A Detailed Description of Needs for the Irish Construction/Built Environment Sector

covering Technology and Innovation, Digital Adoption and Modern Methods of Construction in the context of productivity improvement and sustainability

Enterprise Ireland

November 2021

Final Report - Reliance Restricted

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Detailed Description of Needs for the Irish Construction/Built Environment sector **24 November 2021**

Dear Declan,

In accordance with the terms of our contract signed 31 March 2021, we have assisted you in the provision of a Technical facilitation and production of a Detailed Description of Needs (DDN) in the construction/built environment industry sector in Ireland. Our role is to provide you with an evidence-based set of data to advise on the current position of the construction industry in relation to the adoption of innovation and the increased digitalisation on the construction sector, together with our analysis and findings. We have not performed any management functions or made any management decisions.

Limitations of Scope
We have not, except to such extent as you requested and we agreed in writing, sought to verify the accuracy of any data, information and explanations provided by yourselves, and you are solely responsible for this data, information and explanations. We have therefore relied on any information provided by you to be accurate and complete in all material respects.

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We appreciate the opportunity to have provided our services to Enterprise Ireland. Should you have any queries or comments regarding this report or if we may be of any further assistance, please do not hesitate to contact me on +353 1 4792197.

Yours sincerely

Shane MacSweeney
Partner

Dashboard

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Acknowledgement

This project has benefited from the generous contributions of time, information and insights from many stakeholders and firms in the construction and built environment sector who have been consulted during the course of this assignment, have participated in focus groups and taken time to complete the industry surveys. In particular EY wish to acknowledge the cooperation received from Enterprise Ireland and members of the Construction Sector Group Innovation and Digital Adoption Subgroup for their valuable assistance throughout the project.

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Executive Summary and Recommendations

1 Executive Summary and Recommendations

This report is about ‘future proofing’ the construction industry and formulating a strategy for the next decade with respect to innovation and digital technology; the challenge is immense, but this is a once in a lifetime opportunity

The Irish construction sector is a major driver of economic activity. The industry is responsible for providing the social, economic, and productive infrastructure required to sustain economic growth and competitiveness, and attract foreign direct investment. The sector has perhaps never been as important to the Irish economy as it is in 2021, and will be over the coming decades to 2040.

As Government embarks on a major building and infrastructure investment programme over the next decade, and seeks to tackle housing and climate change, the industry needs to move away from manual processes and traditional forms of construction, to smarter, more efficient, and more sustainable ways of delivering on these plans.

The construction industry is under pressure to increase productivity and efficiency while also meeting the growing needs of an expanding population. It has to move to a new, higher level of performance and quality, while also being attentive to environmental, sustainability and circular economy imperatives. Embracing new innovation and digital construction technologies are fundamental to the future success of the industry. The benefits will be substantial for all concerned. A range of studies suggest that the use of ‘smart construction’ and digital technology can increase productivity and the efficiencies of the construction sector by from 10%-20% with up to a fivefold to tenfold increase in some circumstances.[1]

The rapid pace of technological change is already seeing some early adopters in the construction industry adopt new technological processes and more advanced construction systems to deliver value to their clients. Covid-19 accelerated the trend towards digital transformation. However, this digital and technological transformation needs all companies to build more productively and sustainably, regardless of scale. With 98.4% of construction enterprises employing less than fifty persons, a cultural shift is required at the grass roots level of the industry. [2]

There is now an opportunity to establish the right technical infrastructure to support this digital transformation drive in the construction and built environment sector, especially for micro and small enterprises (i.e., less than 50 employees) who are central to the domestic construction sector. While the establishment of a Construction Technology Centre needs to be industry-led, if the vision for the Centre is to be realised, Government’s role in supporting its development from inception right through to implementation is pivotal.

Purpose of this report

This report is about ‘future proofing’ the construction industry and formulating a strategy for the next decade with respect to innovation and digital technology. The challenge is immense but this is a once in a lifetime opportunity to transform the entire construction industry and deliver an industry that is fit for purpose for decades to come.

This report has gathered significant evidence-based data to produce a Detailed Description of Needs (DDN) for the construction and built environment sectors in relation to three areas:

- Modern Methods of Construction (MMC)
- Digital Adoption
- Technology and Innovation

The DDN is also to pay attention to environmental, sustainability and circular economy imperatives.

The purpose of the DDN is to inform the design of a bespoke Construction Technology Centre which will empower the industry to take ownership of the research, development, and innovation process and promote digital adoption and technology and collaboration among construction related companies and other stakeholders in the construction and built environment sector.

> *“Post the Covid-19 pandemic, Irish construction stands at a crossroads. We cannot afford to stand still. We have to move to a new level of performance driven by both productivity and sustainability.”*
>
> **P J Rudden, Chair - Innovation and Digital Adoption Construction Sector Group**

1 Executive Summary and Recommendations

This study is to inform the objective to establish and fund a Construction Technology Centre - one of 7 Priority Actions identified to address the construction productivity challenge

Context

The rationale for producing this report is based on the work of the Innovation and Digital Adoption Subgroup, part of the Construction Sector Group which was established by the Department of Public Expenditure and Reform in 2018. The subgroup involves almost 100 professionals working together since September 2020 to support the delivery of a more tech-savvy construction industry which adopts digitalisation and integrates innovative and sustainable technologies on their construction projects and in the wider supply chain.

This Innovation and Digital Adoption Subgroup is tasked with delivering on seven priority actions contained in the KPMG/Future Analytics report on Construction Productivity to address the challenges around construction productivity, and deliver a sustainable, innovative, and competitive construction sector for decades to come.[3]

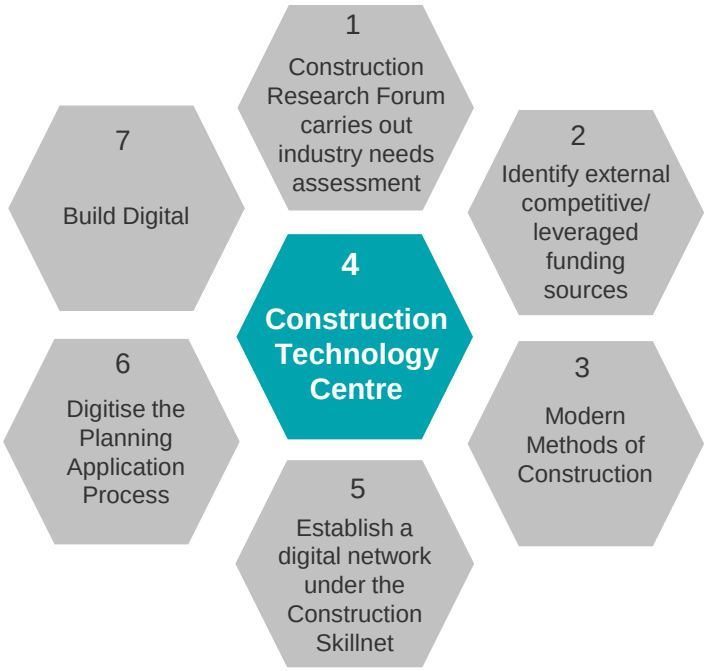
The Subgroup is progressing work on all seven priority actions; this study is informing **Action 4** which is 'To establish and fund a Construction Technology Centre'.

Challenges for the construction sector

There are a number of challenges for the construction sector which need to be addressed if it is to improve its efficiency and find the required building capacity to deliver the demands on the sector over the next decade:

- The cyclical nature of the construction industry - the value of output in the industry has fluctuated between 20.6% of GDP in 2006 and 5.4% of GDP in 2012. It is currently at 6.7% of GDP. [4]
- The fragmented nature of the sector - 92.8% of construction firms employ under six persons. [5]
- The low levels of productivity - the real gross added value (GVA, i.e. profit and wages) per hour worked in construction was €26.55 in 2019, almost unchanged from the level witnessed a decade previously (€26.58 in 2009), and is significantly below other Western European countries, where the real GVA per worker is €40 or higher in eight countries, including Germany. [6]

Figure 1: Seven Priority Actions – How they are linked



Methodology – Key workstreams

- Research on construction trends both globally and nationally in four core focus areas including sustainability
- Assessment of the Irish public research, development and innovation ecosystem and the challenges and opportunities over the next decade
- A benchmarking of international research institutes/initiatives/organisations established to improve innovation in the construction industry
- Two surveys: One for Stakeholder Representative Groups and one for Firms in the construction and build environment sector to inform the DDN profiles and the research more broadly
- Three workshop engagements with firms, stakeholders and government departments to capture views on the key challenges for the built environment sector and to elicit their views on the role of a Construction Technology Centre
- Case studies to examine in detail the approaches adopted by the benchmarked institutions

1 Executive Summary and Recommendations

Digital innovations and megatrends continue to evolve and shape the construction industry

Key advancements in global construction technologies

Our analysis and studies across the globe point to key advancements underway in global construction technologies over the last decade which are shaping the future of the global construction industry. The digital evolution (or revolution) and investment in technology continue to improve efficiency, aid the adoption of modern methods of construction and provide transparency for building management and the measurement of performance indicators, including sustainability.

From our review of the literature, we can see the proliferation of new technologies which are being adopted at a rapid pace throughout the project lifecycle. These include Building Information Modelling (BIM), project control and scheduling software, the use of sensors, as well as the use of cameras and drones to monitor projects and create smarter buildings. Automation is to be found in almost every repetitive process and the industry is seeing an increased take-up of industrial manufacturing and modern methods of construction to compensate for declining on-site construction productivity. By incorporating and expanding these technologies, the global industry is providing more intelligent planning of construction, supply chain management and delivery.

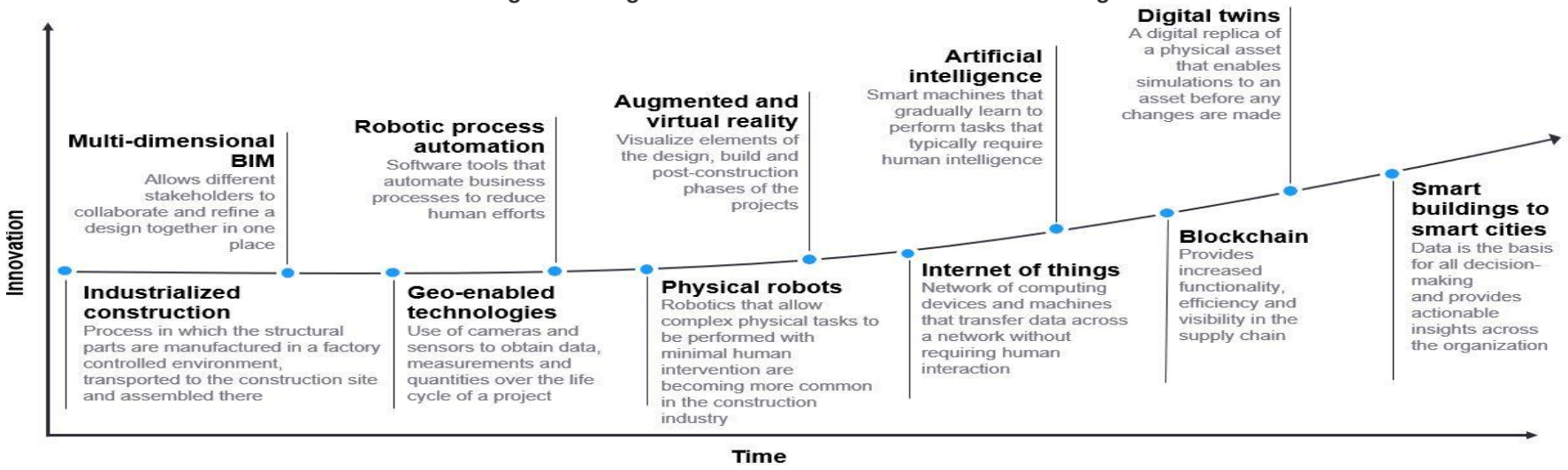
It is also evident that a number of IT and software companies have recognised the demand for digitalisation in the construction industry and are expanding their service offerings to provide solutions for many of the above processes.

