tested. A new National Center would need to have significant scale and investment. It cannot be slow. We need central technical expertise.

The investment is very challenging, particularly when it comes to tax benefits? Fragmentation of supply is challenging.

We don't offer a facade system. We want to go inwards and outwards in terms of our integrated product supply enterprise center. The University of East Anglia has a passive building Center.

There's no public sector demand here yet. At the moment what we can see is only developers. Only the UK can build up above the six stories we have here in Ireland. Multi Story is an issue. Local fire officers also have very subjective views. There's no consensus. A centralized National Fire Officers network with a central fire authority for the country would be a big help. The market here in Ireland is only so big. And even if a dozen large clients got together to show a demand pipeline it would have major implications. The current Housing for al strategy is only be for a very short period of time. Relatively speaking procurement needs to identify what needs to be installed. We need to build efficiency into the system, certain trades or an efficient which affects the overall benefits.

Consultant #6

We have invested significantly in this subject matter area. We're focused on technology digitization and offsite.

We can see client demand 85% of projects to be delivered offsite by certain clients. I focus on the life science, data centers and residential. All residential developers want to get into it. They want competition, and want to support the development of sub-supply chains.

The first challenge is a financial model that requires a major cash injection upfront. Second challenge is design. The process demands a freeze and early sign off.

This can be restricted by planning. Regulation is a major barrier to UK markets being different from here?

ABP and judicial reviews cause a challenge. Fire officers need an education on a single system approach.

I looked at an 800-bed system from Sweden that got planning but it couldn't get approved at the regulation stage. The issue was the facade system tying into the structure. We also looked at a hotel project here with a 100-bed extension and again it couldn't get approval.

In the Nordic market it is 50% off site delivery at the moment.

Second, big issue is mindsets. We are not there yet. People are stopping before they start. Third, is building capacity through offsite factories. Investment will only take place if business demands the OSM option and regulations stop acting as barriers and becoming facilitators.

The fleming model in the UK is very successful.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Our experience is, contractors and designers are afraid they will lose their piece of the pie and erode their services. OSM embraces digitization as the best model.

Take up is constrained by the regulatory system major projects. M&E are already doing it in the Children's Hospital and across the FDI sector both here and across Europe.

The model of the fire officer and regulatory system is broken. There's a two to three billion euro framework in the UK healthcare system alone. Fire regulations here need to change. 2006 since the last changes, the easiest answer is to say no. We don't want to prove it. Productivity is in creating higher value jobs.

An MMC Center should include for manufacturing robots and technology. It should facilitate mass production on a scale that the country can support.

The concept supports better funding and tax incentives which should be available for the supply chain to invest.

We're not doing anything new. This is technology transfer proven elsewhere, geographically and and in other industries. In terms of comparing against traditional for current cost savings there is very little difference. The process should bring efficiencies. The housing delivery model in next five years must change. The current model cannot cope. We looked at a single new model of contract that needs to be collaborative. Share pain and gain. There's no funding model. No early payment, unless there's evidence of value delivered.

The system needs to mature so they can self-sustain.

OSM #11

So, I work for an OSM manufacturing company. We have 175,000 square feet in Kilkenny dedicated to volumetric building.

We also have a new Center for innovation. We set up with the objective of being a modular company. Our first job was in 2009 using MMC.

In 2012 we did one full modular unit for a project and in 2013 for a full pharmaceutical project in the Northwest. In 2019 for a major pharmaceutical project in the northeast of the island.

We work with some of the large tier one mechanical and electrical companies, and they use us as a partner where we do the CSA element. We needed a lab to be up and running within 12 months before the manufacturing in the pharmaceutical plant would start.

We target internal fit out, white walls, clean rooms, datacenters, cold aisles, hotels using companies and partnerships.

We have common shareholders with our cleanroom company.

We use high tech volumetric. We're building a data center in the very north of Sweden, which has major constraints in terms of climatic conditions, and we've identified there a half million saving from no working at height.

With full PI cover in place, we used McElroy and Associates as our designers. With a factory here that enables us to install mechanical modular solutions and metal.

We also use a timber frame facility. We bought that in 2014. As part of our €10 million investment enterprise Ireland have given us some support. We were the main contractors for that pharma project and Wills Brothers did the foundations for the labs.

Number one for us is early engagement, that's key. No point in designing a building and then trying to modulise it.

The consultants pushing former clients to use OSM. Education is critical. You must have an OSM. Module in an OSM mindset shift. This is change in a multi-generational approach to how we do construction.

The second issue for client is to surely understand where value is.

We want to protect their solution and to bring clients on a journey with built prototypes and show clients in data centres. Life Sciences, HSE, etc.

Educating clients is key, showing them how we are saving them capacity in not just architectural but also full M&E services. We have an overhead model for one M&E contractor. We launched an apprenticeship scheme in recent weeks, our internal talent manager looks after all the CSA trades for, supporting trade specialists doing multitasking.

Our key objective is to take more hours offsite in a sustainable way to be the clients choice. We would be glad to change from steel, but that's not a runner in the short term. We have an environmental sustainability manager just started.

From a regulation's perspective, fire engineers. We use the consultants McElroy. Our unit is built using traditional methods in an off-site setting. So why does it need or why does it not pass the existing regulations and technical guidance documents?

BCAR brings complications that are not required. For HSE, the class uses are demanded. They Demand different fire ratings and again that doesn't make sense. Does there need to be a long-term lead? For let's say for example, four years were involved to pre-con a Swedish project. MMC demands centralized support. There are barriers to entry. There's a requirement for R&D, procurement challenges and getting to full operational capacity. The facility is also difficult to set up and run. Different sectors have varying timeline sand capital programmes. MMC centers should critically have fire test, structure, and acoustics. The challenges are the supply chain changing the mindset from construction to manufacture. Operational excellence with a lean approach to tendering process will definitely deliver benefits.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Consultant #7

Regarding my introduction to modular construction, OSM & MMC, in the 1990s, I was a skilled draftsman and would hand draw isometric projections, which would be prefabricated offsite and delivered to site as finished product. Examples of this were: precast concrete stairs and entire hotel floors - bedrooms, bathrooms, and halls. In 2004, I was involved in the development of a package plant room, which was installed on the roof of DCU Nursing School. We also installed bathroom pods in the Shelbourne Hotel. BIM afforded a good opportunity to review our projects in bite size pieces, which provided the potential to identify modular OSM potential.

I found that we always struggled to manage electrical systems when it came to modular, compared to mechanical systems, because you do not have joints, you have one or two of them, one at the end and one of the at the start and mechanical systems have more to the joints, which enter into a greater degree of risk for failure. Then you probably cannot do the full turnkey on a modular build.
The client needs verification that everything up to code before it leaves the factory. If you have not completed the electrical systems at that point, you still have that to contend with.

I think that, as a culture, the industry struggles with respecting everybody else in the supply chain, so for me, the three things we need to focus on are respect, communication, and my company motto, which is “connecting strength”.

There is no communication in the industry. So, I thought about it in terms of technology, the technology we are building into projects and everything else, it is a learning system. It is a continuous learning system, and it has a feedback loop. BMC Systems are constantly telling you what is going on and they’re in your building and your data centres, constantly telling your clients the conditions of the spaces. There are warnings and there are alerts for all of that. We would not deliver a project without that element working and functioning. That is missing, I think, in the construction industry as a whole. But it’s probably natural because of the competitive nature of the industry. You have to stay competitive, and you don’t want to give away your secrets and your unique selling points.

I previously worked on a project in 2009 where the client referred to every single standard. This was an onerous task to deliver, and we were then asked to demonstrate where each standard was evident in the client’s building. This is something that does happen within the industry. It’s something that my company delivers on a daily basis, whereas I don’t think the industry does this as a whole. There needs to be some sort of standard testing, not just whether it’s lean, productive, or whether the products are certified.

I think there is a gap here in Ireland as regards standards, most of us go to the U.K. for that. I also think there is a need for an open culture, everyone is here to learn and here to share be it positive, negative, confidential etc. This won’t suit everyone, and it isn’t a “one solution fits all” but it’s a great opportunity to learn.

Essentially an accessible, open culture that is welcoming for all, a learning centre for all tiers of the supply chain. If everybody shares communication, it’s not just about the top people or the bottom. There are too many people sitting in their bubble and bouncing everything back out. You need people who will fix problems, come up with ideas, be innovative. Innovative isn’t just a company going with a new innovation. It’s every individual having a voice, to a degree.

We need a lifelong learning centre for all tiers of supply chain. A welcome and accessible, open culture.

Consultant #8

There are a significant number of challenges. As a certification body challenges to get lots of different components joined up. To work effectively, first we must work on an assurance scheme for all finances, investors, and factories. Get mortgage lenders to accept the building system insurers and the warranty providers. Or do you get them all to join up to agree to a single process. Second, as you scale it is important to make it efficient and effective and what investors want. We need to create demand so a high number of small manufacturers and a small number of large manufacturers can develop mass produced in a more standardized and more sustainable way.

The condition of the system arriving on site is important. Installation and damage during transit is very inefficient. Traditional versus flat pack. Homeowner versus investor. These are all juxtapositions that need to be considered.

There is a standard in the UK, developed by BRE BPS 7014. It's a standard for modular homes. It's a performance-based standard bringing together one or two manufacturers. Third issues standards. The National Building Control Office, the Chief Fire Officers organization need to have a standardized approach.

We did prove beyond reasonable doubt to give them satisfaction, and you have very successful but subjective opinions.

The LDA move in Mullingar is very welcome. There should be a sharing of knowledge among manufacturers who will participate. We need to support a center dealing with IP and housing multiple providers. A construction innovation hub, such as the one in the UK, has BRE and Digital Built Britain and Manufacturing Technology Center. At its core there are multiple manufacturers in a common system, legal and finance.

They are a challenge, but they can be overcome once we provide the assurance for people and the right documentation chain of evidence.

The DH CLG have set up a new task force. They want their own pilot with stakeholders in the UK and an early adopter group. They provide proof of concept then the insurance federation could step in and support that. We need a cradle to grave across all material systems. Need a quality management system. Order control and certification to back that up. BRE I would like to develop the BOPAS here for Ireland. The BSA are talking about a PS or a British standard funded by a consortium in China. A 2D panel system requires fire and acoustics testing. Approved housing bodies such as cluid could be leading the way here in Ireland.

I suggest the setting up of a national Chief Fire Officer in Ireland. I'm head of sustainability here in Ireland. We need a single national authority for both fire and other technical requirements to be approved, such as disability. That is beyond any local jurisdiction and technically competent.

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Breakdown of Key Requirements for a Construction Technology Innovation Centre

Interviewee #01 stated:

- Integration of research needed with the Façade of a Building.
- Testing is fundamental for Product Confidence i.e., NSAI / BRE / EN standard needed.
- Education & Training of the Stakeholders in MMC / Modular Construction needed. Not fully understood (with CPD points awarded for MMC courses delivered).

Interviewee #02 stated:

- Need façade types, research, modular solutions needed from a Research Centre.
- Fire Engineering - knowledge, research, and testing.
- Volumetric - need a harmonised / digital process for your systems. More Innovation needed from the Supply-chain, also.

Interviewee #03 stated:

- Requirement for Fire Testing facility in Ireland.
- Need to push the boundaries for Acoustic testing.
- An NSAI standard for MMC / Modularisation required, incl. a reduction in testing cycles (too much repeat testing work).

Interviewee #04 stated:

- Testing is a big requirement i.e. Fire, Structural, Acoustic, Thermal, etc.
- Golden Thread required - sharing of information for Quality & Certainty.
- A MMC / Modular Certification scheme is key the approach.

Interviewee #05 stated:

- Enhanced Design capabilities needed - Technical & Engineering knowledge needed.
- Has to be for combined MEP offerings – from OSM providers.
- Lack of capacity in OSM supply-chain – need to develop this further.

Interviewee #06 stated:

- Create a MMC standard for the industry.
- Education & Training needed on MMC / Modular.
- Standardisation of Testing i.e., Fire, Acoustics & Structural.