This advancement of construction technologies is also helping to solve some structural and building performance issues which have emerged in many parts of the world.

Digital transformation is helping to address trust, risk, and cost issues by, for example, using unique product identifiers based on global standards to track and trace building materials throughout the supply chain.

Those construction companies across the world who are pursuing the above technologies are helping to overcome a number of construction challenges, notably speed of deliverability, economic viability, quality, and the enhancement of sustainability.

Figure 2: Megatrends in Global Construction Technologies



1 Executive Summary and Recommendations

Ireland's adoption rate of MMC is low; there are a number of challenges around its adoption but it can deliver a 20%-40% reduction in costs

Modern Methods of Construction

Results from an EY survey of firms, combined with a review of literature, indicate that the utilisation of Modern Methods of Construction (MMC) in the Irish construction and built environment sector remains relatively low.

7.4% of the firms that responded to the firms' survey regarded Off-Site Manufacturing/Modern Methods of Construction (OSM/MMC) as being their main activity. However, a number of large contractors tend to use MMC as part of their main activity of being a 'main contractor'.

When asked to what extent the firms used a range of modern methods of construction, the survey found that the following items were used to a very great/great and moderate extent:

- 39% use sub-assemblies and components
- 36% use panelised systems
- 34% use volumetric or modular systems
- 21% use bathroom/kitchen pods

62% of firms in the EY survey believe that modular construction will be of great importance or of very great importance in the next 10 years. The perceived future importance of MMC was stronger amongst larger firms, with 86% of larger firms highlighting the importance of MMC to the future of the industry.

With an average of 33,000 homes required each year until 2030, according to the Housing for All Plan, MMC and offsite construction can help address the housing supply shortfall more speedily, while also delivering well-designed and high-quality buildings, cost savings, and higher productivity.

MMC has the potential to improve the speed of construction of new homes through the adoption of innovation by 30%, with a potential 25% reduction in costs, as well as the potential for advances in improving quality and energy efficiency (according to a UK Government White Paper). [7]

- The potential benefits of MMC are substantial with [8]:
  - A 20%–60% reduction in construction programme time
  - A 20%–40% reduction in construction costs
  - A 70%+ reduction in onsite labour, which creates improved outcomes in health and safety for workers
  - Greater programme certainty
- 65% of firms identified 'mainstreaming sustainable, modular construction and standardised building elements' as the most important area of circular built environment research that should be undertaken by a Construction Technology Centre.

However, there are significant challenges around the adoption of MMC which can arise along the construction supply chain and need to be overcome, notably: [9]

- Financing challenges, as lenders may see it as a new method of construction with a limited track record, resulting in a hesitancy to commit. This has the potential to result in working capital issues for contractors.
- There are significant upfront capital costs involved with the factories required for MMC. There are also the costs of developing the architectural design and manufacturing processes. Certain oversized vehicles are also required to transport the prefabricated modules to site.
- Related to the above are the logistical controls required to ensure timely and effective deliveries throughout the supply chain. MMC requires efficient management and coordination of both the factory and the construction site.
- Specialised labour is required to operate the specialised equipment and assemble the prefabricated components.

1 Executive Summary and Recommendations

True digital business transformation is an ongoing process that requires cultural change; Ireland's Digital adoption rate is low

Digital Adoption

A range of digital technologies are slowly being adopted in the construction industry. However, there is a lack of understanding of what constitutes digital adoption, and how it can be employed in the construction process. Building Information Modelling (BIM) is often at the forefront of conversations around digital adoption within the industry and has been a feature of the industry for over a decade. However, Ireland does not have a BIM mandate and is currently at 2D and 3D in terms of BIM adoption [10].

It is acknowledged that BIM is not new, and some leading companies have been doing it for many years. The National Development Finance Agency (NDFA), for example, which procures and delivers Public Private Partnership (PPP) projects has been using BIM on PPP projects for a decade.

The main points which emerged regarding BIM adoption are:

- There appears to be mixed results in regard to the level of BIM adoption. Earlier studies from CitA reported high levels of adoption, albeit across small samples of leading professional firms, while the survey for this DDN study is showing more modest levels across the entire industry.
- The level of BIM adoption among smaller firms (i.e., less than 15 people) working on smaller projects (e.g. extensions, conversions, etc.) is significantly below the national average. Even when all parties to a project use BIM, there can be differing levels of maturity adopted across the project team.
- The challenge is to not only increase the level of BIM adoption, but to also grow the level of BIM maturity.
- Central to tackling this challenge is the establishment of the **Build Digital (Action 7)** project which has been awarded by DPER to the three technological universities TU Dublin/CitA (lead), Munster TU, and Connacht-Ulster TU, and which will seek to embed integrated BIM and develop world-class digital practices for the entire industry over the next five years.
- One of the highest-ranked barriers to BIM implementation is a client's lack of awareness of the value proposition of BIM. One suggestion to tackle this issue is for the government to introduce an integrated BIM mandate (1D up to 7D), which would require BIM to be applied on projects above a certain threshold value (to be determined).
- The primary barriers for BIM implementation in Ireland were seen as a lack of in-house expertise (74%), no client demand (67%), and a lack of training (67%). The absence of an established contractual framework for working with BIM was also seen as a critical barrier.

An interesting approach to transforming the built environment sector is Integrated Digital Delivery (IDD).[11] This is enabled by BIM and other digital technologies, and allows the various parties on a construction project to collaborate better by facilitating the seamless sharing and delivery of digital information from design, off-site manufacturing, and site assembly, to operations and building maintenance. IDD is a solution which benefits every stakeholder in the entire supply chain by delivering faster and better design options for the client, faster approvals for the manufacturer, improved project costs, time, quality, certainty, and streamlined cost-effective operations and maintenance for the asset operator. It also promotes an integrated approach to digitalisation covering the whole lifecycle of a building project. This is the approach the Irish construction industry needs to achieve and a Construction Technology Centre can support the industry in this transformation.

To fully transform construction enterprises by enabling the adoption of digital technology, there are three guiding principles:

- True digital business transformation is an ongoing process that requires cultural change.
- Recognise the adoption of technology must be about transforming the business, and not about the technology itself.
- Any new digitalisation must improve value for clients as well as for the businesses serving those clients.

1 Executive Summary and Recommendations

There is a significant lack of knowledge and understanding about construction specific technologies and how technologies can be implemented within day to day projects

Technology and Innovation

Construction technology is an all embracing term for the collection of innovative tools, machinery, modifications, and software used during the construction phase of a project that enables advancement in field-construction methods, including semi-automated and automated construction equipment. The use of technology during the construction phase has become more popular over the last ten years with the use of mobile apps, autonomous heavy equipment, drones, and augmented and virtual reality becoming more commonly used in global construction projects.

The EY survey of firms suggests that there is a significant lack of knowledge and understanding about construction-specific technologies, and how technologies can be implemented within day-to-day projects.

However, when firms were asked about the culture of their firm, 38% of respondents stated that there was a 'great' or 'very great extent' to which they felt their firm was likely to engage in innovation. However, only 29% of respondents felt that there was adequate training for new technologies.

Research has suggested that there are numerous benefits to using technology and innovation in the construction industry, such as tracking workers throughout the day using smartphones or wearables, using site sensors across a construction site to monitor things like temperature, noise levels, dust particulates, and volatile organic compounds to help limit exposure for workers, and using bricklaying robots who work continuously to complete tasks faster than human workers without needing to take breaks.

The evidence from the EY survey of firms is that, on average, 40% of firms in the industry are not using any form of automated technologies within their current projects.

Aggregating the 'very great', 'great extent', and 'moderate extent' responses in the firms' survey for the current use of automated technologies, the most commonly cited technologies within the sector are:

- Document Management Systems (60%)
- e-Procurement (57%)
- Mobile technologies or mobile platforms to manage projects in real time reporting (50%)
- Locating and tracking resources indoors using technologies such as laser scanners, video cameras, ultra-wide band (UWB), and wireless local area network (LAN) instead of manual methods (45%)

Evidence from the EY survey of firms found that the key deterrent preventing firms from implementing new technologies in Ireland is being busy with other priorities (such as the day-to-day running of the business, lack of time, and lack of financial incentives to do so).

Whilst there are a number of challenges to technology adoption within the sector, there is an opportunity for a Construction Technology Centre to assist firms in breaking down these barriers.

1 Executive Summary and Recommendations

The built environment and construction industry is in a position of considerable responsibility and influence, in terms of delivering a more climate resilient economy

Sustainability

In recent years, climate resilience has moved centre stage on both a political and societal level. In March 2021, the Government published the Climate Action and Low Carbon Development (Amendment) Bill which declared that the economy will transition to a climate resilient, biodiversity-rich, environmentally sustainable and climate-neutral economy by the end of 2050. [12] If enacted, this Revised Bill would represent a significant step-change for the built environment and construction sector, with the proposed introduction of carbon budgets which will introduce limits on the total amount of greenhouse gas emissions permitted during a budget period. This will see the government setting an emissions ceiling for different sectors, including construction and the built environment sector, for the five year period within the limits of the carbon budget.

Buildings and their construction together account for 39% of all carbon emissions in the world, with operational emissions (from energy used to heat, cool, and light buildings) accounting for 28%.[13] The remaining 11% comes from embodied carbon emissions, or 'upfront' carbon that is associated with materials and construction processes throughout the whole building lifecycle.

The built environment and construction industry is in a position of considerable responsibility and influence, in terms of delivering a more climate-resilient economy. However, with this great responsibility comes great opportunity, and the EY survey of firms indicates that over the next ten years:

- 80% of firms believe that sustainability and energy will be of 'great' or 'very great' importance.
- 71% of firms believe that innovative/sustainable materials will be of 'great' or 'very great' importance
- 59% of respondents believe that the whole life performance of buildings will be of 'great' or 'very great' importance

When asked similar questions, 88% of the key stakeholder groups surveyed reported that sustainability and energy will be of 'very great' or 'great importance' over the next ten years.

In order for the industry to move forward and improve its level of sustainability, any challenges which prevent the industry from adapting and moving forward will need to be addressed.

When firms were asked about the top challenges facing sustainability in the construction sector, which they believe a Construction Technology Centre should research, the following top five challenges were prioritised:

- Decarbonising construction processes – 67%
- Mainstreaming sustainable modern methods of construction – 67%
- Delivery of affordable and efficient retrofit of buildings – 60%
- Mainstreaming sustainable and locally manufactured materials – 44%
- Delivery of affordable and sustainable multi-family dwellings – 44%

To deliver a more climate resilient economy, a huge culture shift is needed towards actions and policies that tackle the full lifecycle of buildings and their impacts.

All of the actors along each stage of the construction and built environment value chain may need to be incentivised to co-ordinate their efforts and embrace the possibilities for decarbonisation, to reduce the negative environmental impact of their activities.

1 Executive Summary and Recommendations

As with the international institutions benchmarked, the typical technology centres in Ireland are collaborative entities established and led by industry and funded by a mix of public and private sources

Benchmarking

The research is informed by an international benchmarking analysis of seven institutions providing and encouraging the adoption of construction technology across the construction and built environment sector at an international level.

The benchmarking exercise has shown that whilst the majority of the institutions researched are relatively young, a number of initiatives appear to have been extremely successful in increasing the prevalence and use of technologies across the construction sector in their respective jurisdictions.

It is evident that in order to ensure that a Construction Technology initiative is successful, there needs to be a robust governance structure, clear objectives, and clear targets to ensure success. The implementation of a business plan with attention focused on a small number of priority areas to start with is an important element of the journey.

The main sources of funding across all of the institutions examined tend to be a mix of national governments and/or EU and private sources. Initiatives examined across the UK have typically been allocated between €10 million (Construction Scotland Innovation Centre) and €15 million (Dudley Advance II) of public funding to begin with over a multi-year period. Other funding is often provided by academic institutions or other project partners. The remainder of funding tends to be sourced via membership and/or commercialisation of the research.

As with the international institutions benchmarked, the typical technology centres in Ireland are collaborative entities, established and led by industry, and funded by a mix of public and private sources. They are joint initiatives between Enterprise Ireland and IDA Ireland to enable Irish companies and multinationals to work together on research projects in collaboration with research institutions.