Interviewee #07 stated:

- Approval of Products i.e., slip bricks.
- Robotics & Automation.
- Putting companies together with Global Manufacturing initiatives.

Breakdown of Key Requirements for a Construction Technology Innovation Centre *(cont'd)*

Interviewee #08 stated:

- Confidence in Compliance – a certification scheme is required.
- MMC standard(s) needed.
- Research / Knowledge bank - for good conversations on changes coming down the line.

Interviewee #09 stated:

- Back to certainty needed - a Lean Construction contractual approach / framework is required.
- A lot of bravery required in a room - for the contractual relationship & risk sharing model.
- A Right First Time (RFT) attitude - just do it, is required.

Interviewee #10 stated:

- To bring the Main Players together incl. Govt. Bodies & Certification teams.
- Educating People & Clients first - is really needed.
- Nervousness on the operational side, particularly around the Finance, Insurance and Accreditation needed.

Interviewee #11 stated:

- Focus on OSM / MMC Supply-chain further - need regional suppliers.
- Disruption of the Traditional Procurement route / supply-chain approach.
- Greater Automation of the OSM / MMC process, for updates from the Factory & the Field.

Interviewee #12 stated:

- Education, first and foremost.
- Understanding of the different MMC types /definitions.
- Fire Codes / Regulations very stringent - Accreditation scheme needed for MMC.

Interviewee #13 stated:

- RDI - a modern version of a Facility for Research.
- A Training Centre for the Industry - on Sustainability & MMC
- A facility on How to Retrofit & Refurbish old Buildings.

Interviewee #14 stated:

- Integrating 3D / BIM Levels into MMC / Modular Construction.
- Education & Training of People in how projects are delivered successfully.
- Need to close the Skills gap with Education & Training in MMC / Modular Construction (as +50-year-olds will be retired soon). How do we measure MMC / Continuous Improvement / Productivity?

Interviewee #15 stated:

- A Group of People experienced in MMC / Modular to go to.
- Much quicker place to Research & Investigate MMC solutions - Trust & Confidentiality is key.
- Building of a Knowledge Library / Bank on MMC / Modular (no need to go to the UK).

APPENDIX 3: **STAKEHOLDER INTERVIEWS** *Continued*

Breakdown of Key Requirements for a Construction Technology Innovation Centre *(cont'd)*

Interviewee #16 stated:

- Research around Sustainable materials.
- Link between difference Material Providers, particularly for Embodied Carbon, Additives, Polymers, GGBS, Glass, etc.
- Digitalisation tools - an ecosystem of Digital solutions needed.

Interviewee #17 stated:

- For Factory Acceptance Testing (FATs) - to an Approved Certification system / scheme.
- Need Early Involvement from the start and an agreed framework for same.
- Financing arrangements and Procurement route and Payments (is a concern) – need a solution for this.

Interviewee #18 stated:

- A place for good Knowledge of MMC / Modular expertise.
- A Testing Facility - is actually important in the long run i.e., Fire, Thermal, Acoustics.
- Building regulations - to ensure they are clear for MMC / Modular & for the exploration of Green Funding by Irish Government.

Interviewee #19 stated:

- To have the Market & Stakeholders conversant in MMC / Modular Construction.
- Education & Training - to bring OSM Providers / Contractors along.
- To QC check everything with certainty - Virtually if possible. (No old approach of the previous Inspection regime)

Interviewee #20 stated:

- Seeing 'cutting edge' technology in use.
- New MMC / Modular alternatives / solutions.
- Pushing the boundaries of MMC / Modular Construction
- Driving Innovation & Value.

Interviewee #21 stated:

- As a Testing facility.
- As a Research & Development hub - we need agility, for the future.
- Education & Training for upskilling in MMC / Modular Construction.

Interviewee #22 stated:

- A Proof of Concepts test bed facility.
- As a Research, Development & Innovation (RD&I) facility.
- Different levels of Quality / Standards at present, need to research an agreed approach / approval scheme.

Breakdown of Key Requirements for a Construction Technology Innovation Centre *(cont'd)*

Interviewee #23 stated:

- Robotics / Automation applied to MMC / Modular Construction.
- More Mass production, through research / innovation.
- Need to bring everyone along on MMC / Modular.
- Also, where Tax Incentives would be beneficial, if available.

Interviewee #24 stated:

- Fire Testing facility - Doors & Panels tested together.
- Protection of company IP (Intellectual Property) on MMC / Modular Construction.
- Technology along with BIM is Key.

Interviewee #25 stated:

- Degree of confidence for all – Certification scheme.
- Standardisation – acceptance by Certifiers
- Sharing of Research & Knowledge required.
- Multiple OSM providers of the same materials / solutions, is needed.

Interviewee #26 stated:

- To have MMC expertise - that is pragmatic.
- Strong People that are involved in MMC / Modular, as a support organisation.
- Lesson Learnt library – developed with some Training & Support videos / explainers, also.

Interviewee #27 stated:

- As a Learning Centre - an open culture for People / Industry.
- Sustainability: For the reuse of materials and packaging.
- As a Technical Engineering hub for SME's to utilise.

Interviewee #28 stated:

- A TGD needs to be developed for Modular Construction - to refer to as a standard i.e. a safety net on standards.
- Need a certification scheme / system for MMC / Modular structures i.e. BRE 7014 standard, BOPAS / NSAI led.
- Client understanding: Need to understand the importance of a 'design freeze', once modules are In Production.

Interviewee #29 stated:

- Training & Education - particularly with the Software available.
- Learning - need to improve the Procurement process / discussion (how this is managed and fully integrated).
- Structural testing facility.

APPENDIX 4: **EXISTING INDUSTRY INITIATIVES RELATED TO SUSTAINABILITY**

EPD Ireland Database

All current material suppliers that have EPDs are listed on this platform. This is facilitated by the IGBC. Environmental Product Declarations allow specifiers to make informed decisions on the carbon in the materials they choose. EPDs also make life cycle analysis of buildings easier and more accurate.

https://www.igbc.ie/epd-search/

Transport Infrastructure Ireland

TII has developed a country-specific calculation tool for assessing life cycle carbon emissions for national road and light rail infrastructure projects in Ireland. It is used for assessing "embodied" and "operational carbon" and is a requirement for the development of all future national road and light rail projects. This is the best example of a state body mandating embodied carbon analysis on projects.

https://www.tii.ie/technical-services/environment/changing-climate/1_PSF-ENW-0003-01-StrategyForAdaptingToClimateChange_Final_December_2017_Print_Version.pdf

Chartered Surveyors Sustainability Declaration

https://scsi.ie/members-area/my-professional-journey/surveyors-declare/

Surveying Activities:

- Ensuring environmental practices are included in my assessment of suppliers and contractors and that their performance in this area forms part of the selection criteria utilised.
- Purchasing products and services that have the least known environmental impact, where this is feasible.
- Encouraging suppliers and contractors to implement sustainable environmental systems.
- Minimising the use of hazardous chemicals and solvents and instructing agents acting on my behalf to do the same
- Using materials, fittings and furnishings from sustainable sources where feasible

RIAI Sustainable Design Pathways

https://www.riai.ie/discover-architecture/riai-research-and-policy

2 of the 10 principles of note:

- Commit to a target of net zero emission building, with further development of metrics in line with the RIAI 2030 Climate Challenge to be published later in 2021.
- Replace 5 material products with low impact, low embodied carbon products in each project going forward.

European Cement Industry CEM Bureau Roadmap 2050

https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf

Details the steps required to decarbonise the industry by 2030 and 2050
Needs to be incorporated into Irish industry decarbonisation plans for the built environment
The Little Green Book of Concrete 2021 from the Federation of the European Precast Concrete Industry:

https://bibm.eu/the-little-green-book-of-concrete-2021-new-edition/#:~:text=The%20Little%20Green%20Book%20of%20Concrete%202021%20%E2%80%93%20New%20edition!,solutions%20for%20the%20built%20environment.

Mentions design efficiencies and replacement materials.
Nice summary of all the benefits of precast concrete, useful for methods section as well as materials

APPENDIX 4: **EXISTING INDUSTRY INITIATIVES RELATED TO SUSTAINABILITY** *Continued*

MPA UK Precast Report 2020

https://www.britishprecast.org/Publications/Sustainability-Matters-2020.aspx
Precast became the first in the sector to commit to a NET ZERO carbon sector roadmap.

BRE Global

Circular Economy and work BRE is doing as part of Building as Materials Bank (BAMB) AND CIRCUIT
https://www.bregroup.com/buzz/buildings-as-materials-banks-enabling-a-circular-way-of-building/
https://cordis.europa.eu/project/id/821201

BREEAM In-Use (BIU)

https://www.breeam.com/discover/technical-standards/breeam-in-use/
BRE SmartWaste which will also be embedded into BIU
https://www.bresmartsite.com/products/smartwaste/

Building Collaboration for Climate Action Event

This was hosted by RIAI, EI, SCSI and The Institute of Planners – the best cross sectional collaboration I've seen in the industry. The content was exceptional and really highlighted that the private sector are leading the charge in decarbonising the industry and policy really hasn't caught up yet. We can get the video link from the conference if of interest

Association of Chartered Engineers Ireland: Sustainability Vision and Commitment Climate Action 2021

3 Key points:

1. Projects will be planned and designed to go beyond the traditional focus on function, cost minimisation and programme, to also address resilience, long-term sustainability, and societal impacts.
2. Understanding climate change implications and urgency and promoting the required changes
3. Designing realistic, practical, and sufficient solutions to deal with the issues

ACEI: ***https://www.acei.ie//ws-content/uploads/ACEI_SustainabilityVision_2021.pdf***

CIF Guide to Supporting Green Construction

The guide is designed to reflect the Government's policy on climate change and in particular to the EPA'sGreen Public Procurement Guide published in 2020.

By 2023, all procurement using public funds will need to include green criteria. Similar moves are being made by investors and clients in the private sector with for example the European Investment Bank committing up to 50% of its future investments to green related projects. Many investment houses are now considering how to apply Environmental, Societal and Governance performance measures into their investment decisions.

The construction sector has an enabling role to play in supporting in the Governments objective to transition Ireland to a sustainable and carbon-neutral economy and society.

https://cif.ie/wp-content/uploads/2021/11/1253-CIF-Guide-to-Supporting-Green-Construction-final.pdf

APPENDIX 4: **EXISTING INDUSTRY INITIATIVES RELATED TO SUSTAINABILITY**

Engineers Ireland: Sustainability Framework 2020 to 2023

In February 2020 Engineers Ireland stated "Climate breakdown and biodiversity collapse are the most serious issues of our time and transformational action is required"

- Promote the principles and practices of sustainable development and the needs of present and future generations.
- Strive to accomplish the objectives of their work with the most efficient consumption of natural resources which is practicable economically, including the maximum reduction in energy usage, waste and pollution.
- Promote the importance of social and environmental factors to professional colleagues, employers and clients with whom they share responsibility and collaborate with other professions to mitigate the adverse impacts of their common endeavours.

https://www.engineersireland.ie/LinkClick.aspx?fileticket=xzHYhYGm980%3d&portalid=0&resourceView=1

A class of synthetic chemicals, known as PFAS (poly- and perfluoroalkyl substances), are now under the spotlight and, in some regions, are being phased out altogether.

Offsite Manufacturers need to ask if their products contain PFAS, as some manufacturers may not realise that they're using PFAS in their modules or offsite solutions / products, which will become a long-term downstream problem in the future.

This group of chemicals known as PFAS is enormous. There are over 4,700 of these fluorine-based compounds. Often dubbed "forever chemicals" for their extraordinary persistence, they've been detected in drinking water, dust and even the human bloodstream. The leading organisation, ChemSec, a Swedish 'not-profit' organisation is advocating for safer use of chemicals.

EU countries have restricted certain types and uses of PFAS. But environmental campaigners and certain European governments are calling for PFAS to be regulated as a chemical group.

Finding alternatives has been easier in some industries than others. The textile industry has been in the forefront of finding alternatives. Yet some companies have been swapping out PFAS-containing materials for others that are better for human health but still harmful to the planet, such as plastic-based clothing.