Given the fragmentation of the construction sector, the target clients are outside the normal public research ecosystem available to IDA Ireland and Enterprise Ireland clients, who are predominantly enterprises with an export dimension. In the EY survey, construction firms are unaware of the funding initiatives available from both agencies, apart from Innovation Vouchers provided by Enterprise Ireland (52% of firms are not aware of these according to the firms' survey). Hence, it is fundamental to the success of the Centre that the largely domestic construction and built environment sector is supported on its innovation journey.

The benchmarking exercise provides a number of insights that are instructive for potential approaches that could be adopted in Ireland. Three important lessons that emerge for the establishment of a Construction Technology Centre in Ireland are:

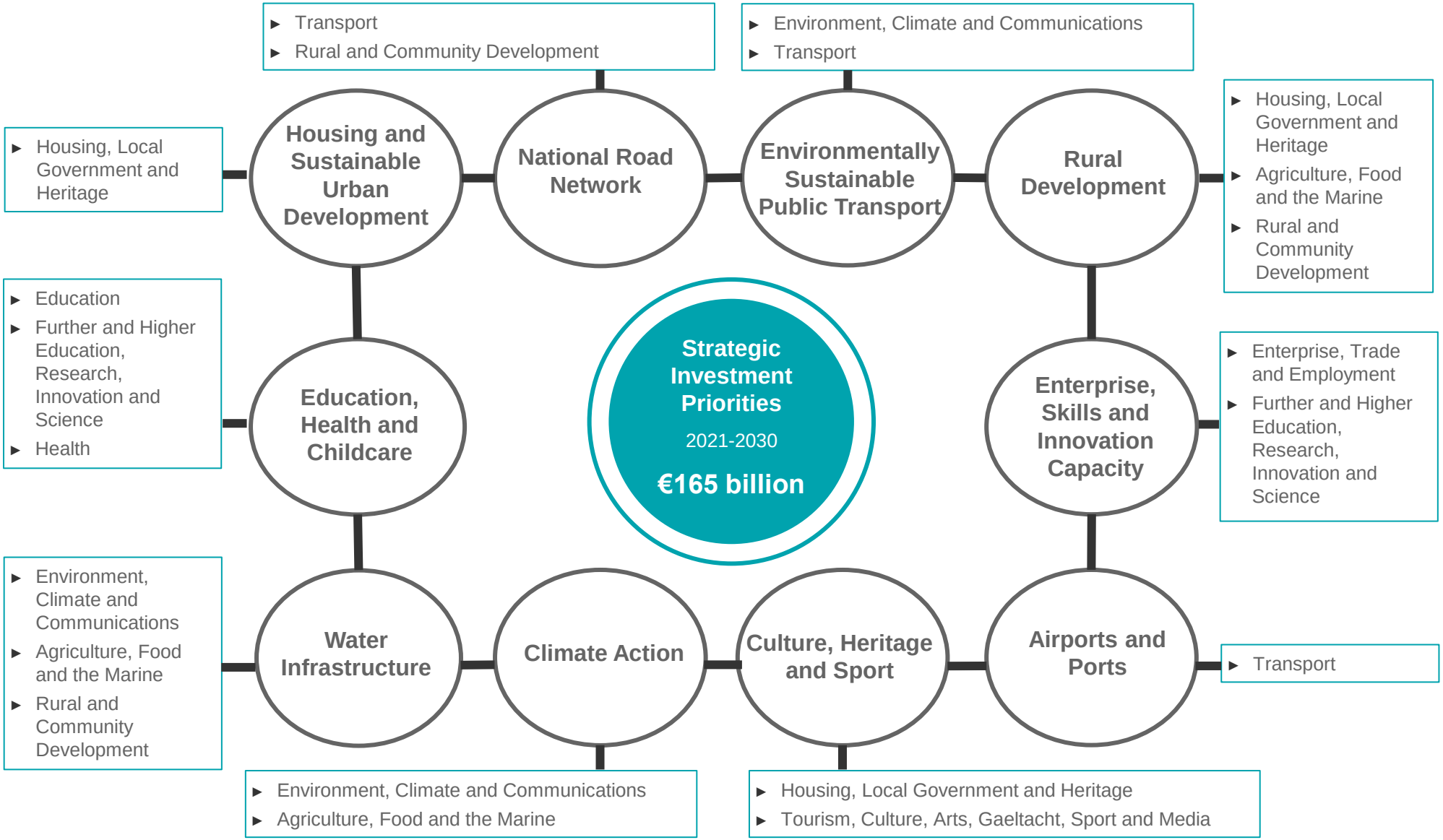
- **Communication** and the need for clear guidance from the research institute on the available research/support for businesses. There is a need to promote what the centre can actually do to support businesses, but there also needs to be a willingness from businesses to actually innovate.
- **Collaboration** between government, industry, and academia, to ensure there is buy-in across the board for the Centre to work and deliver a positive impact on innovation within the sector.
- **Commercialisation** of some services and initiatives could optimise them whilst generating income to sustain and scale them.

Other learnings include the requirement for a clear definition of needs, appropriate benchmarks and key performance indicators, buy-in from the industry and government, and a willingness to collaborate which can be achieved by ensuring that support and resources are tailored to the needs of construction enterprises.

When deciding the mix of funding for the Centre, consideration should be given to the fact that in the region of ten government departments who are the project promoters for the building and infrastructure projects in the National Development Plan 2021-2030 (NDP), Project Ireland 2040, the Housing for All Plan, and the Climate Action Plan, rely on the construction industry to deliver their capital projects, based on the Strategic Investment Priorities in the NDP (see next page).

1 Executive Summary and Recommendations

Based on the Strategic Investment Priorities in the National Development Plan (NDP) and the National Planning Framework, 10 government departments rely on the construction industry to deliver their capital projects[14]



1 Executive Summary and Recommendations

There are a number of questions which need to be addressed in relation to the planning and design of a Construction Technology Centre

The Detailed Description of Needs

The most important role of the DDN is to inform the approach to the establishment of a Construction Technology Centre and the interventions required to improve innovation, competitiveness, and productivity in the construction sector. In this regard, a number of questions arise in relation to the planning and design of a Construction Technology Centre ("Centre"):

- What part should government play in supporting the development of the Centre?
- How should the Centre be governed?
- How should the Centre be funded to ensure that it can sustain the entire construction sector on its innovation journey over the next decade and beyond?
- What should the areas of focus of the Centre be?
- How does the Centre ensure sustainability and circular economy imperatives are embedded in its operations?
- Who are the target clients for the Centre?
- What are the competencies that these clients need as they seek to digitally transform their businesses and start their innovation journey?
- What interventions are required from the State to ensure all enterprises in the domestic construction sector (DCS), regardless of scale, are on board the innovation journey?

These questions are addressed in the recommendations set out in the following pages.

> *A National Construction Technology Centre could provide a go-to source of advice, R&D capacity, funding avenues, advanced industry expertise, and access to potential collaboration partners for the entire construction industry and its supply chain and stakeholders. A diverse industry membership would give the Centre and its members access to knowledge in multiple applications and technology areas across the value chain that would not be available to individual companies. It would leverage investment (industry and competitive) in existing academic research capabilities, and build critical mass for the sector. It would harness the collective learnings and ideas of the industry in one place to maximise innovation, minimise wastage of resources across the sector, and raise the profile of construction in Ireland in a sustainable and exciting way for the future.[8]"*
>
> **CIF Response to public consultation on the EU National Recovery and Resilience Fund [15]**

1 Executive Summary and Recommendations

Recommendations – Centre needs to be industry led with Government playing a key role

There is now an opportunity to establish the right technical infrastructure to drive transformation in the construction and built environment sector, especially for small and medium-size enterprises, that are central to the domestic construction sector.

In advance of making recommendations, the **overarching considerations** for the Construction Technology Centre are:

A. Creating a digital vision and roadmap: A formal roadmap helps in identifying technologies, hiring talent and determining success factors and performance metrics.

B. Prioritising and starting small: Not every technology needs to be disruptive at a large scale.

C. Managing risk: Identifying and monitoring risks to implementation; ensuring the focus and vision stays on track.

Based on the research conducted, insights gathered from workshops and surveys, the comparison with international leading practice and the Detailed Description of Needs assessment, the following recommendations arise for the establishment of a Construction Technology Centre ("Centre") in Ireland.

Recommendations

1 Centre needs to be industry led with Government playing a key role

1.1 For the vision of the Centre to be realised, the project needs to be industry-led with Government playing a key role from inception to implementation

While this project should be industry-led, it is essential that Government plays a vital role in supporting the development of the Centre from the outset.

A Government endorsement of, and confidence in, the Centre will be important for the following reasons:

- Government has already signalled a clear commitment to the construction sector with the establishment of the Construction Sector Group to support and ensure a sustainable and innovative construction sector for the future.
- The latest National Development Plan 2021-2030 set out a capital investment programme of €165 billion over the next decade. Construction is central to the delivery of the economy's social, productive, and economic infrastructure and it is in the interest of Government to ensure that the industry accelerates the digital transformation process and delivers increased productivity, value for money and a more sustainable built environment.
- With housing a major policy challenge for the last decade, the Centre can support the housebuilding industry by providing research and training on the move to more modern methods of construction to ensure the targets in the Housing for All Plan are met. This can assist the speed of delivery, reduce the cost, and improve the quality of buildings, their maintenance and their running costs.
- Central to the focus of the Centre will be environmental, sustainability, and circular economy imperatives. The Centre can lead on upskilling the workforce to deliver on the retrofitting ambitions of the Government's Climate Action Plan.
- Clear and visible government support for, and confidence in, the Centre, will play a key part in marketing the Centre, encouraging buy-in from all of the relevant stakeholders, and improving the reputation of the Irish construction sector both at home and abroad.

From the benchmarking exercise, the national government was involved in leading the vision for the Construction Innovation Hub in the UK. This was born out of the UK Governments' Construction Sector Deal, a partnership between the UK Government and the construction industry to provide funding for construction technology. The Sector Deal included a government commitment to invest £170 million into the Transforming Construction Programme, to develop and commercialise digital and offsite manufacturing technologies to produce safe and sustainable buildings. A total of £72 million was provided for the Construction Innovation Hub.

1 Executive Summary and Recommendations

Recommendations – Robust governance structure which is industry led but with Government playing a key role

2 Governance

2.1 The Centre should be an autonomous body, organised under the aegis of a Government department that can give it the level of sponsorship and drive the level of collaboration across all relevant Government departments and stakeholders. Setting up such a Centre would give a clear signal of the Government's commitment to, and confidence in, developing a successful construction centre of excellence renowned for best in class RD&I and process improvement.

2.2 Development of a clear and robust governance structure will be required to ensure the realisation of the Centre from a conceptual basis, to a viable and successful centre of excellence, where all stakeholders in the construction and built environment sector can go to for support.

2.3 An industry-led Chair to be appointed by Enterprise Ireland.

2.4 The Chair, in consultation with Government, will appoint an oversight Project Board and a management team to set the strategic plan and monitor its implementation against performance metrics.

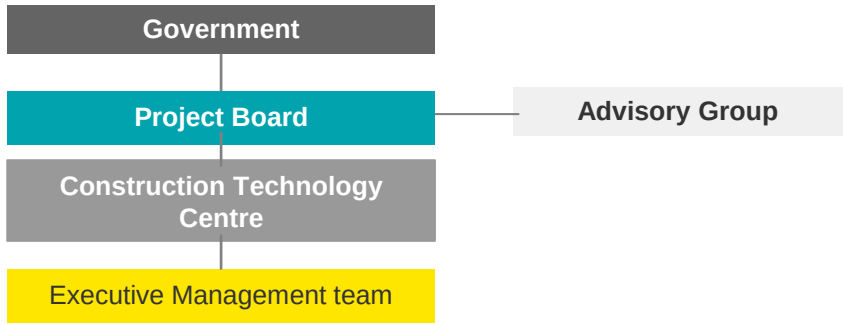
2.5 Implementation and operationalisation of the initiative will be managed by an Executive team. The team should include heads of research, technical, and policy experts and representatives of academia.

2.6 The appointment of a credible Chief Executive/National Director, supported by the Executive team, will be important. Within 6-9 months they should have a fully crystallised business plan that sets out the core research and development and areas of focus for the Centre which industry will co-fund.

2.7 Based on the information available and the benchmarking analysis of other areas, the following key objectives for the CEO/ND and the Executive team should be:

- Establish and drive the Vision for the Centre
- Develop a 90 day plan for the identification of immediate "quick win" interventions that can be developed to tackle tactical challenges and to create solutions, such as, for example, for the housing crisis
- Develop the Business Plan within 6-9 months of being appointed
- Monitor the implementation of the Plan
- Complete a present state analysis of funding currently in place for RD&I across the construction and built environment sector and academia to ensure transparency and avoid duplication
- Secure funding for the Centre
- Set out the core areas of activities which the Centre will fund
- Develop and promote the Centre
- Make recommendations to the Project Board as appropriate

Proposed Governance Structure for Construction Technology Centre



2.8 The Project Board will provide oversight and support to the Executive team. The Project Board should include six to eight individuals who should be recruited based on competencies in the requisite areas, rather than the organisations that they represent.

1 Executive Summary and Recommendations

Recommendations – Mix of funding sources comprising Government, industry, EU and the public research ecosystem

3 Governance

3.1 A wider reference group or Advisory Board should be established consisting of representatives of all major stakeholders.

3.2 The Advisory Board would comprise a research arm, which would be responsible for continuously benchmarking the Centre against international best practice.

3.3 The Centre will have an agreed set of key performance indicators and critical success metrics:

- These will be used to manage the Centre's outputs and activities, and to ensure that value is being created for industry
- They will be monitored and reviewed on an ongoing basis to ensure progress in line with agreed timelines

4 Funding

Based on the benchmarking exercise, other successful construction technology centres and initiatives are typically funded by government with industry funding scaled up over time:

- The Construction Scotland Innovation Centre received a total funding of £9.5 million initially (2014), and a further £11 million in 2019, in addition to £8 million from industry and other project partners.
- Dudley Advance II in the UK received £15 million of public sector investment and £5.5 million of private sector investment.
- The Canada Centre for Innovation in Construction & Infrastructure Engineering & Management receives 57% of its funding from federal government, 14% from provincial government, 14% from non-government agencies, 6% from other government sources, and 10% from external sources.

The recently established Build Digital Project has been awarded by DPER to TU Dublin/CitA for five years 2021-2026. The purpose is to embed integrated Building Information Modelling (BIM) in the construction industry up to Level 7D (Ireland currently at Levels 2D and 3D), and to work and upskill clients, consultants, contractors, and suppliers, including SMEs, over the five years. A budget of €2.5 million over the five-year period (€500,000 per annum) has been provided for this initiative.

The funding set out below does not include funding for advancing Modern Method of Construction (Action 3); this forms a parallel track and is the subject of a separate report.

4.1 Based on the experience in centres across other jurisdictions, and the funding typically allocated to same, the funding for the Centre should comprise a mix of Government, industry, and other sources (e.g. EU) over time. Centres of this nature will likely require cumulative funding of €10 to €15 million in their initial years, although it does depend on scale. Thus, following the completion of a Business Plan, the following indicative high-level funding profile is recommended:

- Based on the benchmarking exercise, an indicative investment of the order of €15 million in the first five years (€3m per annum) from the State. A review/audit after three years should determine whether the plan is on track, and whether funding should be continued.
- In line with the State's tendency to ramp up its allocation to RD&I over time, the State's contribution in the second five years is set at €21 million, and to €5 million by year 10.
- The industry ramps up its funding over time to €3 million per annum by year 10, diluting the State's share and generating a total public and private investment in the order of €8 million after ten years.
- Other sources, notably the EU, should be available in the first decade (from, for example, the EU National Recovery and Resilience Plan, the EU Green Deal, EU Innovation Fund), generating an increasing contribution over time from EU and other sources, to in the region of €2 million by year ten. This would deliver a diverse funding mix after ten years of a total of €10 million from the three sources (50% from the State, 30% from industry; 20% from EU and other sources).
- There is also the potential to leverage other competitive sources from the public research ecosystem such as Horizon Europe and the Disruptive Technology Innovation Fund.

1 Executive Summary and Recommendations

Recommendations - Recognise scale and digital maturity of enterprises across the sector

5 Funding

5.1 The ten government departments who are the project promoters for the building and infrastructure projects in the National Development Plan 2030, and Project Ireland 2040, the Housing for All Plan, and the Climate Action Plan should provide a proportion of their budgets towards funding for the Centre.

5.2 The Centre should provide flexible options in the form of membership fees and/or Pay-As-You-Go for renting and use of equipment. The international benchmarking showed how commercialisation of the Centre can work well by using membership fees as an additional source of revenue for the Centre and/or paying for, or renting, equipment. (See Case Studies on Scotland and Norway, Appendix 4, pages 182, 183 and 188).

5.3 The Centre would provide a combination of grants/vouchers to partially fund projects and programmes. The target clients are outside the normal public research ecosystem available to IDA Ireland and Enterprise Ireland clients, who are predominantly enterprises with an export dimension. In the EY survey, construction firms are unaware of the funding initiatives available from both agencies, apart from Innovation Vouchers provided by Enterprise Ireland (52% of firms are not aware of these according to the firms' survey). Hence, it is fundamental to the success of the Centre that the domestic construction and built environment sector is supported with researching new products, processes, businesses models and services across the sector.

6 Scale of organisations in the sector

The Centre must appreciate that the majority of industry players are micro, small, and medium-sized enterprises – almost 100% of construction enterprises are SMEs, and 99.6% employ less than 50 persons, accounting for 80.9% of persons employed. The Centre must develop its offerings to reflect this fragmentation of the sector as well as appreciating the limited budgets, human capital, and capacity that organisations of this scale have to dedicate to digital transformation, as informed by the survey.

6.1 Specifically, the target client focus needs to be on the domestic construction sector and on those enterprises who do not have the time to implement new technologies. There needs to be a strategy for these micro (employ <10) and small (employ 10-49) firms which between them make up the vast bulk of construction enterprises (99.7%). The Centre must ensure the key competencies that these clients need are provided by the Centre as they seek to digitally transform their businesses and start their innovation journey.

6.2 To ensure that the services provided by the Centre filter down to all enterprises in the domestic construction sector, regardless of scale, appropriate measures should be put in place to support domestic firms on their innovation journey.

6.3 The Centre needs to cater for the above groups in particular, while also catering for medium (employ 50-249) and large (employ 250 and above) enterprises. Only by having all enterprises on board, can the success of the Centre be guaranteed and the total productivity of the entire industry value chain be raised.

7 Digital maturity of organisations in the sector

7.1 The Centre must also reflect the varying levels of digital maturity between stakeholders and sub-sectors in the industry. Many firms will have a different interface with clients – ranging from being sub-contractors to large firms using advanced technology, to acting as sub-contractors down a long supply chain of sub-contractors working on small contracts.

1 Executive Summary and Recommendations

Recommendations – Focus on developing capability in three core areas

8

The Centre must focus on developing capability in three core areas

For the Centre to enable Digital Transformation and Innovation across the construction and built environment sector in Ireland, it must focus on developing capability in three core areas – each of equal importance: **People, Process and Technology**

8.1: People - Provision of effective training and accredited training in collaboration with local academics/universities, to improve the capabilities of the construction workforce, such as those listed below:

- To enable digital transformation within the construction industry, individuals will require the appropriate digital skills to equip them for success. This will include foundational digital skills including DESIGN Thinking and Agile. It is suggested that a significant focus of the Centre be education and alignment to educational infrastructure such as Skillsnet and the National Framework of Qualifications (NFQ) framework for the deployment of training and courses for industry.
- One or two-day training courses in accreditation BIM and Modern Methods of Construction should be provided by the Centre at market/commercial rates. Advance Dudley II in England partners with academics and industry experts to upskill the industry and increase productivity. Such courses could help businesses win larger contracts.
- The Construction Scotland Innovation Centre in collaboration with the Scottish Federation of Housing Associations (SFHA) and a consultancy firm, developed an intensive two-day Continuing Professional Development (CPD) training course aimed to equip those responsible for the design and delivery of affordable housing projects across Scotland, including the benefits of applying integrated BIM (up to 7D) to a construction project. This CPD workshop was aimed at development teams, maintenance teams, and design teams including architects, engineers, construction partners, and their supply chains (see Case Study p197).
- Government stakeholders from procurement teams could also be involved to support their understanding of construction technology usage at a procurement level.

8.2: Process – Develop a good practice process library

- To expedite efficiency in the delivery of buildings as well as to support administrative tasks, it is recommended that the Centre develop a ‘good practice’ process library for core commoditised industry processes. These can be mapped to a process automation maturity model to enable firms of varying size and scale to adopt and deploy these ‘good practice’ processes to maximise output. The model will benchmark to automation tools including standard workflow, business process management (BPM), and intelligent automation, e.g., robotic process automation.

8.3: Technology - Create a technology ‘reference architecture’ for the construction industry

- To enable automation, the enhanced use of data, and process execution between parties, the Centre should create a technology ‘reference architecture’ for the construction industry. This will highlight the centralised infrastructure that is required in a shared services model for commoditised processes in construction, the integration layer that is required to enable firms of all size and maturity to access this infrastructure, as well as the governance, security, and data protection requirements to enable this capability. The architecture will serve as a blueprint or roadmap for the technology evolution of the sector, and how economies of scale can be achieved in the model as opposed to firms building siloed solutions within their own environments.

1 Executive Summary and Recommendations

Recommendations – Having set out the governance, funding and the three core areas of capability for the Centre, the following are the more detailed areas of focus in the immediate term

9 Immediate priority areas – fifteen in total

9.1 To make a significant impact and to tackle the most pressing challenges, e.g., the housing crisis, the Centre must focus immediately on interventions that create quick wins.

9.2 A dedicated team to create such solutions and to deliver sprints for development will prepare the 90-day plan, referred to under Governance, to identify the immediate interventions that can be developed to tackle tactical challenges and to create solutions.

9.3 The Centre can help to increase the take-up of MMC for housebuilding, by firstly raising the profile of the wide range of innovative techniques that cover MMC. Taking the UK Construction Innovation Hub (UKCIH), as an example, they are working in collaboration with industry, clients, and government to develop a platform-based design for manufacture and assembly, which consists of a standardised 'kit of parts' that can be deployed across multiple building types and sectors, including housing. The programme at the UKCIH involves a number of elements, including innovation workshops, regular manufacturing demonstrator events, and working with clients to establish the needs of the buildings to incorporate them in the platform specification. The Centre in Ireland could test and develop these principles for housing specifically, although the platform can also be developed for other building types.

9.4 It is important that the existing initiatives that are doing great work to support the transformation of the industry, all of which are individually funded, are invited to become part of the competency of the Centre over time. This means that the Centre should act as a magnet to draw all of those early adopters in, to ensure a collaborative role between them and the Centre. This could be achieved over time by having Service Level Agreements (SLAs) between the Centre and these existing initiatives.

9.5 Provide a one-stop online shop information resource/resource library

- The Centre should provide a one-stop online resource/library, which supports the industry and its stakeholders (and specifically SMEs) with a glossary of terminology, information on existing research and databases available, information on existing national and EU standards and regulations, as well as information about regulatory bodies. This would provide a single trusted source of information. This would extend to interacting with experts in different technical areas who would enhance the body of knowledge in the Centre.
- As discussed, the fragmented nature of the sector invariably means that such companies do not have time/resources to invest in technology and innovation. The Centre, therefore, can play a key role from an education perspective, by providing information on the incentives that are already available from Government, and exploring additional incentives with Government which maximise the return for all members of the construction and built environment sector as well as for the economy

9.6 There is no BIM mandate in Ireland. There needs to be an integrated BIM mandate (1D up to 7D) to drive BIM standards throughout the industry supply chain. This has been successful in jurisdictions like Norway and the Netherlands. It could be required for projects above a certain threshold, to be determined.