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021)

1) PURPOSE OF THE REPORT:

This report has been prepared by the CSG Innovation & Digital Adoption Subgroup's – Sustainability Consultation Group to outline key research areas for disruptive and scalable innovation in sustainability, carbon reduction and climate action in the Irish Construction Industry, required to achieve to the objectives of the National Development Plan, The Climate Action Plan 2021 and Housing for All.

In particular the report focusses on research areas to ensure the ambition of increased construction activities over the next decade, addressing the vacant building stock in Ireland, retrofitting existing stock and providing new built to meet the targets of the National Development Plan. This includes a 50% increase of housing construction, and the deep energy renovation of 500,000 homes, as well as additional construction of schools, healthcare and infrastructure which all must be achieved within the national and sectoral carbon budget under the Climate Action Plan 2021.

https://cif.ie/wp-content/uploads/2021/12/Action-2_Sustainability-Consultation-Group_Report.pdf

As outlined in a recently published report by the Irish Green Building Council ***(https://www.igbc.ie/wp-content/uploads/2021/11/IGBC-PRELIMINARY-RECOMMENDATIONS-REPORT-11-11-2021.pdf and https://www.igbc.ie/wp-content/uploads/2021/11/21-IGBC-COP-report-v0.93-1.pdf)*** delivering the ambitions of National Development Plan and Housing for All with 'business as usual' will result in a failure to achieve the targets of the Climate Action Plan. The report in particular highlight the need to rapidly understand the whole-life carbon of the Irish built environment, support greater re-use of existing stock and reduce the embodied carbon of building products and materials.

The research areas also cover how to ensure the health and wellbeing of the Irish population whilst achieving these objectives, both now and in the future.

In addition to identifying required research and innovation to achieve these national objectives, the purpose of the report is to communicate current barriers to innovation facing the industry and how these might be addressed.

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

2) INTRODUCTION TO THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP:

The **Sustainability & Climate Action Consultation Group** have been set up under **Action 2: *Explore and Mobilise Construction Innovation Funding***. The group consist of representatives from RIAI, Engineers Ireland, ACEI, SCSI, CIF, BMF, NSAI and the Irish Green Building Council.

Under Action 2 the following themes are being addressed of which item 3 and 4 has been of primary focus for the consultation group. Items 1 and 2 have already been addressed in a report published by the CSG Innovation & Digital Adoption Group in February 2021, and item 5 will be addressed following the conclusion of this report.

1. Identify suitable funding for innovation in the construction industry to respond to Ireland 2040, The Climate Action Plan and Housing for All
2. Develop a communication programme aimed at micro and small firms in the sector to raise awareness of available funding and how to access it (in cooperation with DPER)
3. **Identify disruptive and scalable innovation in sustainability, carbon reduction and climate action and link them to suitable funding streams**
4. **Establish pilot projects to obtain 'short term goals' and communicate positive outcomes**
5. Advocate the necessity for funding and current barriers to innovation

The purpose of the Sustainability & Climate Action Consultation Group has been to assist with the development of theme 3 and 4 under Action 2. To do so, the key purpose of the group is to:

1) **Act as a think tank** on disruptive innovation opportunities relating to sustainability and climate action in the built environment
2) **Build a library** of innovation opportunities
3) **Identify three suitable projects/year** responding to the ambitions of The National Development Plan Ireland 2040, Housing for All and the Climate Action Plan
4) **Assist in identifying barriers to innovation**

3) THE WORK OF THE CONSULTATION GROUP

The work of the consultation group has occurred over four workshops held between June and October. The focus of the workshops derived from a survey conducted under Action 2 in April 2021 to identify the biggest challenges of sustainability, carbon reduction and climate action currently facing the Irish design and construction sector, and how they can be addressed through research and disruptive, scalable innovation.

The survey asked 100 key stakeholders of their opinion on innovation required under the themes Decarbonisation, Circular Built Environment, Climate Change Resilience and Social Value & Community Wellbeing. The sustainability consultation group have used the initial outcome from this survey to develop the initial proposals for potential research/innovation projects that can have meaningful impact in the near future. For the full survey results please refer to: ***https://www.linkedin.com/posts/innovation-and-digital-adoption-for-construction-sector-group-csg_csg-priority-action-2-sustainability-survey***

In addition to the survey results, the consultation group used the report on Available Funding produced under Action 2 in February 2021 to link potential innovation/research proposals to suitable funding streams. The list of available funding considered is outlined in the following chart:

AVAILABLE FUNDING CONSIDERED

	EI Innovation Vouchers	EI Innovation Partnership	Energy Resilience and the Built Environment Fund MPhil/PhD	Disruptive Technologies Innovation Fund (DTIF)	Horizon Europe 2021-2027	SEAI National Energy (RD&D) Funding	EPA Research Funding	Climate Action Fund/EU LIFE (CAF)
Themes	All	All	All	TBC	All	Decarbonization	All	All
Support	€5000 - €20,000	80% of cost up to €200,000	Funded PhD programme	Min. €1.5 million	Varies	€200,000 – 1,000,000	€100,000-600,000	Up to €1.5 million
Outcome	Product, process, service, business model	Product, process, service, business model	PhD in Flexibility & resilience, Technology, Comfort/Health & wellbeing	Large collaborative projects, technology-based with commercial impact (export) within 3-7 years	Varies – tender opportunities regularly posted	Industrial research or experimental development	Products, process and research	Varies – needs to relate to 6 key objectives of EU LIFE
Complexity to apply	Low	Low	Medium	High	High	Medium	Medium	High
Likelihood of success	High	High	unknown	Medium	Small	Medium	Medium	Medium
Other	Targeting SME's	Need to be registered EI client	Ends 2027	Next call will see targeted themes	At least three partners, international	University and public body	Specific topics for every call	Need to apply for co-funding

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

4) IDENTIFIED BARRIERS TO INNOVATION IN THE IRISH CONSTRUCTION SECTOR

The Sustainability & Climate Action Group acknowledge that there is plenty of research and innovation taking place in the Irish Construction Industry to address sustainability, both in academia and the private sector. However, they also acknowledge that there are existing barriers to utilize this existing knowledge and scale up innovation which could be addressed through the right support, particularly from the government and public sector.

Amongst the current key barriers to innovation in the Irish Construction Sector the group listed:

- Lack of leadership from the public sector, particularly in acknowledging and awarding innovation in public procurement.
- Current planning system, legislation and building regulations do not currently advocate for innovation nor create a level playing field for novel and sustainable solutions. The industry requests stricter legislation, particularly on demolition practice and embodied carbon of construction, to assist the demand for more sustainable and innovative solutions.
- Difficulties to scale up innovation due to lack of demand and economy of scale – this could change through the public sector being the source for this demand.
- Available funding opportunities are too small – there is a need for significant, focused, and long-term funding on decarbonizing the Irish Construction Sector to meet national objectives.
- Available funding often focusses on export – Ireland is in need of a Domestic Investment Fund for local innovation and manufacturing of sustainable products for the construction industry.
- The fragmented nature of the industry – the many disciplines and types of construction is currently a barrier to innovation but can be an enabler through cross-industry collaboration
- Current research and innovation is slow due to lack of transparency of what has already been done – there is a need for a central repository for greater efficiencies and collaboration which could be done through the proposed Construction Technology Centre under Action 4
- The cyclical nature of the industry makes investing in research and innovation less enticing – the government, through construction demand favouring innovative solutions, could assist in creating a more stable industry
- The industry lacks a culture of mentorship to encourage innovation and personal growth – currently it is difficult to retain people

5) IDENTIFIED RESEARCH AND INNOVATION PROPOSALS FROM THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP TO ACHIEVE THE OBJECTIVES OF THE NATIONAL DEVELOPMENT PLAN, THE CLIMATE ACTION PLAN AND HOUSING FOR ALL

The following list of research and innovation proposals have been put forward by the Sustainability & Climate Action Consultation Group as key opportunities to achieve the objectives of the National Development Plan, The Climate Action Plan and Housing for All.

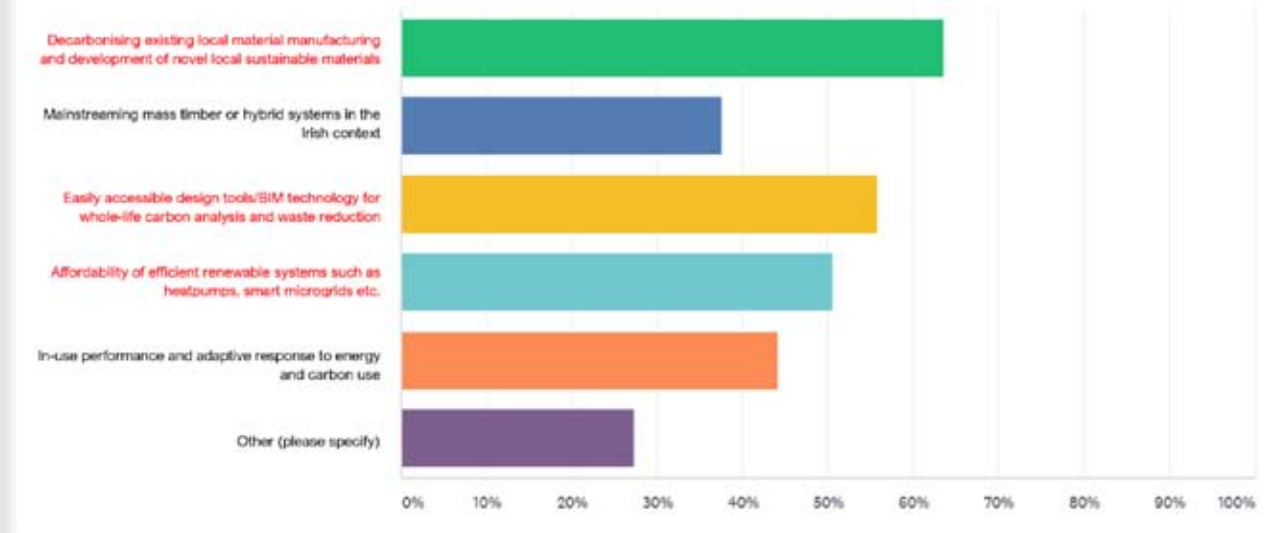
The proposals are divided according to the four themes outlined in the stakeholder survey. However, it should be noted that many of the proposals could, and should, stretch across themes to ensure a holistic approach to sustainability is considered when planning and constructing our future built environment.

5.1 DECARBONISATION:

Under this theme the group looked at proposals of innovation relating to the built environment that will support the ambitions of The Climate Action Plan to reduce the sector's green house gas emissions with 50-60% from 2018 emissions and the national target to reduce by 7% annually, and become climate neutral by 2050 whilst delivering on the objectives under the National Development Plan and Housing for All Policy. **Proposals focus on zero and low-carbon solutions to reduce carbon** in planning, design, manufacturing and operation. Reduction through retrofit, re-use and circular principles will be covered under the theme Circular Built Environment.