9.7 Public procurement processes should incorporate innovation and climate action targets into their tendering processes to incentivise digital adoption, technology, modern methods of construction and sustainability.

9.8 Introductions to like-minded businesses and experts

- The Centre should hold conferences to bring together like-minded businesses and key experts from other international centres and have sessions to promote and get to know the Centre, thereby encouraging increased membership. Through a membership option, the Centre could encourage collaboration on bidding for projects across a range of disciplines. These initiatives would facilitate networking across the industry and introduce firms to other like-minded firms. With the increasing complexity of roles being created as a result of digitalisation and technology, this networking would also support the building of a workforce of T-shaped workers across the construction supply chain with discipline specific skills in at least one area and knowledgeable or skilled in several others which would be transferable across the organisation.
- The Centre can provide equipment suppliers who donate equipment with the opportunity make sales down the line to interested parties.

1 Executive Summary and Recommendations

Recommendations – Sustainability is a key priority area

9

Immediate priority areas – fifteen in total

9.9 The centre should establish a Sustainability Action Plan within the first 90 days of the Centre being established. The Sustainability Action Plan will keep the Centre focused and accountable, by ensuring that every action undertaken is concerned with building a sustainable environment within the industry.

9.10 The Centre should have a Sustainability Workgroup like the Centre for Innovation in Construction and Infrastructure Engineering Management in Canada, which has formed a workgroup that is specifically focused on the 'circularity of construction' and is seeking smarter ways for the management of rehabilitation and construction waste. The Sustainability Workgroup would bring together key stakeholders to establish best practices in regard to sustainability within the industry.

9.11 The Centre can also support the retrofitting ambitions in the Climate Action Plan by the provision of training courses and workshops on retrofitting buildings, in particular old and protected buildings. Training on using sensors, for example, to capture the energy efficiency of buildings based on the materials used, could provide valuable information to the building owner who, being more informed, may be more likely to change their behaviour.

9.12 The cost of retrofitting for the property owner will be important, as is the question on how it will be paid for, and by whom. The Centre could support on the financial modelling around retrofitting, helping firms to understand the total costs involved, and what incentives might be provided by Government to ensure that climate change ambitions are met.

9.13 The Centre should take forward research into the following four key areas following its establishment, based on the research areas recognised as most important in the firms' survey:

- Research on innovative materials to reduce impact of climate change
- Research on a national database of buildings in need of climate change adaptation – flood protection, façade upgrade for warmer climate
- Research into digital mapping and visualisation of climate change impacts including urban heat island pockets, storm water flood risk, and stress on infrastructure
- Research into integrated climate change mitigation with urban design and planning

9.14 The Centre should advocate a pathway to Net Zero Ireland by 2050 by exploring feasible targets for the construction industry to support the Government's climate change targets. This could be achieved by completing research into baseline emission levels produced by the industry, and how an abatement could be achieved by the adoption of construction technologies. This would ensure buy-in from Government, as the industry would be helping to achieve Ireland's climate change targets.

9.15 The Centre should develop relationships with all those stakeholders/initiatives who are currently funded by the State and have been undertaking excellent work on specific initiatives relating to, for example, climate change and retrofitting (e.g., SEAI, the Irish Green Building Council, EPA) to ensure the Centre assembles all of the existing talent that currently exists in this area. Indeed, some of these experts may become members of the Project Board. A number of these stakeholders currently provide training on aspects of sustainability.

1 Executive Summary and Recommendations

Recommendations – Key areas of focus for the short to medium to long-term

10 Areas of focus for the short to medium-term – two in total

10.1 Facilitate research.

- The Centre can facilitate market validated research by linking academics with businesses etc. It is important that there is an element of applied research similar to that in Canada that will actually add value and be of benefit to firms. This model currently works well for IDA Ireland and Enterprise Ireland clients who have access to a range of funding initiatives which facilitate links with academia for research. These interventions need to be commercial and can help to de-risk projects by having support from academia on research projects.

10.2 Provide industry infrastructure for the future.

- Provide suitable laboratory spaces - facilities suitable for research and materials testing will be required. The Construction Technology Innovation Lab in Singapore, for example, initially focused on research projects, in consultation with construction companies, on implementing innovative construction technologies for deep foundation and excavation, to achieve improvements in various construction areas such as water systems, piling systems and crack and corrosion-resistant concrete.
- In addition to tactical capability, the Centre should include a dedicated team to focus on the implementation of new construction industry infrastructure, shared services and associated standards. It is suggested that the starting point for this be a national BIM solution (up to 7D) which can be accessed and leveraged by firms across Ireland. This can involve the development of one or more platforms which firms can deploy across projects. The platform, once implemented, would form the foundation for the development and deployment of Digital Twin solutions.
- To enable these works, the Centre would be provided with a dedicated multi-year budget (as set out under Funding) to secure dedicated delivery teams and to progress projects that have a significant sectoral impact.

11 Areas of focus for the long-term – three in total

11.1: Develop an assurance framework.

- An update to the assurance framework that allows the end user to have greater trust in the quality of the building product provided. This would involve the Centre providing a Building Materials Standards and Compliance Centre to advise and aid industry for the betterment of the sector. There also needs to be lessons learned from the Grenfell fire report in the UK with regard to the quality of wall and roof insulation, especially for the new Building and Housing Retrofit projects that are planned.
- An augmented assurance framework would address legacy issues while also providing more confidence when seeking access to finance for projects. The establishment of a CTC, replacing previous entities such as the Institute for Industrial Research & Standards (IIRS), Eolas, and the National Institute for Physical Planning and Construction Research Limited (An Forás Forbartha Teoranta), will also have the benefit of ensuring that such compliance issues are prioritised.

1 Executive Summary and Recommendations

Recommendations - Areas of focus for the Centre for the long-term

11.2 Provide a Technology sandbox.

- Provide the technologies for firms to try before they buy, by offering options to rent equipment on a daily rate. This would be especially helpful for those micro and small firms who do not have large resources. Potentially, a model similar to that used by the Scotland Innovation Centre (see Case Studies, Appendix 4, p180 and p181) could be used.
- The Centre can provide equipment suppliers who donate equipment with the opportunity to make sales down the line to interested parties.

11.3 Explore the option to develop a key 'flagship' building to accommodate the Centre under one roof.

- As the Centre becomes established and proves its worth in terms of performance and impact, the Project Board should consider a Phase 2 option to develop a key flagship building to house the Centre. This would create a vibrant innovation ecosystem for knowledge sharing and the development of best in class RD&I in the construction sector. The Construction City Cluster in Norway, officially opened in September 2019, accommodates an area where the complete construction and real estate value chain comprising educational institutions and enterprises is clustered about technology, business models and sustainability.

Detailed Description of Needs

The Detailed Description of Needs (DDN) for firms and stakeholders, identifies the key activities that the Centre should undertake to ensure it adds the greatest value to participants in the sector. These activities are summarised in heatmaps for Stakeholders on page 24 and for Firms on page 25 and are based on the two surveys (Appendices 4a and 4b) and the DDN dashboards that stemmed from these surveys (Section 9). The most important elements for each group are ranked as follows:

For Stakeholders	For Firms
Funding	Funding
Relevant training/Continuing Professional Development (CPD)	Relevant training/Continuing Professional Development (CPD)
Hub for prioritised processes	Technology Sandbox
Modular assemblies and research for collaboration at the pre-competitive stage	Introduction to like-minded people
Introduction to like-minded people and technology sandbox	Modular assemblies
Robotics and Automation	Hub for prioritised processes
Community of Practice, Materials prototyping and Materials based technologies	Creation of a mentor network

An interesting observation from the Heatmaps is that stakeholders strongly believe a Centre can benefit the industry; firms appear to be less convinced of the benefits based on the shades in their heatmap. This may be a reflection of the lack of understanding of the role of a Centre, and how it would help the industry as well as the overall low adoption levels of MMC, digitalisation, and technology which are evident from the firms' survey. This suggests that stakeholders have a body of work to do to engage with their members to drive the initiative.

9 Executive Summary and Recommendations

Detailed Description of Needs (DDN) - Stakeholder Groups: Extent of elements of a Centre that could assist organisation's clients

Not at all ◀ ▶ Very Great Extent

	Community of practice	Creation of a mentor network	Funding	Hub for prioritized processes	Introductions to like-minded firms	Material Proto-typing	Modular Assemblies	Network-based technologies	Relevant Training/ CPD	Research hub for collaboration at the pre-competitive stage	Robotics / Automation	Technology sandbox
Irish Timber Frame Manufacturers Association												
National Standards Authority of Ireland												
Association of Consulting Engineers of Ireland												
Irish Homebuilders Association												
Engineers Ireland												
Society of Chartered Surveyors Ireland												
BRE Global Ireland												
Enterprise Ireland												
Property Industry Ireland												
Irish Green Building Council												
Centre for Excellence in Universal Design												
Mechanical and Electrical Contractors Association												
Royal Institute of the Architects of Ireland												
Alliance of Specialist Contractors Association												
Construction Industry Federation												
Irish Hardware Association												
Lean Construction Ireland												
Construction IT Alliance												
Master Builders' and Contractors' Association												
Civil Engineering Contractors Association												
IDA Ireland												

1 Executive Summary and Recommendations

Detailed Description of Needs (DDN) - Firms: Extent of elements of a Centre that could assist your firm

Not at all  Very Great Extent

	Community of practice	Creation of a mentor network	Funding	Hub for prioritised processes	Introductions to like-minded firms	Material Prototyping	Modular Assemblies	Network-based technologies	Relevant Training /Continuing Professional Development	Research hub for collaboration at the pre-competitive stage	Robotics / Automation	Technology sandbox
Architecture												
Main Contractor												
Consulting Engineering												
Other firms *												
Materials Manufacturer												
Off-Site/Modern Methods of Construction (MMC)												
Sub-Contractor												
Trades (carpentry, bricklaying, plumbing, electrics etc.)												
Developer												
Engineering - Structural and Civil												
Tech Start-Up												

The ‘other firms’ category include firms which were not allocated an activity as none reached the minimum response number of 5 to be classified as an activity. The following activities (representing 10 firms) were not included in the DDN: Fire Safety, Life Safety Systems; Facilities Management; Finance/Investment; Planning; Assigned Certifier; and Government Contracting Authority.

2

Introduction

2 Introduction

A once in a lifetime opportunity for the construction and built environment sector in Ireland

Introduction

Many sectors of the Irish economy are embracing digitalisation and technology to transform how they conduct their business, keep their clients and employees happy while also reducing overhead costs. The global pandemic and working from home have accelerated the pace of digital transformation in a number of sectors with some sectors embracing it more rapidly than others.

The Irish construction sector is a key sector of the Irish economy which cannot afford to stand still when it comes to digitalisation and technology. The construction industry is under pressure to increase productivity and efficiency while also meeting the growing needs of an expanding population. It has to move to a new higher level of performance and quality, while also being attentive to environmental, sustainability and circular economy imperatives. Embracing new innovation and digital construction technologies are both fundamental to the future success of the industry. Critically, these changes are also essential for the successfully delivery of Project Ireland 2040, the National Development Plan and the 'Housing for All Plan' over the next decade.[1] Delivering the ambitions of the aforementioned plans must also be achieved while reducing emissions from buildings and accelerating the transformation of the built environment sector to meet the targets in the Climate Action Plan. [2] An effective policy is needed to drive these changes forward.

The rapid pace of change is already seeing some leaders in the construction industry adopt new technological processes and more advanced construction systems to deliver value to their clients and gain a competitive advantage over their peers. They are embracing digital transformation to deliver construction projects in a better, more streamlined and efficient way. Many are working with international clients and are well regarded in terms of their building processes and quality and their ability to deliver on time and within budget.

However, with most companies in construction comprising SMEs and smaller subcontractors working in the indigenous sector, they too need to be on board this journey of innovation. This digital transformation needs all companies to build more productively and sustainably, regardless of scale. There needs to be a move away from the traditional way of building towards more modern methods of construction to ensure the demands on the industry can be delivered in an efficient and cost-effective way. A cultural shift is required from the grass roots level of the industry. More collaboration across the whole supply chain will deliver better value to clients. This report is about 'future proofing' the construction industry and formulating a strategy for the next decade with respect to innovation and digital technology. The challenge is immense, but this is a once in a lifetime opportunity to transform the entire construction and built environment sectors and deliver an industry that is fit for purpose for decades to come.