Outcomes from the initial survey:

Q3: Under the heading DECARBONISATION, what areas of research do you think are most important to achieve disruptive innovation in the construction sector for sustainability and climate action (select three)



RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
1.	**Whole-life carbon calculation of typical Irish construction practice and existing Irish building stock.**	Use exiting carbon calculator tools such as EC3/ OneClick to determine whole-life carbon (embodied and operational) specific to the Irish built environment to be used for design & planning and set Irish baselines. **a.** Incorporate Irish averages of materials performance and available EPD's **b.** Analyse average of current Irish construction across various typologies to establish baseline **c.** Develop template to analyse and compare carbon of existing buildings proposed for demolition/alterations compared to new built by Local Authorities **d.** Build database of carbon related to existing built environment in Local Authorities. **e.** Formally report carbon calculations in a INSPIRE compatible way	A standard method and tool to calculate whole-life carbon is crucial for future legislation of the same. Likewise there is currently no baseline data for typical Irish Construction to be used to set future legislation or planning guidelines. Similar tools and baseline data have successfully been developed and used for planning in Belgium, Germany and Denmark. IGBC is underway to develop a baseline tool with Irish standard construction systems which would be used for the research.	NPOBJ13 NPOBJ52 NPOBJ54 HfAOBJ21 CAP 54 CAP 192 CAP 193
2.	**Cement decarbonization**	Research on how to accelerate the decarbonization of cement **a.** Research extent of potential for clinker substitution **b.** Assess raw material potential in fine grained C&D waste streams **c.** Research other potentials to decarbonize the cement industry	Cement is currently one of the greatest contributors to carbon emissions, however will continue to be a necessary resource for future construction hence the importance to decarbonize the industry rapidly. The current strategy for decarbonization of cement in the Climate Action Bill relates to alternative fuels – this will not achieve a significant reduction in industrial emissions.	NP OBJ56 HfA OBJ21 HfAOBJ23.12 CAP 54 CAP 191

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
3.	**Overcome barriers for low- embodied carbon materials – such as timber solutions, hemp, natural fibre insulation etc.**	Full scope research to understand and overcome potential barriers for low-carbon materials. **a.** Review fire regulations **b.** Review standards **c.** Structural assessment **d.** Durability assessment **e.** Offsite potential **f.** Regulatory system review **g.** Policy review to encourage use of low-carbon materials	There is a current lack of full-scale research on overcoming the barriers to scaling up the use of low-carbon material solutions. A holistic research is required to build confidence amongst regulators, planners, insurance companies and the market. Other countries/city's with stricter regulations (for example NY) have in recent years changed its building regulations to accommodate more extensive use of innovative materials such as timber in construction. The UK Government published a report in October 2021 supporting timber construction of all low-rise projects at scale A testing centre is needed in Ireland which is not a Technology Centre and DHLGH needs to amend standards towards acceptance of EU standards.	NP OBJ53 HfA OBJ21 HfA OBJ16 CAP 54 CAP 191 CAP 194
4.	**Detailed carbon modelling of National Development Plan (NDP)**	Research on the embodied and operation carbon impact related to all proposed construction, renovation and infrastructure according to the NDP. **a.** Outline carbon impact with current standards **b.** Outline potential reduction strategies including re-use of existing building stock and reduced embodied carbon of new construction	Initial studies from IGBC and UCD are indicating that Ireland will miss its proposed carbon targets if the ambitions of the NDP are delivered with the same standards used today. A detailed study is required to understand what is required to prevent this.	NP OBJ13 NP OBJ 54 HfA OBJ21 CAP 54 CAP 192 CAP 193 CAP 188

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
5.	**Building decarbonization into public procurement**	Research on how to build decarbonization into procurement including: **a.** Promoting building re-use of existing buildings **b.** Promoting modularization/offsite construction **c.** Use of low-carbon materials	Current procurement practice inhibits innovation in building re-use and the scaling up of low-carbon materials and MMC. Public procurement should drive demand for more sustainable solutions.	NP OBJ56 NP OBJ54 HfA OBJ19 HfA OBJ20 HfA OBJ21 HfA OBJ23 CAP 54 CAP 55 CAP 176 CAP 195 CAP191
6.	**Overcome barriers for MMOC at scale for new built and retrofit**	Full scope research to scale up MMOC in Ireland. **a.** Life-Cycle Analysis of traditional vs Off-site to create baseline database and demonstrate benefits of MMOC **b.** Development of prototypes for MMOC using different materials and levels of off-site manufacturing **c.** Analysis of off-site opportunities for retrofit **d.** Pilot projects showcasing alternatives and benefits	There is a need for better overview of available MMOC technologies and the benefits they offer to support them being adopted at greater scale both for new built and retrofit. This can reduce carbon, waste and cost whilst increasing productivity.	NP OBJ56 HfA OBJ16 HfA OBJ21 HfA OBJ23 HfA OBJ25 CAP 54 CAP191 CAP194 CAP 411

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
7.	**Research development of new national industry of low-embodied carbon construction materials**	Identify best sectors for development of low-carbon materials in Ireland. Carry out a focused investment ready business plan for these sectors as initial areas of research with a long-term view to develop a national industry of low-carbon materials. **a.** Technical feasibility of what type of material can be produced **b.** Economic feasibility of product **c.** Policy research on supporting investment success **d.** Delivery – structure of investment	There is currently a lack of locally produced sustainable materials in Ireland. Low-carbon materials are being imported from abroad. Potential to build on existing or past successes of semi state companies such as Coillte and Bord Na Mona in developing vertically integrated manufacturing from nationally or privately owned natural resources.	NP OBJ32 NP OBJ 53 HfA OBJ16 HfA OBJ21 HfA OBJ25 CAP54 CAP191
8.	**Whole-life carbon impact of zoning in development plans**	Research on whole-life carbon associated with zoning decisions: **a.** Ground conditions **b.** Infrastructure requirements **c.** Densities **d.** Height **e.** Car parking requirements **f.** Commuter patterns of users	There is currently no comprehensive study on the impact on whole-life carbon emissions caused by different zoning decisions. This should be factored into planning and zoning of land in development plans.	NP OBJ13 NP OBJ33 NP OBJ52 NP OBJ 53 NP OBJ 54 HfA OBJ21 CAP 54

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
9.	**Feasibility for efficient renewable energy systems for different housing typologies**	Full scale study of the suitability, affordability and efficiency of heat pumps, district heating and solar PV's for different housing typologies. **a.** Whole-life carbon assessment of different systems for different typologies **b.** Life-cycle cost assessment **g.** Future proofing for future technological advancements	There is need for guidance on what systems is most suitable for particular types of developments to ensure environmental performance, cost efficiency and future proofing for changes and technological advancements.	HfA OBJ16 HfA OBJ21 HfA OBJ23 HfA OBJ26 CAP 54 CAP 176 CAP 182 CAP 184 CAP 186
10.	**Carbon optimal study for retrofit**	Research on whole-life carbon optional study for retrofit of different building typologies. **a.** Analysis of whole-life carbon for deep and shallow retrofit for different typologies in the Irish context at building scale **c.** Multi-benefit renovation rating system to analyse whole-life carbon for retrofit at wider scale – to include future life-span, location etc.	The current approach to retrofit according to the NDP and Climate Action Plan does not consider the embodied carbon impact of retrofit. Furthermore, the current approach does not consider other factors influencing the suitability of retrofit including potential lifespan of building, location, use and contribution to local community. There is a potential to develop a rating system factoring these in to direct finances to more beneficial retrofit projects.	NP OBJ6 NP OBJ54 HfA OBJ12 HfA OBJ16 HfA OBJ 19 HfA OBJ20 HfA OBJ21 HfA OBJ23.12 CAP 54 CAP 58 CAP 179

*Full overview of policy objectives are listed in the appendix

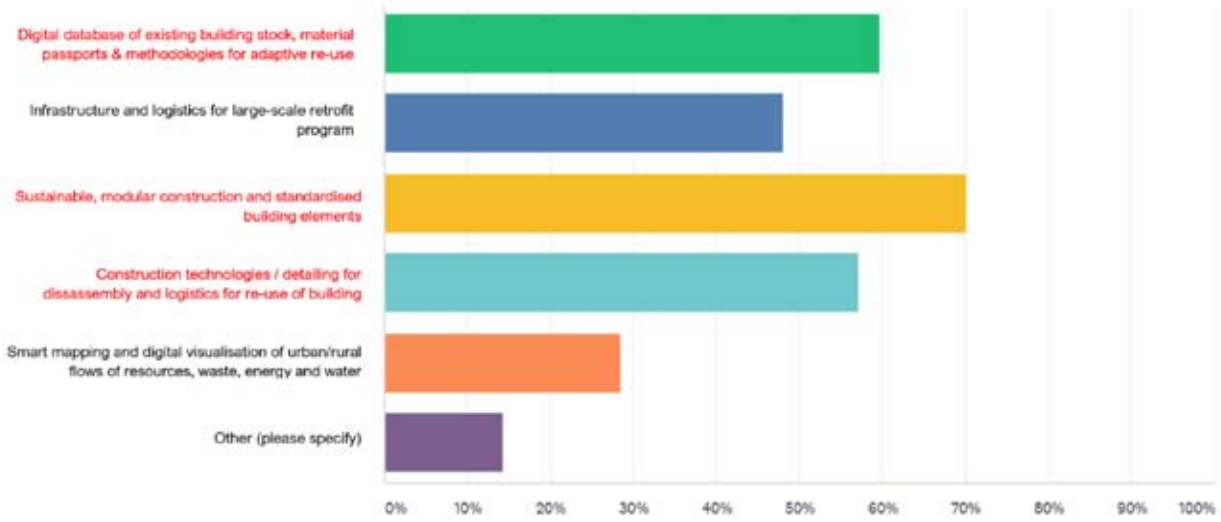
APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

2.2 CIRCULAR BUILT ENVIRONMENT:

Under this theme the group looked at proposals of innovation relating to the built environment that will support the ambitions of Ireland's Climate Action Plan to reduce the sector's green house gas emissions with 50-60% from 2018 emissions and retrofit 500,000 homes to BER B2 by 2030. The proposals also consider Ireland's Circular Economy Strategy as well as the EU's Circular Economy Action Plan to significantly reduce the use of raw materials. **Proposals focus on resource and material efficiencies** in the planning, design, manufacturing and operation of the built environment.

Outcomes from the initial survey:

Q4: Under the heading CIRCULAR BUILT ENVIRONMENT, what areas of research do you think are most important to achieve disruptive innovation in the construction sector for sustainability and climate action (select three)



APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP				
Item	**Topic**	**Description**	**Reasoning**	**Related Policy Objectives***
1.	**Standardising Existing Asset/ Pre-Demolition Assessment**	Build digitalised methodology to assess re-use/recycling potential of different building elements and materials in existing buildings **a.** Build on forthcoming EN 17680 Standard and assessment conducted by Limerick City & County Council **b.** Map entire value chain for re-use skills/logistics/supply/ regulatory framework **c.** Review of potential carbon saving and financial value of re-use/recycling	A methodology to assess the whole value-chain and potential for re-use/recycling of building elements, including the logistics of it, is required as a starting point to allow further research in the field of circular construction.	NP OBJ6 NP OBJ35 NP OBJ56 HfA OBJ20 HfA OBJ21 HfA OBJ23.12 CAP 54 CAP 195 CAP 411
2.	**Research on potential for adaptive re-use of buildings and building elements**	Study on re-usability potential for different building typologies (existing and new built) **a.** Review of adaptive re-use of different existing building typologies (office to residential etc) and requirements to allow future re-use of new built **b.** Review of re-use potential of building elements in existing buildings and requirements to increase potential in new built projects. **c.** Develop guidance on designing for re-use **d.** Technical and financial feasibility of re-use including review of standards to allow re-use at scale. **e.** Planning laws to be modified to allow for change of use	The Irish Construction Industry is currently struggling to move past 'recycling' as a goal for the circular economy. There is a great potential to shift to 're-use' and save greater amounts of carbon and costs. This will require a full study on what the potentials are to re-use existing buildings, but also how we should design and build for future re-use. In particular there needs to be research on benefits of changing the use of buildings to also allow greater access to funding for such activities.	NP OBJ6 NP OBJ35 NP OBJ56 HfA OBJ16 HfA OBJ20 HfA OBJ21 HfA OBJ23.12 CAP 54 CAP 195 CAP 411

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
3.	**Material and Maintenance / Renovation Passport**	Research digitalised methodologies to track materials in buildings and their forthcoming maintenance/renovation requirements. **a.** Potential for BIM to be used in planning to track materials and future maintenance of new built **b.** Potential to build library of existing building stock's renovation needs at Local Authority level	Material passports will be critical in the future to enable re-use of buildings. The understanding of required maintenance and retrofit of existing building stock will assist in increasing buildings life span.	NP OBJ6 NP OBJ54 HfA OBJ16 HfA OBJ20 HfA OBJ21 HfA OBJ23.12 CAP 54 CAP 223 CAP 411
4.	**National quality assurance scheme for secondary aggregates**	Investigate opportunities for crushed concrete as secondary aggregated to be recycled back into concrete and other construction products. **a.** Technical and feasibility research on recycling C&D waste as secondary aggregates **b.** Identify suitable governance and standards to ensure quality and environmental impact– independently certified	Similar research has been conducted on EU level for precast concrete (SeRamCo) but not yet taken up/implemented in Ireland. EPA had a recent call on crushed concrete with research that could be built upon and further developed.	NP OBJ56 HfA OBJ16 HfA OBJ21 HfA OBJ23.11 HfA OBJ23.12 CAP 54 CAP 191 CAP 195 CAP 411

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
5.	**Structural material efficiencies**	Review of current national practice on specification of material and development of guidance for design efficiencies to reduce material use in structural elements – particularly of steel and concrete. **a.** Research on potential for structural efficiencies to reduce embodied carbon – including potential for alterative technologies such as 3D printing **b.** Review national practice and potentially engage professional practice committees **b.** Digital library of Material Efficiency Guidelines and NSAI Accredited construction details for high performing buildings.	Numerous reports suggest that current practice is resulting in over-engineered buildings with higher embodied carbon than necessary. Material efficiencies will contribute to lower cost and lower carbon emissions. NSAI's renewed standards are not adequately adopted in industry.	NP OBJ54 HfA OBJ16 HfA OBJ20 HfA OBJ21 HfA OBJ23 CAP 54 CAP 195 CAP 411
6.	**Planning and design efficiency to reduce total carbon (not only CO2/m2)**	Research on the cumulative carbon impact of resource inefficiencies in design and planning. **a)** Research on the impact of growing average dwelling sizes on the cumulative embodied carbon of the building stock. **b)** Research on the 'right sizing' of new homes	The size of new homes will significantly impact the related embodied carbon of the welling. Research is required on how to plan for the 'right size' of new built and re-use the existing stock.	NP OBJ33 NP OBJ52 NP OBJ54 HfA OBJ16 HfA OBJ20 HfA OBJ21 HfA OBJ23 CAP 54 CAP 411

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
7.	**Mapping resource flows in the economy to foster 'industrial symbiosis'**	Research on existing resource flows in the Irish economy and potential to 'close loops' through industrial symbiosis. **a.** Potential for waste of one sector to become resource for another **b.** Potential for straw waste from agriculture to produce low-carbon construction materials **c.** Technical & feasibility studies on delivery **d.** Resource mapping to link into national database such as GeoHive	Moving to a circular economy requires us to look at the entire system of resources. There is great potential to make better use of resources with cross-sectoral collaboration and research. This can also assist in achieving a 'just transition' when addressing climate change.	NP OBJ32 NP OBJ56 HfA OBJ16 HfA OBJ20 HfA OBJ21 HfA OBJ 23.12 CAP 54 CAP 384 CAP 411
8.	**Complete Ireland's vacancy register and potential for it to be used to meet the NDP targets**	Detailed research into the existing vacant building stock in Ireland to speed up the National Vacant Housing Reuse Strategy. **a.** Research on barriers for councils to complete the vacancy register **b.** Research on potential for national library of vacant site **c.** Research on potential of vacant site to be used for the NDP housing targets and benefits in terms of carbon savings.	Ireland has one of Europe's highest percentages of vacancy in its building stock. Previous strategies have failed in completing a detailed vacancy register which is urgently needed to understand how these existing building might be used to meet the NDP targets in a carbon efficient way.	NP OBJ32 NP OBJ35 NP OBJ56 HfA OBJ4 HfA OBJ19 HfA OBJ20 HfA OBJ21 HfA OBJ 23.12 CAP 54 CAP 223 CAP 224

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
9.	**Standardising retrofit**	Research into opportunities to standardise retrofit of Ireland's existing building stock: **a.** Potential for off-site manufacturing of certain elements **b.** Potential to standardise heatpumps **c.** Potential to use economy of scale to make retrofit cheaper	The broad variety of Irish housing typologies makes retrofit at scale difficult. Research and innovation is required to overcome this in similar ways done in Netherlands and UK.	NP OBJ6 NP OBJ56 HfA OBJ4 HfA OBJ19 HfA OBJ20 HfA OBJ21 HfA OBJ 23.12 CAP 54 CAP 224

*Full overview of policy objectives are listed in the appendix

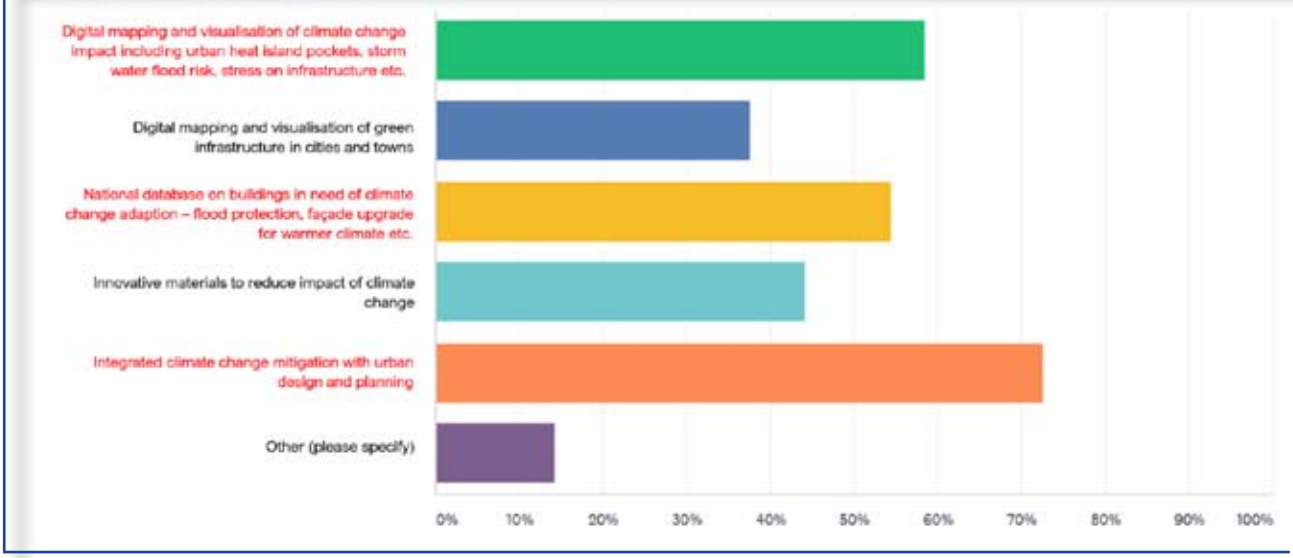
APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

2.3 CLIMATE CHANGE RESILIENCE:

Under this theme the group sought proposals of innovation relating to the built environment that will support the ambitions of Ireland 2040 and Ireland's Climate Action Plan to ensure Climate Adaptation of the built environment to protect human health and wellbeing. **The proposals focus on strategies for environmentally and socially sustainable mitigation of climate change impact.**

Outcomes from the initial survey:

Q5: Under the heading CLIMATE CHANGE RESILIENCE, what areas of research do you think are most important to achieve disruptive innovation in the construction sector for sustainability and climate action (select three)



RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
1.	**Step by Step programme to measure, manage and report adaptation and mitigation of climate change impact with confidence**	Develop a digital National Geospatial Hub as single source for spatial data sets and review of planned development. To contain: **a.** Finalised national land use character assessment **b.** Met Eirann geospecific weather conditions **c.** LA and OPW input on floods and other environmental impacts **d.** Planning authorities list of new/proposed development **e.** Reporting on climate change impact **f.** Opportunity to test proposed development areas in future scenarios	A digital one-stop shop, as per the ISNPIRE Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007, to analyse current and future environmental data impacting development is required for a holistic approach to climate resilience.	NP OBJ6 NP OBJ13 NP OBJ33 NP OBJ52 NP OBJ53 NP OBJ54 HfA OBJ12 HfA OBJ13 HfA OBJ26 CAP 59 CAP 197 CAP 200
2.	**Simple system for proposed development to be analysed in its context for planning**	Develop a simple digital tool using the datasets from the geospatial hub to analyse risk and opportunities for proposed developments. Amongst areas to be analysed: **a.** Whole-life carbon **b.** Daylight/Sunlight of public realm **c.** Urban heat Island Effect **d.** Flood impact **e.** Suitable Renewable Energy Systems **g.** Soil conditions impact on embodied carbon	With the planning system being digitalised there is opportunity to leverage this and develop a tool to analyse proposed developments in a virtual context. Similar approach is taken in Singapore (planning applicant submit BIM model) and London (3D model submitted) amongst others.	NP OBJ6 NP OBJ13 NP OBJ33 NP OBJ52 NP OBJ53 NP OBJ54 HfA OBJ12 HfA OBJ13 HfA OBJ16 HfA OBJ26 CAP 59 CAP 197 CAP 200

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
9.	**All County, and subsequent Local Area Plans to include robust, evidence-based social-cost-benefit analysis, economic appraisals, and post evaluations.**	Research comparing different planning models including a hierarchical framework that embodies sustainable land management and prudent planning. **a.** Research framework to analyse valid reasons for different types of developments based on socio-economic aspects. **b.** Research on implementing Town Centre First approach in planning	County/Local Area Development Plans should not merely zone. All zoning should have a hierarchical framework considering social-cost-benefits, economic appraisal and the environment. It is important that no new greenfield development is permitted without compelling reason where there are already used plots more suited to development. Socio-economic appraisals for all developments should accompany each planning application.	NP OBJ4 NP OBJ6 NP OBJ33 CAP 224

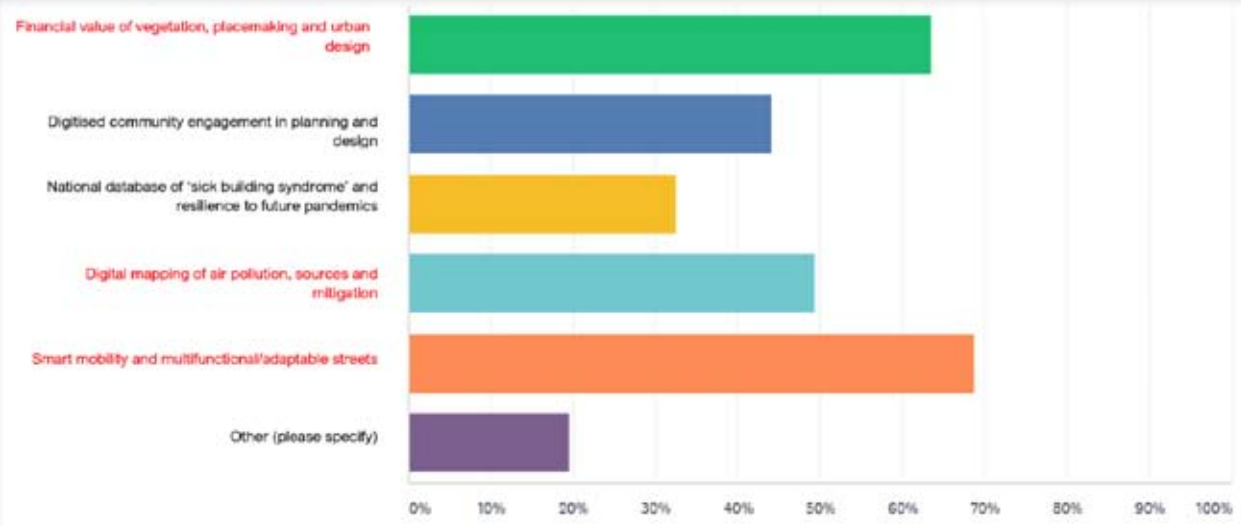
APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

2.4 VALUE & COMMUNITY WELLBEING:

Under this theme the group sought proposals of innovation relating to the built environment that will ensure social value and community wellbeing is enhanced through the realisation of Ireland 2040, Housing for All and Ireland's Climate Action Plan. Proposals focus on protecting human health and wellbeing, support local economies and increase community engagement.