> *"Post the COVID-19 pandemic, Irish construction stands at a crossroads. We cannot afford to stand still. We have to move to a new level of performance driven by both productivity and sustainability. We should not be daunted by this once in a generation opportunity in human and financial terms."*
>
> **P J Rudden, Chair, Innovation and Digital Adoption Construction Sector Group**

2 Introduction

This report is focused on one of the seven priority actions which are the responsibility of the Innovation and Digital Adoption Subgroup

Context for this study

Construction productivity across the world has suffered for decades from poor productivity relative to other sectors, most notably manufacturing. Research published in 2019 by the Department of Public Expenditure and Reform (DPER) on productivity in the Irish construction sector highlighted Ireland's poor construction productivity performance when compared with a number of reference countries.[3] While many causes of low productivity were identified, seven priority actions, which centred on seven areas of innovation and digital adoption, were highlighted to support productivity enhancements in the construction sector. Following implementation, these actions will ensure the efficient delivery of housing and infrastructure over the next decade and beyond, by embracing new technology and better use of materials to create a more sustainable built environment.

The Construction Sector Group (CSG) was established in 2018 to ensure regular dialogue between Government and construction stakeholders, and to focus on issues that may impact the successful delivery of the commitments in Project Ireland 2040, while also delivering value for money for the State. A new Innovation and Digital Adoption Subgroup was set up in September 2020 to implement these seven priority actions (Figure 3, page 29). This report concerns:

Action 4: Establish and fund a Construction Technology Centre

Accordingly, Enterprise Ireland commissioned EY to gather significant evidence-based data to advise on the current state position of the construction industry relative to the adoption of innovation and the increased digitalisation of the construction sector, in order to ascertain a Detailed Description of Needs (DDN) for the construction and built environment sectors in relation to the following:

- Modern Methods of Construction
- Digital Adoption
- Technology and Innovation

The research is embedded in environmental, sustainable and circular economy imperatives. The purpose of the DDN report is to recommend and inform decisions on the interventions required to improve innovation, competitiveness and productivity in the construction sector. It will also be an important component of the rationale and business case to seek public and private funding for the implementation of Action 4, namely the establishment of a Construction Technology Centre.

Contents of this report

Section 1: Contains the Executive Summary and Recommendations

Section 2: Sets out the opportunity, background and context for the report.

Section 3: Acknowledges the importance of the construction sector and examines the challenges which are likely to impact the construction sector's ability to deliver the demands on it over the next decade

Section 4: Reviews the key advancements in construction technologies that are driving the global industry forward and providing opportunities for increased research, development and innovation (R, D & I).

Section 5: Examines national trends in, and the appetite for, construction specific technologies, as well as sustainability challenges and considers how a Technology Centre could assist construction firms and stakeholders.

Section 6: Provides an analysis of the insights garnered from the three individual workshops regarding the role, priorities and potential impact of the Construction Technology Centre.

Section 7: Provides the international benchmarking exercise which identifies seven relevant international research initiatives established to improve innovation in the construction industry. Key learnings and takeaways are noted for the approach to be adopted in Ireland.

Section 8: Reviews and elaborates on the Irish public research, development and innovation ecosystem and the challenges and opportunities over the next decade.

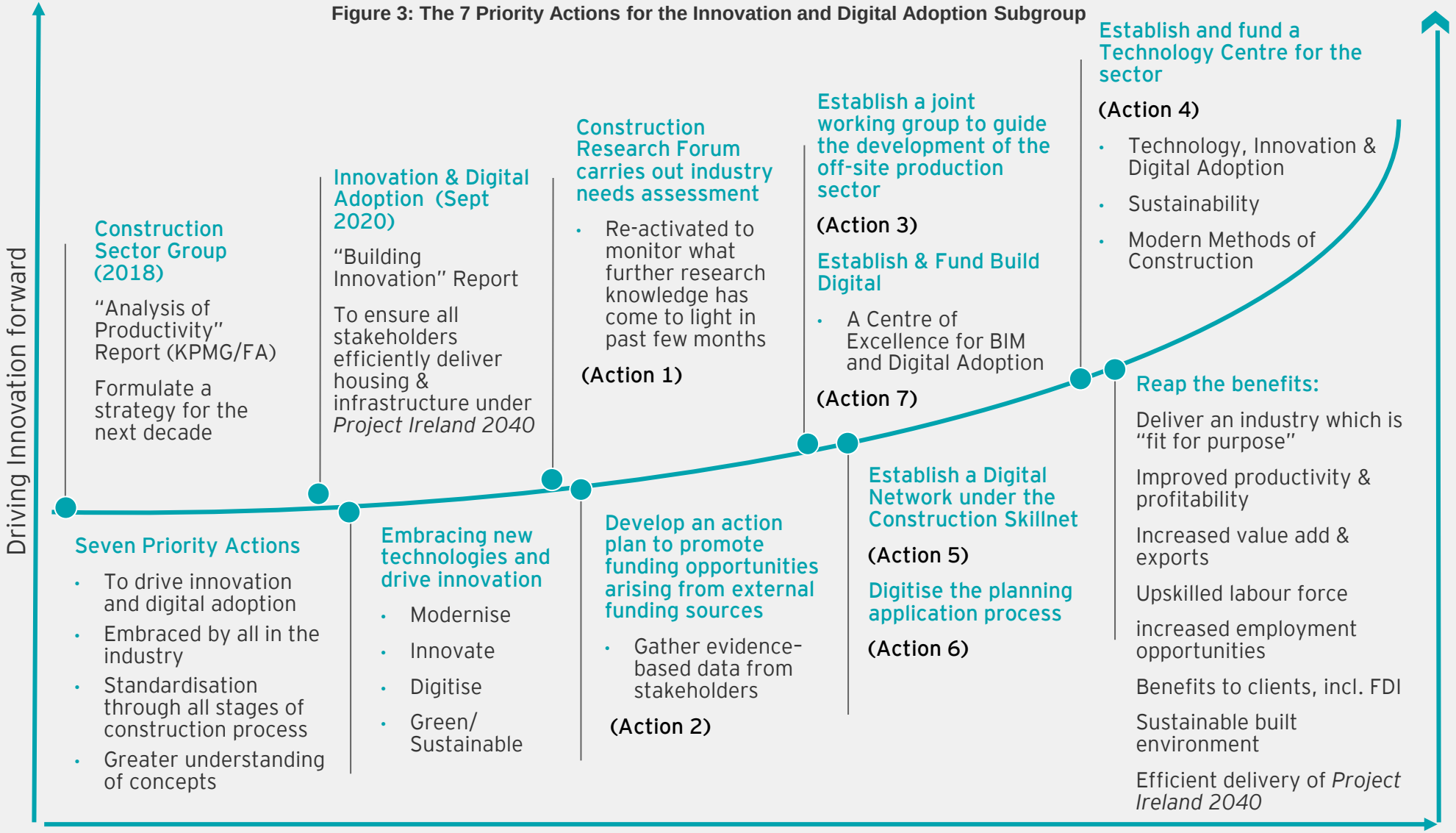
Section 9: Presents the individual Detailed Description of Needs (DDN) for representative persona for each stakeholder and type of activity, based on the evidence-based data gathered and research and analysis undertaken by the project team.

Section 10: Contains the Appendices.

2 Introduction

Seven Priority Actions for "Future Proofing" the construction industry

Figure 3: The 7 Priority Actions for the Innovation and Digital Adoption Subgroup



2 Introduction

Background on progress on seven priority actions

Significant resources are employed to deliver the 7 Priority Actions

The KPMG/Future Analytics report on Construction Productivity contained a total of eight recommendations and 36 actions to address the challenges around construction productivity. The Innovation and Digital Adoption Subgroup is responsible for the seven priority actions set out in Figure 3, page 29. The subgroup comprises the chairperson and seven project leaders who report to the Construction Sector Group. There are approximately 100 persons involved who are working together to ensure the seven priority actions are implemented to deliver a sustainable, innovative and competitive construction sector for decades to come.

Progress on the seven priority actions of the Innovation and Digital Adoption Subgroup is provided here to give context to the current study.

Action 1: Establish Construction Research Needs – is focused on assembling international research knowledge which is available. The team responsible will be assisted in this task by the three technological universities who have been awarded the Digital Build project (Action 7). It is expected that going forward this research action will be a task for the Construction Technology Centre.

Action 2: Identification of Innovation and Sustainability Options – a report on Innovation Funding Options was completed by ACEI in May 2021 and addresses the biggest sustainability challenges for the construction sector. Currently available funding opportunities are identified and will be useful for research funding applications by the Innovation and Digital Adoption Subgroup.

Action 3: Guide the development of Modern Methods of Construction – the group responsible is due to complete a report on advancing MMC in Ireland and has identified the upskilling, knowledge and digital gaps which need to be addressed to support the adoption and further roll-out of MMC.

Action 4: Construction Technology Centre – is the subject of this report. More detail on what is involved in this study, how it links with the other actions and why it is being undertaken is contained on the next page.

Figure 4 : Construction Innovation and Digital Adoption Actions

Action 5: Establish a Digital Network under the Construction Skillnet – this workstream involves identifying upskilling and funding measures which will address the skills deficiencies in regard to digital adoption, MMC and digital build.

Action 6: Digitisation of the planning process – a rollout of digital planning applications to local authorities is due to commence in Q1 2022.

Action 7: Establish and Fund Build Digital - this project has been awarded by DPER to the three technological universities, TU Dublin/CitA (lead), Munster TU and Connacht-Ulster TU. This project has an ambitious 5-year programme (2021 to 2026) to embed integrated Building Information Modelling (BIM) in the construction industry up to 7D ('Dimension') (Ireland is currently at 2D and 3D) to include programme and cost monitoring of buildings and infrastructure projects against approved budgets.

There are remaining actions from the KPMG/Future Analytics report to be implemented and these will need a similar drive and momentum to ensure Ireland has a construction sector which is best in class.

2 Introduction

The relationship between the seven priority actions to support productivity enhancements in the construction sector

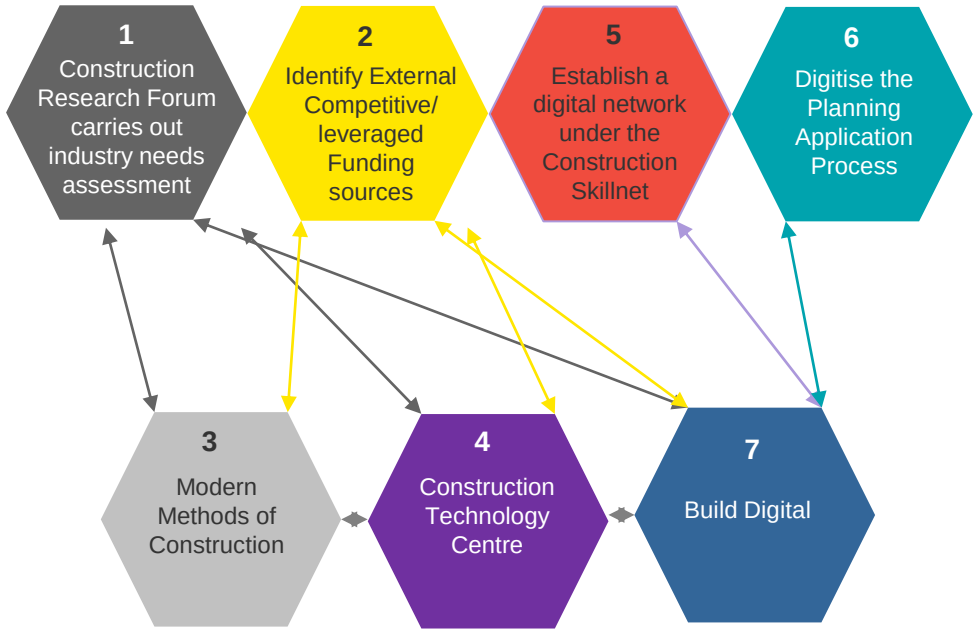
Why undertake this study?