Outcomes from the initial survey:

Q6: Under the heading SOCIAL VALUE & COMMUNITY WELLBEING, what areas of research do you think are most important to achieve disruptive innovation in the construction sector for sustainability and climate action (select three)



RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
1.	**Research on successful models for community driven planning processes**	Review local and international best practice examples of community driven planning processes. **a.** Creation of digital tools for better communication and participation **b.** Implementation plan for greater community participation in Local Authorities – including necessary interfaces for delivery Digitalisation opens up a great opportunity for greater community engagement in planning.	Digitalisation opens up a great opportunity for greater community engagement in planning. Many cities are using digital models to test scenarios and proposed developments with input from residents. (e.g Vancover)	NP OBJ4 NP OBJ6 NP OBJ13 NP OBJ32 HfA OBJ4 HfA OBJ6 HfA OBJ13 HfA OBJ22
2.	**Encourage biodiversity in the built environment**	Research into introducing a 'green area ratio' for proposed development in Irish planning. **a.** Health/cost benefit analysis of increased biodiversity in Irish towns and cities. **b.** Site specific scoring system for various ecological solutions **c.** Potential implementation strategy for planning	'Green Area Ratio' or 'Biotope Factor' is used as a measure to encourage enhanced ecosystems in towns and cities across many European cities (e.g Malmo, Berlin, London). Introducing a green area ration requirement in Irish planning would encourage healthier and more resilient communities.	NP OBJ4 NP OBJ52 HfA OBJ13 HfA OBJ22 CAP 377 CAP 390

RESEARCH/INNOVATION PROPOSALS BY THE SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP

Item	Topic	Description	Reasoning	Related Policy Objectives*
3.	**Social and Environmental Post-Occupancy Evaluation Methodology for Public Buildings and Projects**	Research on suitable, cost efficient methodology to conduct post-occupancy evaluation (POE) of all public buildings and projects capturing their social and environmental performance. **a.** POE of both existing and new built assets. **b.** Data to be collated and used as 'lessons learnt' for future projects.	POE in public buildings is currently only conducted for operational energy. With plans to delivery a significant amount of housing and other important public projects under Ireland 2040 and Housing for All there is a necessity to put in place a system for capturing the in-use performance of these projects and their contribution to community health & wellbeing.	NP OBJ4 NP OBJ6 NP OBJ13 HfA OBJ16 HfA OBJ21 HfA OBJ22 CAP 54 CAP 196
4.	**Collation of successful, liveable and sustainable Irish and European Towns and Cities**	Research into a small, selected group of Irish and European towns to understand the factors that make them successful in terms of urban planning and development approaches. **a.** Review of a number of towns and cities covering both urban planning/development and governance/funding. **b.** Identification of key take aways for future of Irish towns and cities	A cohesive overview of successful approaches to sustainable development can assist the delivery of Ireland 2040 and Housing for All with a focus on protecting human health and wellbeing in an environmentally and financially sustainable manner.	NP OBJ4 NP OBJ6 NP OBJ13 HfA OBJ16 HfA OBJ21 HfA OBJ22 CAP 296
5.	**Economic and financial analysis tools for social interventions in towns and cities.**	Research the development of tools for effective analysis of social and financial value of interventions in planning such as: **a.** Preservation of heritage and cultural assets **b.** Enhanced public realm **c.** Planting in urban areas **d.** Reduced car traffic	Similar tools have been successfully developed in the UK (RIBA Social Value Toolkit) and could be adopted to Irish context to showcase financial benefits of social interventions to local authorities.	NP OBJ4 NP OBJ13 HfA OBJ 4 HfA OBJ6 HfA OBJ16 HfA OBJ21 HfA OBJ22

*Full overview of policy objectives are listed in the appendix

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

5) CONCLUSIONS

The proposals in this report is just a start of immediate research and innovation required to meet the objectives of the National Development Plan, The Climate Action Plan and Housing for All.

Following this report, the Sustainability & Climate Action Consultation Group will search for, and reach out to, potential research/innovation partners for these proposals and encourage them to apply for funding under suitable streams. We welcome everyone who are interested in any of the topics to reach out to us.

The group will share the findings of this report with other suitable stakeholders such as the newly established Retrofit Taskforce and relevant government departments.

The group will also continue to meet and discuss the other actions under the CSG Innovation & Digital Adoption Sub-Group to ensure sustainability and climate action is adequately integrated.

If you are interested in a research topic or have other suggestions please contact Action Leaders David Browne (RIAI) and Karolina Backman (RIAI) with the emails below:

dbrowne@rkd.ie
kbackman@rkd.ie

APPENDIX: SUSTAINABILITY & CLIMATE ACTION CONSULTATION GROUP:		
Construction Sector Organisation	**Name**	**Organisation or Company**
RIAI	David Browne	RKD
	Karolina Backman	RKD
	Asiling Kehoe	SISK
Engineers Ireland	Susan McGarry	Ecocem
	Fergal Timlin	Mid-West National Roads Design office
	Emma McKendrick	AECOM
	Brian Cassidy	Cork City Council
ACEI	Warren Phelan	RPS
	Frances O'Kelly	Roughan & O'Donovan
	Cian Desmond	Gavin & Doherty Geosolutions
SCSI	Sarah Sherlock	Murphy Surveys
	Gary Comerford	Linesight
CIF	Tadgh Lucey	BAM Civil Ltd
	Jo-Ann Garbutt	Mercury Engineering
BMF	Brian Gilmore	Cement Manufacturers Ireland
NSAI	Sean Balfe	NSAI
Irish Green Building Council	Pat Barry	Irish Green Building Council

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

APPENDIX: FULL LIST OF RELEVANT OBJECTIVES

National Policy Framework Ireland 2040:

OBJ 4. Ensure the creation of attractive, liveable, well designed, high quality urban places that are home to diverse and integrated communities that enjoy a high quality of life and wellbeing.

OBJ 6. Regenerate and rejuvenate cities, towns and villages of all types and scale as environmental assets

OBJ 13. In urban areas, planning and related standards will be based on performance criteria

OBJ 32. To target the delivery of 550 000 additional households to 2040

OBJ 33. Prioritise the provision of new homes at locations that can support sustainable development and at an appropriate scale of provision relative to location

OBJ 35. Increase residential density in settlements through a range of measures including reductions in vacancies, re-use of existing buildings and infill development schemes.

OBJ 52. The planning system will be responsive to our national environmental challenges and sure that development occurs in environmental limits

OBJ 53. Support the circular and bio economy including in particular through greater efficiency in land management, greater use of renewable resources

OBJ 54. Reduce our carbon footprint by integrating climate action into the planning system in support of national targets for climate policy mitigation and adaptation objectives, as well as targets for greenhouse gas emissions

OBJ 56. Sustainably manage waste generation, invest in different types of waste treatment and support circular economy principles prioritising prevention, reuse, recycling and recovery to support a healthy environment, economy and society.

Housing for All Objectives:

OBJ 4. Increase social housing delivery

OBJ 6. Increase and improve housing options for older people

OBJ 12. Deliver a new approach to active land management

OBJ 13. Improve the functioning of the planning system

OBJ 16. Improve Sector Innovation and Attractiveness

OBJ 19. Address Vacancy in housing

OBJ 20. Make more efficient use of existing housing stock

OBJ 21. Drive environmental sustainability in our housing stock

OBJ 22. Drive social sustainability and foster sustainable communities

OBJ 23. Drive economic sustainability and reduce Construction Costs (23.5 and 23.9 in particular)

OBJ 23.11 Reduce C&D waste and associated costs through demonstration projects

OBJ 23.12 Reduce demand for virgin raw materials and support re-use

OBJ 25. Drive compliance and standards through regulatory reform

OBJ 26. Support Critical Infrastructure Development

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

Climate Action Plan 2021:

ACTION 54 Develop a strategy to achieve at least a 51% reduction in GHG emissions and a 50% improvement in public sector energy efficiency by 2030

ACTION 55 Expand the successful public sector energy efficiency monitoring and reporting programme to incorporate GHG emissions reduction

ACTION 58 Support the retrofit of public sector buildings

ACTION 59 Mandate the inclusion of green criteria in all procurements using public funds, introducing requirements on a phased basis and providing appropriate support to procurers

ACTION 62 Set a trajectory for commencing and implementing a deep energy retrofit programme for education sectors

ACTION 176 Carry out research to inform the development of options, policies and measures to decarbonise the heating and cooling sectors to 2050

ACTION 177 Develop proposals to achieve complete phase out of fossil fuel heating throughout our building stock in line with our climate neutrality objective

ACTION 179 Develop an approach to retrofit commercial buildings

ACTION 182 Conduct appropriate research to inform and support the growth and development of district heating in Ireland

ACTION 184 Ensure national, regional and local planning frameworks encourage and facilitate the development of district heating where appropriate to facilitating compact urban development

ACTION 186 Assess the viability of district heating systems within higher density urban/periurban developments through a demonstration project

ACTION 188 Undertake regulatory review of cost optimal performance requirements for Part L (Conservation of Fuel and Energy) of the Building Regulations

ACTION 191 Work with industry stakeholders to increase the use of low carbon materials, taking into account international best practice

ACTION 192 Develop an embodied carbon Building Rating calculation methodology

ACTION 193 Support the development of a tool for early design stage comparative analysis of embodied carbon in typical Irish construction typologies

APPENDIX 5: **CSG SUSTAINABILITY CONSULTATION REPORT** (November 2021) *Continued*

ACTION 194 Design and construct two exemplar public sector buildings using alternative construction techniques and materials, and monitor their performance

ACTION 195 Pilot project to assess the adaptive re-use potential of existing traditionally built structures as residential accommodation

ACTION 196 Evaluate potential for further emissions savings through changing consumer behaviour to lower household heat demand

ACTION 197 Develop specific climate maps and data for use in building design to enhance resilience in support of climate change adaptation

ACTION 198 Assess and monitor climate impacts on heritage sites and identify threatened heritage sites

ACTION 200 Build public awareness of the risks of climate change (in general and for heritage) and of efforts to mitigate it and adapt to it

ACTION 223 Enhance the collection and monitoring of retrofit activity data delivered with Government support

ACTION 224 Enhance the capacity of local authorities to deliver their retrofit programme according to budgets allocated

ACTION 296 Review further linkages between accessibility and climate action

ACTION 377 Build on the commitments made under the National Biodiversity Action Plan 2017-2021

ACTION 384 Conduct research and engage on how to support climate just transition in agriculture

ACTION 390 Engage stakeholders in all sectors to protect biodiversity in order to increase resilience to climate change

ACTION 411 Reduce demand for virgin raw materials and support re-use, by keeping material out of waste streams

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021)

No.	Company	Website	Address	County
1	EPS Water	https://epswater.ie/manufacturing-fabrication/	Mallow Business & Technology Park, Quartertown, Mallow, Co. Cork	Cork
2	Modubuild	https://www.modubuild.net/	5A, IDA Purcellsinch, Dublin Road, Kilkenny	Kilkenny
3	Ardmac	https://www.ardmac.com/building-offsite/	Swords Business Campus, Swords, Co. Dublin	Dublin
4	Asgard	https://www.asgardcleanrooms.com/	Unit E, Sark Business Park, Purcellsinch Industrial Estate, Kilkenny	Kilkenny
5	Clearsphere	https://www.clearsphere.com/	Carrigaline Industrial Park, Carrigaline, Co. Cork, Ireland	Cork
6	Holden Installations Limited	https://holden.ie/	Block 7/8, Little Island Industrial Estate, Little Island, Cork	Cork
7	Cleanroom.ie	www.cleanroom.ie	See Asgard and Modubuild	Kilkenny
8	NGS Cleanroom Solutions	https://ngscleanrooms.com/ and www.ngsindustrial.com	E2 Smithstown Industrial Estate, Shannon, Co. Clare, Ireland	Clare
9	DWS Facilities	http://www.dwsfs.ie/	56 Ballybane Beg, Ballybane Ind. Estate, Tuam Road, Galway, Ireland	Galway
10	ADCO Contracting	https://adco.ie/	Unit 2A, Nangor Road Business Park, Dublin 12	Dublin
11	Vision Built Manufacturing Limited	https://www.vision-built.com/	Unit 1, Deerpark Industrial Estate, Oranmore, Co. Galway	Galway
12	G Frame Structures Limited	www.gframe.ie	5 Fitzwilliam Square, Dublin 2, Ireland	Dublin
13	Evolusion	https://www.evolusioninnovation.com/	Bank House, Main Street, Innishannon, Co. Cork	Cork
14	Tehcrete Ireland	https://techrete.com/	Stephenstown Industrial Park, Balbriggan, Co. Dublin	Dublin

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
15	Oran Pre-Cast Limited	http://www.oranprecast.ie/	Deerpark Industrial Estate, Oranmore, Galway, Ireland	Galway
16	O'Reilly Concrete	https://www.oreillyconcrete.com/	Larchfield, Kingscourt, Co. Cavan, Republic of Ireland	Cavan
17	Banagher Concrete	https://banagherprecast.com/	Queen Street, Banagher, Co.Offaly, Ireland	Offaly
18	Shay Murtagh Precast Limited	www.shaymurtagh.com	Raharney, Mullingar, Co. Westmeath	Westmeath
19	Concast Precast Group	www.concastprecast.co.uk	Hazelhatch, Newcastle, Co.Dublin	Dublin
20	Gleeson Precast	www.gleesonprecast.com	Golden, Cashel, Co.Tipperary	Tipperary
21	Killeshal Precast Concrete	www.killeshal.com	Killeshal, Daingean, Co.Offaly, Ireland	Offaly
22	Flood Precast	www.floodprecast.ie	Hilltown, Oldcastle, Co.Meath	Meath
23	Irish Concrete Federation (74 members)	https://www.irishconcrete.ie/members-directory/	Unit 8 Newlands Business Park, Newlands Cross, Clondalkin, Dublin 22	Dublin
24	Ecochem	www.ecocem.ie	TBC	Dublin
25	Irish Timber Frame Manufacturing Association (17 members)	https://itfma.ie/members/	TBC	All Counties
26	E+I Switchgear	https://www.e-i-eng.com/modular_power_solutions/	Ballyderowen, Burnfoot, Co. Donegal, Ireland	Donegal
27	Core Solutions	www.coreelectrical.ie	Unit 19 Goldenbridge Industrial Estate, Tyrconnell Road, Inchicore, Dublin 8.	Dublin
28	Modula	https://modula.ie/problems-we-solve/#	Unit 3A, Avonbeg Industrial Estate, Longmile Road, Walkinstown, Dublin 12	Dublin

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
29	Tempohousing	http://www.tempohousing.com/	22 Northumberland Road, Ballsbridge, Dublin 4, Ireland	Dublin
30	Frame Form	TBC – a new company in Galway	TBC	Galway
31	CitiFab	https://citifab.xyz/about	Unit 14, Block 12, Clarion Quay, IFSC, Dublin 1, Ireland	Dublin
32	Mac Group	https://www.mac-group.com/	4th Floor, South Block, Rockfield, Dundrum, Dublin 16, Ireland	Dublin
33	Modern Homes Ireland (MHI)	https://mhi.ie/	Oldcastle Road, Ballyjamesduff, Co. Cavan	Cavan
34	Castle Modular Group	https://www.castlemodular.com/	Raheen, Gort, Co Galway, Ireland	Galway
35	CPAC Modular	https://www.cpacmodular.com/	1 Dunshaughlin Business Park, Dunshaughlin, Co.Meath	Meath
36	Cygnum	https://cygnum.ie/	IDA Industrial Estate, Coolcower, Macroom, Co. Cork	Cork
37	LMC Group	https://www.lmcgroup.ie/LMC-Modular/Home-Page	Gortlandroe Industrial Estate, Nenagh, Co. Tipperary	Tipperary
38	ACB Group	https://www.acbgroup.ie/	Ranrenagh, Ballyjamesduff, Co. Cavan	Cavan
39	Altherm Insulating	https://altherm.ie/	Unit F Airport Business Campus, Santry, Dublin 9.	Dublin
40	Amvic Insulating Ireland	www.amvicireland.com	Unit 7 Naas Industrial Estate, Naas, Co. Kildare	Kildare
41	Carlow Concrete Limited	www.carlowconcrete.com	Burren Precast Concrete, Milltown, Garryhill, Co. Carlow	Carlow
42	Extraspace Advance System / Extraspace Solutions	www.extraspacesolutions.com	Crag Avenue Business Park, Clondalkin Industrial Estate, Clondalkin, Dublin 22	Dublin
43	Glavloc Build Systems Limited	https://www.glavloc.com	Unit C, Collins Buildings, IDA Kilbarry Business Park, Dublin Hill, Cork, Ireland.	Cork

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
44	Horizon offsite Steel Frame Building System (Etex Group)	www.horizonoffsite.ie	Unit A Cahir Business Park, Cahir, Co. Tipperary.	Tipperary
45	Metal Frame Construction Offiste	www.metalframeconstruction.ie	Lismullen, Garlow Cross, Navan, Co. Meath	Meath
46	Modular Steel Frame Building System	www.mhi.ie	MHI (Modern Homes Ireland) Ltd, Oldcastle Road, Ballyjamesduff, Co Cavan	Cavan
47	RBC Modular (Timber Frame)	www.rbcmodular.ie	RBC Modular Ltd. Crossagalla, Ballysimon Road Co. Limerick	Limerick
48	Thermohouse ICF	www.thermohouse.ie	Thermohouse Ltd., Coolcaslagh, Killarney, Co. Kerry	Kerry
49	KORE Insulation Formwork	www.kore-system.com	Kilnaleck, Co. Cavan	Cavan
50	Glenfield Engineering	https://www.gleneng.com/	Kilmallock, Co. Limerick.	Limerick
51	PWM Limited	https://www.pressurewelding.ie/	Archerstown Industrial Estate, Thurles, Co. Tipperary, Ireland	Tipperary
52	Radley Engineering	www.radleyeng.com/capabilities/modular-construction/	Killadangan, Dungarvan, Co. Waterford, Ireland	Waterford
53	Jones Engineering Manufacturing Limited	https://joneseng.com/additional-services/modular-bespoke-manufacturing-solutions/	Bagnelstown, Co. Carlow	Carlow
54	Mercury Engineering	https://learn.mercuryeng.com/osa/cover/	Elm Road, Toughers Park, Newbridge, Co. Kildare	Kildare
55	Dornan Engineering	https://www.dornan.ie/design-manufacturing-assembly/	Paradise Way, Coventry, UK	UK
56	Kirby Group Engineering	www.kirbygroup.com	Monivea Road, Ballybane, Galway	Galway

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
57	Cental Engineering	http://www.cental.ie/	O'Brien Road, Carlow, Ireland	Carlow
58	AE Global Engineering	https://www.aeglobal.uk/	Unit 2, Eight Trees Business Park, Burt, Co. Donegal, Ireland	Donegal
59	Gallagher & McKinney Limited	http://www.gmck.com/home	Unit 4, Link Business Park, Skeoge Ind. Est., Beraghmore Road, Derry	Derry
60	Lynskey Engineering	http://lynskeyeng.ie/	Unit B3, Dartmouth House, Kylemore Road, Dublin 10, Ireland	Dublin
61	BCD Engineering	https://www.bcd.ie/Main/Home.html	Railway Road, Charleville, Co Cork, Ireland	Cork
62	BMD Mechanical & Process Engineering	https://www.bmd.ie/what-we-do/off-site-manufacturing	8 Eastgate Avenue, Little Island, Cork, Ireland	Cork
63	BCL Ventilation	http://www.bcl.ie/	Unit 7a, Little Island Industrial Estate, Little Island, Cork, Ireland	Cork
64	Christ Aqua Technology Ireland Limited	https://www.abec.com/2015/05/14/abec-to-acquire-kells-stainless-ltd-to-further-expand-global-manufacturing-capacity/	Unit 1A, Ashbourne Business Park, Ashbourne, Co. Meath, Ireland	Meath
65	Dunreidy Engineering	https://dunreidy.com/engineering-services/fabrication-services/	Unit 53 Hebron Industrial Estate, Kilkenny, Ireland	Kilkenny
66	MCM Engineering	http://www.mcmengineering.ie/index.php/services/	Unit 7A Bagenalstown Business Park, Royal Oak, Bagenalstown, Co. Carlow	Carlow
67	MSL Engineering Limited	https://www.mslengineering.ie/services/modular-assemblies-fabrication-installation/	Ringport Business Park, Ringaskiddy, County Cork, Ireland	Cork
68	O'Sullivan Darcy Engineering	http://www.osullivandarcy.com/	Ballycasheen, Killarney, Co. Kerry, Ireland	Kerry
69	ABEC Limited	https://www.abec.com/contact-us/	Coolcarron, Cork Road, Fermoy, Co. Cork, Ireland	Cork

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
70	Pro-Duct Ventilation	http://www.pro-ductventilation.com/	160 Western Industrial Estate, Dublin 12, Ireland	Dublin
71	Breffni Air	https://www.breffniair.ie/products-and-services/bespoke-modular-services/	The Green, Kilnaleck, Co Cavan, Ireland	Cavan
72	Actavo Group	https://actavo.com/services/manufacture-of-modular-buildings/	Westland House, Willow Road, Dublin 12, Ireland	Dublin
73	King & Moffatt	https://www.kingmoffatt.com/services/offsite/	Boyle Road, Carrick on Shannon, Co. Roscommon	Roscommon
74	Tritech Engineering	https://tritech.ie/	Clonlara House, Clonlara Road, Baldonnell Business Park, Dublin 22	Dublin
75	Promech Engineering	http://www.promechengineering.ie/	Clonminam Business Park, Portlaoise, Co. Laois	Laois
76	Brodeen Fabrications	https://www.brodeenengineering.com/	Brodeen, Tipperary Town, Tipperary	Tipperary
77	JF Mechanical	N/A	Sligo	Sligo
78	Raymond Masterson Mechanical Services	https://rmmsltd.ie/	Unit 1, Greenhills, Enterprise Centre, Bunree Road, Ballina, Co. Mayo	Mayo
79	Spectac International	https://www.spectacinternational.com/ (Faye Healy)	Finnabair Business Park, Dundalk, Co. Louth	Louth
80	G&S Stainless Services	https://www.gandsstainless.com/	Ballybinaby, Dundalk, County Louth, Ireland	Louth
81	Quality Fabrications	http://www.qfab.ie/	Wallingstown, Little Island, Co. Cork	Cork
82	AC Manufacturing	http://www.acmanufacturing.ie/	Unit 5, 10B Stadium Business Park, Ballycoolin Road, Dublin 11	Dublin
83	AA Manufacturing	https://www.aaventilation.ie/	Unit 62, Western Parkway Business Park, Ballymount Town, Dublin	Dublin

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
84	Davenham Engineering	http://www.davenham.com/	Unit 10 Weatherwell Industrial Estate, Clondalkin, Dublin 22, Ireland.	Dublin
85	Kyte Powertech (CG Power Systems Ireland)	https://www.kytepowertech.com/	Dublin Road, Cavan, County Cavan, Ireland	Cavan
86	EDPAC International	http://www.edpac.com/	Carrigaline Industrial Park, Carrigaline, Cork, Ireland	Cork
87	Flaktwoods (Ireland) Limited	https://www.flaktgroup.com/ie/	Unit 1, Broomhill Business Park, Tallaght, Dublin 24	Dublin
88	Dannan Air	https://danann.ie/	Unit 5, M1 Business Park (at Exit 5), Balbriggan, Co. Dublin, Ireland	Dublin
89	Lindab (Ireland) Limited	www.lindab.ie	Nangor Road Business Park, Nangor Road, Dublin 12	Dublin
90	Schneider Electric Ireland	https://www.se.com/ie/en/product-category/4000-panelboards-%26-switchboards/	Head Office, Block A, Maynooth Business Campus, Maynooth, Co. Kildare	Kildare
91	ABB Ireland Limited	https://new.abb.com/ie/about/abb-in-ireland	Belgard Road, Tallaght, Dublin 24	Dublin
92	Oak Project Management	https://www.oakpm.ie/	Business Barn, Kellystown Lane, Kellystown, Leixlip, Co. Kildare	Kildare
93	ChicCrest	https://crestchicloadbanks.com/loadbank-products/	UK based (not sure of Irish based contact details - as operating here)	UK based
94	Procon Modular (NEW)	https://www.procon.ie/	Knocksedan Heliport, Knocksedan, Dublin, Republic of Ireland	Dublin
95	Lidan Designs (NEW)	www.lidandesigns.com	Unit 1, Lanesboro Road, Roscommon Town, Co. Roscommon	Roscommon
96	B-POD (Ireland) Limited (NEW)	https://www.b-pods.com/	Claire Road, Ballyhaunis, Co. Mayo	Mayo