The information generated from the work in Actions 1, 3 and 7 will inform and guide the DDN exercise, which is part of the normal scoping exercise for an Enterprise Ireland Technology Centre (Action 4).

This DDN study is being undertaken by Enterprise Ireland for a number of reasons:

- To establish the extent to which there is a culture of innovation in the broader construction sector
- To establish the needs and current challenges amongst construction stakeholders with respect to the adoption of innovation, digitalisation and digital systems and technology
- To ascertain if significant numbers of stakeholders have the capacity and appetite for co-funding research on a collaborative basis to invest in innovation and personnel, subject to there being a solid business case for doing so
- To recommend and inform decisions on the interventions required to improve innovation, competitiveness and productivity in the construction sector

Figure 5: Seven Priority Actions – How they are linked



Key workstreams in this study

This research involved a number of workstreams:

- An examination of construction trends both globally and nationally in the three core focus areas
- Two surveys of stakeholders and firms to gather views in relation to their current activities and business challenges in the innovation space, their capacity to allocate funding and personnel to undertake research and development (R&D), their willingness to collaborate and the key constraints
- Three workshop engagements with firms, stakeholders and government departments to capture views on the key challenges for the built environment sector with respect to the adoption of technology, digitalisation and modern methods of construction, and to elicit views on the role of a Construction Technology Centre
- A review of the Irish public research, development and innovation ecosystem and the challenges and opportunities over the next decade
- A benchmarking exercise of international research institutes established to improve innovation in the construction industry
- A profile of the DDN across the construction industry, based on the information, insights and findings obtained from the various workstreams

3

Root causes of the productivity challenge

3 Root causes of the productivity challenge

Key observations

1. **Low productivity is a major negative for the industry and recognising the reasons for such low productivity is key to finding solutions.**

2. **The root causes of Ireland's low productivity arise at every stage of the construction process which impact productivity. Poor project management and a lack of communication and collaboration throughout the project stages can give rise to inaccurate budgeting and cost estimation.**

3. **A common theme is the slow pace of adoption of technology and digitalisation and the lack of skills to support digital adoption. These issues arise time and time again in the surveys and the workshops.**

4. **The lack of investment in the life cycle of buildings and consideration of the total cost of ownership is not being adequately addressed and will need to be if there is to be a more sustainable built environment.**

5. **There are a number of challenges for the construction sector which need to be addressed if it is to improve its efficiency and find the required building capacity to deliver the demands on the sector over the next decade:**

A. **The cyclical nature of the construction industry - the value of output in the industry has fluctuated between 20.6% of GDP in 2006 and 5.4% of GDP in 2012 and is currently at 6.7% of GDP.**

B. **The fragmented nature of the sector - 92.8% of construction firms employ under six persons and 99.6% employ less than 50 persons.**

C. **The low levels of productivity - the real GVA per hour worked in construction was €26.55 in 2019, almost unchanged from the level a decade previously (€26.58 in 2009), and is significantly below other Western European countries, where the real GVA per worker is €40 or higher in eight countries, including Germany.**

3 Root causes of the productivity challenge

An efficient and sustainable construction and built environment sector is now more necessary than ever

Construction sector a primary economic driver over the coming decade

Ireland's population increased at an annual average rate of 1.3% over the last two decades to reach 5 million in April 2021.[1] Over the next two decades, the population is projected to experience steady growth, ranging from annual average growth rates of 0.5% to 1.0% between 2020 and 2040, according to the CSO. This growth is equivalent to an additional population of between 510,000 (weakest scenario) and 1.1 million (strongest scenario) to generate a total population of between 5.4 million and 6.1 million by 2040.[2] The strong growth scenario is consistent with the 1.1 million additional persons projected by 2040 according to Project Ireland 2040. [3]

This population increase will require significant investment in housing, non-residential building and civil engineering infrastructure to sustain population, economic growth and competitiveness. With the substantial investment of circa €165 billion in the new National Development Plan and an average of 33,000 homes required each year until 2030, the construction sector will be one of the primary economic drivers in the economy over the coming decade. As such it will need to ensure it delivers good quality, efficient and sustainable buildings and infrastructure which meet the changing demands of the future. Achieving long-term value for money will be critical and will require the 'whole life costs' of building and infrastructure to be taken into account to ensure a quality built environment for all citizens.

An efficient and sustainable construction and built environment sector is now more necessary than ever. The industry is endeavouring to make progress in this regard by developing efficiencies through the adoption of technology, the development of capabilities such as modern methods of construction, enhancing the skills profile and embracing research and innovation.

Covid-19 has acted as a catalyst for the drive towards digital transformation

Some construction companies were making progress towards digital transformation before Covid-19, as they looked to technology for enhanced efficiencies, schedule reduction and cost savings. The onset of Covid-19 led to the construction industry being shut down for 23 weeks (16 of which were a partial shutdown) between March 2020 and May 2021.

This period probably accelerated the trend towards digital transformation for others as:

- Many contractors, suppliers and clients/investors were pushed into remote working environments
- Companies needed to diversify risk and open new revenue streams to ensure business continuity
- The advantages of digital tools were recognised as their utilisation increased and users became familiar with them.

However, there needs to be a long term sustainable and behavioural change across the entire industry, from top to bottom, including clients, contractors and the entire construction supply chain. The construction industry is under pressure to increase production and the quality of output and a commitment to innovation and digital adoption is fundamental to achieving its ambitions for growth. Government can play a key role in supporting this commitment with an effective digital strategy and an appropriate regulatory framework on data policy. Support for research, development and innovation is also central to raising the profile of the construction industry.

These and other issues were raised in the Build 2020 and Building Innovation Reports from DPER[4], which highlighted three themes which can help boost productivity, output and profits and wages in the sector:

- The need for all stakeholders in the industry, including clients and contractors and especially SMEs, to increase investment in innovation and digital adoption to deliver significant gains to the industry. This requires the promotion of a greater culture of innovation in the entire construction supply chain.
- The need for ongoing regulatory reform of public procurement, environmental, labour and other areas to streamline and assist in achieving competitiveness and sustainability
- The need to increase certainty and visibility of the pipeline of project opportunities in order to provide the industry with the confidence to invest.

This report is concerned with the first theme; all three are being addressed by the Construction Sector Group.

3 Root causes of the productivity challenge

Challenges impacting the sector's ability to efficiently deliver over the next decade need to be addressed

Key challenges for construction

However, there are a number of challenges which need to be addressed if the sector is to improve its efficiency and find the required building capacity to deliver the demands on the sector over the next decade:

- The cyclical nature of the construction industry
- The fragmented nature of the sector
- The low levels of productivity

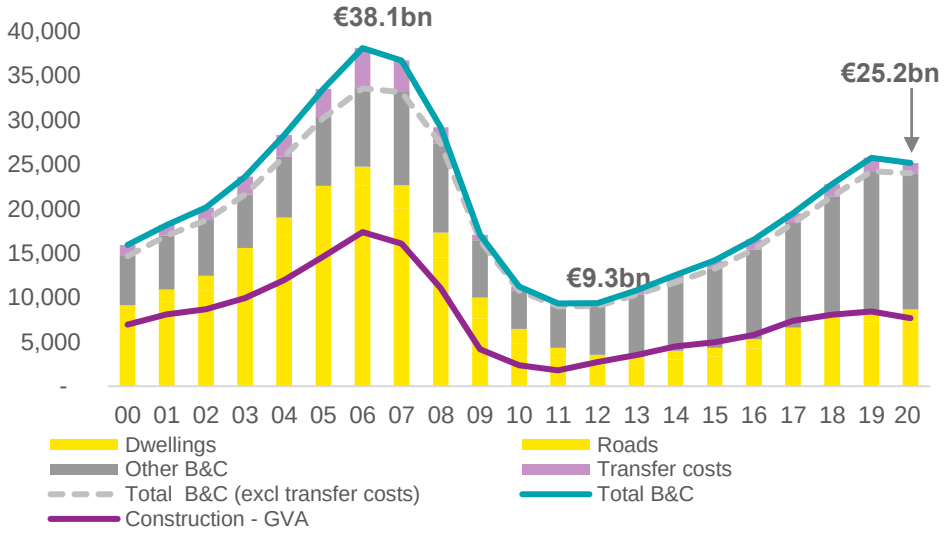
Construction is a cyclical industry

The construction sector is one of the most cyclical sectors of the Irish economy (Figure 6 & 7). The value of construction output was €25.2 billion in 2020, which was equivalent to 6.7% of GNP or 12.1% of GNI* [5]. The sector had peaked at 24.2% of GDP (20.6% of GNI*) or almost one-quarter of economic activity in 2006. The Gross Value Added (GVA = profits and wages) was €7.7 billion in 2020 or 2.1% of GDP compared with €17.4 billion in 2007 (9.4% of GDP). This cyclical nature is a barrier to attracting talent and encouraging younger workers to develop the skills necessary for the new ways of working in construction.

Construction output measures the value of work put in place on the construction of residential and non-residential buildings and structures and on civil engineering projects (Appendix 2). While much of the focus over recent years has been on the housing sector, the value of new housing output in 2020 accounted for 18.5% of the total €25.2 billion. The other categories provided are housing renovation (10.5%), roads (5.3%) and all other building and construction (61.1%). [6] The balance of 4.6% represents transfer costs associated with the acquisition of land and building.

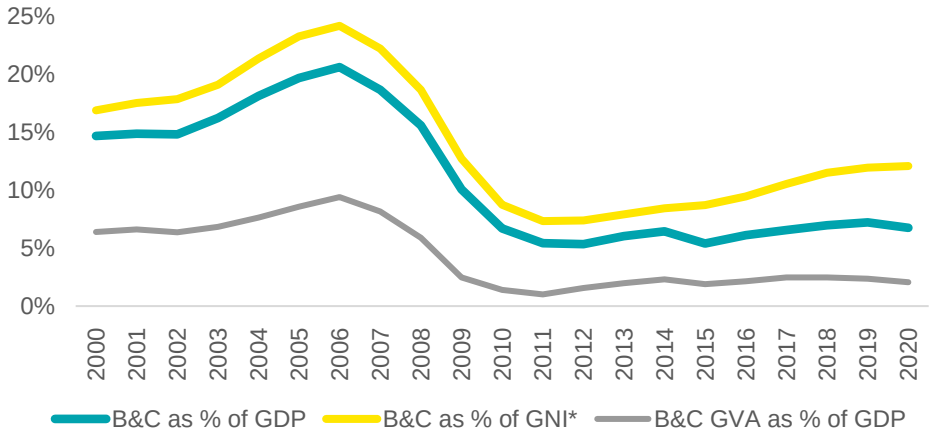
Estimates derived by EY suggest that 60% of the value of output is generated by the private sector and 40% by the public sector – firms surveyed reported a 71%/29% split. This distribution may shift more in favour of the public sector over the next decade, given the expected increase in the number of larger more complex projects in the new NDP and the higher projections for social, affordable and cost rental homes in the Housing for All Plan compared with the previous decade. This increasing volume of larger and more complex projects is one reason to transform the way construction projects are delivered. A transition to more modern methods of construction and the adoption of new technologies can deliver better value to construction firms and clients, including the public sector.