APPENDIX 6: **OSM SUPPLY CHAIN PROVIDER LIST** (December 2021) *Continued*

No.	Company	Website	Address	County
97	Shomera Limited (NEW)	www.shomera.ie	Unit 10, Dunshaughlin Business Park, Dunshaughlin, Co Meath	Meath
98	Sky Clad Limited (NEW)	www.skyclad.ie	Milltownpass, Co. Westmeath, N91 KH67, Ireland	Westmeath
99	Therma House Limited (NEW)	www.thermahouse.ie	22, Newbridge Industrial Estate, Kilbelin, Newbridge, Co. Kildare, Ireland	Kildare
100	Big Red Barn Limited (NEW)	https://bigredbarn.ie/	PND Business Park Foxford Road Swinford Co. Mayo	Mayo
101	Scandinavian Homes Limited (NEW)	www.scanhome.ie	Scandinavian Homes, Moycullen, Co. Galway, Ireland	Galway
102	KD Eco Homes Limited (NEW)	www.kdecohomes.ie	Bray, Co.Wicklow, Ireland	Wicklow
103	Buildwright (NEW)	www.buildwright.ie	Swanns Cross, Rockcorry, Co. Monaghan, Ireland	Monaghan
104	MEF Electrical (NEW)	https://mef.co.uk/	MEF (Belfast), 134 Townhill Road, Portglenone, Ballymena, Northern Ireland	Down
105	Build-a-brackets.com (NEW) - UK	https://www.buildabracket.com/configurator#/	Unit 6 Central Trading Estate, Marine Parade, Southampton, UK	UK
106	CarlowBuild (NEW)	https://carlowbuild.com/service/overview/	CarlowBuild, Milltown, Garryhill, Co. Carlow, Ireland	Carlow
107	Kyron Innovative Technologies	http://kyroninnovativetechnologies.com/	Unit C4, M4 Buisness Park, Celbridge, Co. Kildare	Kildare

APPENDIX 7: **OSM SUPPLY CHAIN CONSOLIDATION IN THE IRISH MARKETPLACE** (Recent)

a. Vertiv purchase E+I Engineering for €1.8bn (Sept 2021)
Ref:
https://www.rte.ie/news/business/2021/0908/1245406-ei-engineering-bought-by-vertiv-holdings-for-1-8bn/

b. Ardmac bought a stake in Central Engineering (July 2020)
Ref:
https://www.ardmac.com/ardmac-acquires-stake-in-modular-builder-cental/

c. Etex acquires Horizon Offsite (July 2021)
Ref:
https://irishbuildingmagazine.ie/2021/07/09/etex-acquires-horizon-offsite/

d. Modern Homes Ireland owned by BAM Ireland (Jan 2019)
Ref:
https://www.theconstructionindex.co.uk/news/view/bam-buys-stake-in-irish-modular-homes-business

e. Modubuild part owned by Asgard Cleanrooms
Ref:
https://www.asgardcleanrooms.com/links/modubuild/

f. Vision-Built Group Ireland owned by Sisk Construction
Ref:
https://www.johnsiskandson.com/news/john-sisk-son-acquires-off-site-construction-company-vision-built-group

APPENDIX 8: **LITERATURE REVIEW**

- McKinsey report on The next normal in construction: How disruption is reshaping the world's largest ecosystem, June 2020, authors Maria João Ribeirinho, Jan Mischke, Gernot Strube, Erik Sjödin, Jose Luis Blanco, Rob Palter, Jonas Biörck, David Rockhill, and Timmy Andersson (a collaborative effort)

  Ref: ***https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/The%20next%20normal%20in%20construction/The-next-normal-in-construction.pdf***

- McKinsey report on Modular construction: From projects to products, June 2019, Authors Nick Bertram, Steffen Fuchs, Jan Mischke, Robert Palter, Gernot Strube, and Jonathan Woetzel

  Ref: ***https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Operations/Our%20Insights/Modular%20construction%20from%20projects%20to%20products%20NEW/Modular-construction-from-projects-to-products-full-report-NEW.pdf***

- Brazil Ao Cubo Limited: Agile Constructive Solutions – Modular thinking for all types of work

  https://brasilaocubo.com/portfolio/ and https://brasilaocubo.com/portfolio/edificio-level [Accessed online on 20th September 2021]

- BBC Inside Out visited the ilke Homes factory to see how they manufacture amazing Modular homes:

  https://www.youtube.com/watch?v=yPCHXMCk8xw [Accessed online on 16th June 2021]

- BPS 7014 standard – BRE Standard for Modular System for Dwellings

  Ref: ***https://files.bregroup.com/breglobal/BPS_7014_Issue_1.0.pdf***

- NHBC Technical document for Prefabricated Building Units

  Ref: ***https://www.nhbc.co.uk/binaries/content/assets/nhbc/tech-zone/nhbc-standards/nhbc-accepts/prefabricated-building-units.pdf***

- Some Irish NSAI Agrément Certificates for individual Companies

  Ref: ***https://www.nsai.ie/images/uploads/certification-agrement/IAB080311.pdf***

- ISO 21723: 2019 standard – Buildings and civil engineering works — Modular coordination — Module

  Ref: ***https://www.iso.org/standard/71507.html***

- BS 6750:1986 standard – Specification for modular coordination in building (Current: as of 29 Aug 1986)

  https://middleware.accord.bsigroup.com/pdf-preview?path=Preview%2F000000000000158454.pdf&inline=true

- Brazil – Modular Coordination Standard for Buildings: ABNT NBR 15873 standard

  Ref: ***https://www.mapadaobra.com.br/inovacao/nbr-15873-entenda-a-norma-da-construcao-modular/***

- BESA (in conjunction with Build Offsite) – An Offsite Guide for the Building and Engineering Services Sector, April 2015, Authors, a collaboration of:
  - Nigel Fraser, Gay Lawrence Race, Richard Kelly, Anna Winstanley and Paul Hancock.

- 2019 MOC Summit: MODULAR AND OFFSITE CONSTRUCTION (MOC) SUMMIT PROCEEDING submissions) - Banff, Alberta, Canada held on 21st – 24th May 2019,

  Ref: ***https://journalofindustrializedconstruction.com/index.php/mocs/issue/view/7 [Accessed online on 09th February 2021]***

- Cygnum Building Offsite case studies, based in Macroom, Co. Cork

  Ref: ***https://cygnum.ie/case-studies/***

- Modern Homes Ireland (MHI) recent Projects completed for Housing solutions in Ireland.

  Ref: ***https://mhi.ie/case-studies/***

- Dublin City Council Modular Housing Programme - 2D panelised housing units (Sisk Construction)

  Ref: ***https://www.johnsiskandson.com/case-studies/springvale-co-dublin?selected-locale=default***

- Ref: ***https://www.cogentassociates.ie/on-site-delivering-modular-housing-for-dcc/***

- Recently published Property Industry Ireland (via IBEC) in early October 2021 - on INNOVATION INCREASING SUPPLY How offsite construction

  Ref: ***https://www.ibec.ie/-/media/documents/media-press-release/property-industry-ireland---off-site-construction-report.pdf***

- Recent News articles on Student Accommodation and Housing supplies, calling for Modular solutions Ref: DCU demands Government end student accommodation crisis and slam Housing for All plan.

  Ref: ***https://www.msn.com/en-ie/news/other/dcu-demands-government-end-student-accommodation-crisis-and-slam-housing-for-all-plan/ar-AAOJzAR?ocid=winp1taskbar***

- Warning of mass emigration if Government doesn't tackle housing crisis article

  Ref: ***https://www.msn.com/en-ie/money/homeandproperty/warning-of-mass-emigration-if-government-doesn-t-tackle-housing-crisis/ar-AAPbQ1R?ocid=winp1taskbar***

- Sunday Business Post news article Re: CarlowBuild, a modular manufacturer

  Ref: ***https://www.businesspost.ie/houses/carlow-company-delivers-prefab-homes-for-eur200000-66b66e90*** [Accessed online on 21st September 2021]

- ikle Homes (UK) - Modular Housing solutions: Following Homes England's £30m investment into modular manufacturer ilke Homes, in Hull, Northeast England have short YouTube video tours of their factory - see links below:
  - Ref: ***https://www.youtube.com/watch?v=hktMBFNMK7c*** (31 May 2019)
  - Ref: ***https://www.youtube.com/watch?v=UIB7Ar22drs*** (6 Nov 2019)
  - Ref: ***https://www.youtube.com/watch?v=wHivVHqQ-Gc*** (7 Nov 2019)
  - Ref: ***https://www.youtube.com/watch?v=yPCHXMCk8xw*** (7 Nov 2019)
  - Ref***: https://www.youtube.com/watch?v=TjsNlkqgqt4*** (4 Mar 2020)

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland)

Figure 1

Brodeen Fabrications, Tipperary modular Vessel fabricated offsite for installation in Tipperary Co-operative ***21st June 2021.***

Figure 2

Brodeen Fabrications, Tipperary modular Vessel fabricated offsite for installation in Tipperary Co-operative ***21st June 2021.***

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 3

Brodeen Fabrications, Tipperary
delivery of modular Vessels fabricated offsite for installation in Tipperary Co-operative
21st June 2021.

Figure 4

Brodeen Fabrications, Tipperary
delivery of modular Vessels fabricated offsite for installation in Tipperary Co-operative
21st June 2021.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 5

Kavco Group, Annesley Bridge, North Strand, North Dublin
pre-cast construction of a Residential block.

Figure 6

Kavco Group, Annesley Bridge, North Strand, North Dublin
pre-cast construction of a Residential block.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 7

Breffni Ductwork
fabrication offsite for a Semiconductor facility
8th March 2021

Figure 8

Breffni Ductwork
fabrication offsite for a Semiconductor facility
8th March 2021

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 9

Breffni Ductwork
fabrication offsite for a Semiconductor facility
8th March 2021

Figure 10

Cygnum onsite erection of offsite fabricated components
11th November 2020.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 11

Cygnum onsite erection of offsite fabricated
11th November 2020.

Figure 12

Cygnum onsite erection of offsite fabricated components
11th November 2020.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 13

Cygnum onsite erection of offsite fabricated components
11th November 2020.

Figure 14

Cygnum offsite fabricated assembly line
11th November 2020.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 15

Cygnum offsite fabricated assembly line equipment
11th November 2020.

Figure 16

Kirby Group Engineering
offsite fabricated Electrical Switchgear module
July 2020.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 17

Dornan Engineering
offsite fabricated MEP module, UK residential development
July 2020.

Figure 18

Dornan Engineering
offsite fabricated MEP module, UK residential development
July 2020.

APPENDIX 9: **PHOTOGRAPHS OF RECENT MODULAR SOLUTIONS** (Ireland) *Continued*

Figure 19

Dornan Engineering
offsite fabricated MEP module, UK residential development
July 2020.

Figure 20

Jones Engineering
dedicated offsite fabricated facility in Co. Carlow
July 2020.

CIF Headquarters

Construction House
Canal Road
Dublin 6

Phone 01 406 6000
Email info@cif.i.e.

CIF Cork

Construction House
4 Eastgate Avenue
Little Island
Cork

Phone 021 435 1410
Email cifcork@cif.i.e.

CIF Galway

Construction House
8 Montpelier Terrace
The Crescent
Galway

Phone 091 502680
Email cifgalway@
cif.i.e.

www.cif.i.e.
@CIF_Ireland