Figure 6: Building & Construction Gross Output (€million)



Source: CSO

Figure 7: Building and Construction Output as % of GDP and GNI* and GVA as % of GDP



Source: CSO

3 Root causes of the productivity challenge

92.8% of construction enterprises employ less than 6 persons

The fragmented nature of the sector

There are 59,175 active enterprises in the construction sector (2019 data), 21.7% of all enterprises in the business economy. This figure is up from a low of 47,349 enterprises in 2014.The core issue for construction is the very fragmented nature of the sector, with 92.8% of construction firms employing under six persons. When analysed by number of persons engaged, 47.3% work in firms with under six persons and 68.5% work in firms employing less than 20 persons.[7]

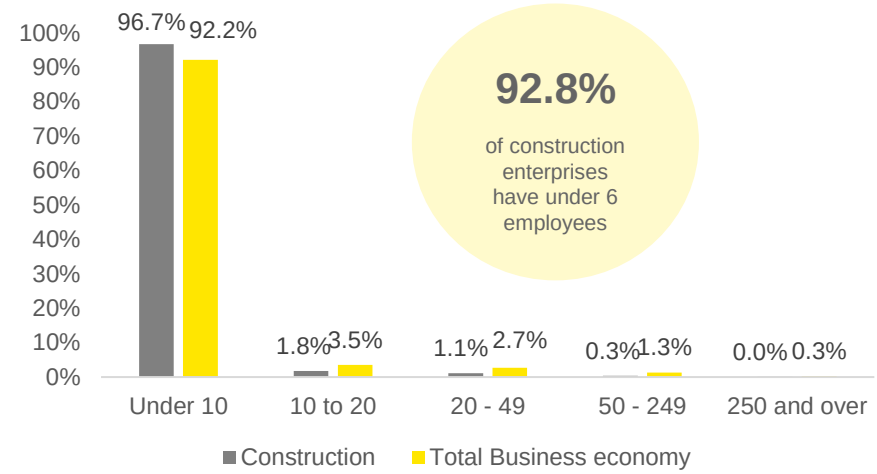
Construction is well known as one of the most labour-intensive forms of economic activity and an important contributor to job creation. The industry currently employs 119,000 persons (Q1 2021), 5.3% of the total employed workforce in the economy, having peaked at almost 150,000 in Q3 2019 (6.4% of total). [8] In addition, other firms throughout the supply chain also contribute to the economy, by generating jobs in these firms. However, this labour intensity creates challenges for productivity (next page).

Construction enterprises and the persons working in them are defined to include enterprises and employees involved in the complete construction of buildings and civil engineering works, as well as specialised construction activities (i.e. special trades). Specialised construction activities are mostly carried out under subcontract. Hence, the enterprise and employment figures exclude specialised professional, scientific and technical activities which are captured separately in the labour force data by the CSO. These activities would include, for example, architectural, engineering, planning and related technical and consulting services, as well as the persons employed in the activities of head offices.

The Construction Industry Federation (CIF) has reported that the top 50 construction firms exported over €3.3 billion in construction expertise out of a total turnover of over €10 billion in 2019 [9]. However, with the industry worth over €25 billion, it is clear that the vast majority of construction enterprises operate in the domestic market. The central issue is the preponderance of micro and small firms in the domestic construction sector employing less than 6 and up to 20/30 persons and working on very small projects. The significant challenge is encouraging these firms to embrace technology given their resistance to change. In the firms' survey, micro firms mentioned the following three items as the most challenging (i.e. to a great extent and a very great extent) when it comes to implementing new technologies:

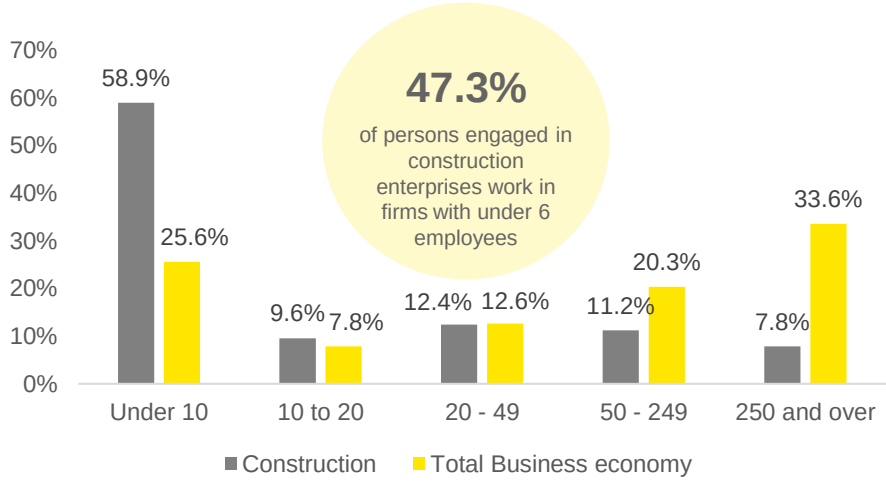
- 59% mentioned other priorities (e.g. day to day running of the business)
- 51% mentioned a lack of time
- 47% mentioned a lack of budget

Figure 8: Number of active enterprises by employment size, 2019



Source: CSO

Figure 9: The size of enterprises by persons engaged, 2019



Source: CSO

3 Root causes of the productivity challenge

Construction productivity has been persistently below other sectors in the Irish economy and lags behind other western European countries

Persistent low productivity

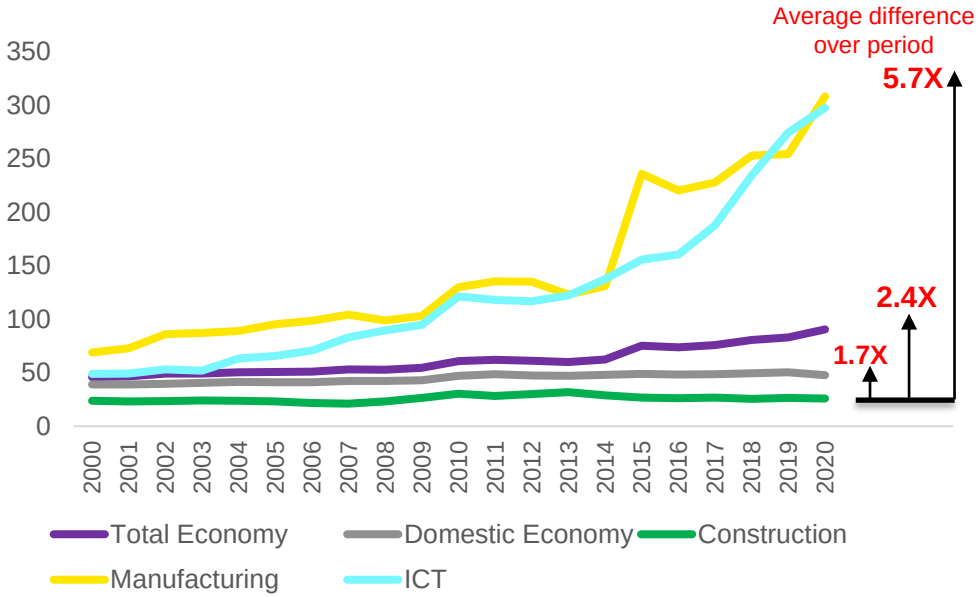
Productivity is a key driver of economic growth, living standards and competitiveness. The primary focus tends to be on labour productivity, which determines wages and contributes to standards of living. It essentially measures economic efficiency, as it examines the relationship between inputs (total hours worked) and outputs.

The measure of construction productivity is real GVA per hour worked. GVA is used as it captures the profits and wages generated by the industry. The measure of GVA used is GVA at basis prices chain linked to 2019, meaning inflation is excluded.

In 2019 the construction sector accounted for 7.9% of the total hours worked in the economy, up from 5.1% in 2012 and 2013 but way below the 2006 share of 13.6%. [10]The sector's productivity performance since 2000 is shown in Figure 10. The striking features are as follows:

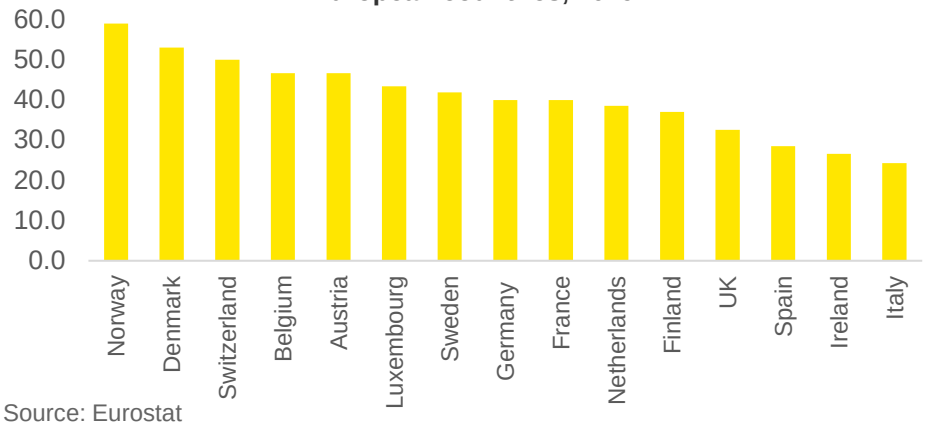
- The real GVA per hour worked in construction, at €26.55 in 2019, was almost unchanged from the level a decade previously (€26.58 in 2009) but was 16.5% below the corresponding level in 2013 (€31.80).
- Average productivity in construction increased by 11.5% over the twenty years 2000-2019 compared with 29.3% in the domestic economy, 80.4% in the total economy and 268.5% in manufacturing.
- The GVA per hour worked in the total economy is 2.4 times the productivity level in construction, while manufacturing is a multiple of 5.7 times the corresponding productivity in construction.
- In a comparison with 14 other selected western European countries, it is evident that construction productivity in Ireland is significantly below other countries, with the exception of Italy (€24.20) [11]. The real GVA per worker is €40 or higher in eight countries in the chart, including Germany. It is noted that the value of construction output in all of these countries would be a multiple of the Irish construction industry. Taking a country like Portugal, where the value of construction output (€22.3bn) is close to Ireland's level, the real GVA per worker was €13.2 in 2019.

Figure 10: Productivity in Ireland: Real GVA per hour worked, 2000-2020



Source: CSO

Figure 11: Construction - Real GVA per hour worked in selected European countries, 2019



Source: Eurostat

3 Root causes of the productivity challenge

Root causes of Ireland's low productivity can be identified at every stage of the construction process

Low productivity is a major negative for the industry and recognising the reasons for such low productivity is key to finding solutions.

The root causes of Ireland's low productivity are summarised in the table opposite. There are factors which arise at every stage of the construction process which impact productivity.

A common theme is the slow pace of adoption of technology and digitalisation and the lack of skills to support digital adoption. These issues arise time and time again in the surveys and the workshops.

Other factors include poor project management and a lack of communication and collaboration throughout the project stages, which can give rise to inaccurate budgeting and cost estimation.

The lack of investment in the life cycle of buildings and consideration of the total cost of ownership is not being adequately addressed and will need to be if there is to be a more sustainable built environment.

Root causes of the industry's low productivity

Macro and sectoral issues	Pre-construction phase	Construction phase	Post-construction phase
► Volatile cycle in construction and public investment	►Unpredictability of the planning process and vulnerability to challenge (legal)	► Inadequate design processes	► Capturing and retaining documentation and data
► Highly fragmented industry	►Weak contractual structures	► Poor project management and execution	► Lack of investment in life cycle of buildings
► Lack of digital savvy resources to support the use of digital tools	►Lack of early contractor involvement	► Lack of skills in technology and digitalisation	
► Increasing project complexity	►Lack of investment in upfront planning and design	► Changes and indecision	
► Pressure on margins	►Inaccurate budgeting and cost estimation		
	►Supply chain management		

3 Root causes of the productivity challenge

There are significant benefits for clients, contractors and supply chain businesses from a wider adoption of technology and digital solutions

Enhancing productivity can generate significant economic benefits, resulting in higher GVA (i.e. profits and wages). Where those productivity improvements are the result of digital transformation, the adoption of technology and more modern methods of construction, they can yield substantial benefits ranging from more efficient build times, lower costs, greater safety and quality to greater value creation. By embracing innovative construction methods and digital tools and processes, the capability of the industry's workforce will be transformed and high quality jobs will be created. More innovation in the supply chain will enable all firms, regardless of scale, to develop new ways to reach clients and access international markets, delivering a more competitive and sustainable industry for the long term. Benefits include the following:

The industry can deliver the volumes required in a more efficient and cost effective way

Significant time savings with the adoption of offsite manufacturing and modern methods of construction due to parallel construction being performed onsite and offsite

Potential environmental benefits by reducing carbon emissions due to waste reduction and recycling of materials

Enhanced employee and labour safety due to job execution in controlled factories

Improved safety and quality due to use of digital adoption and innovative solutions

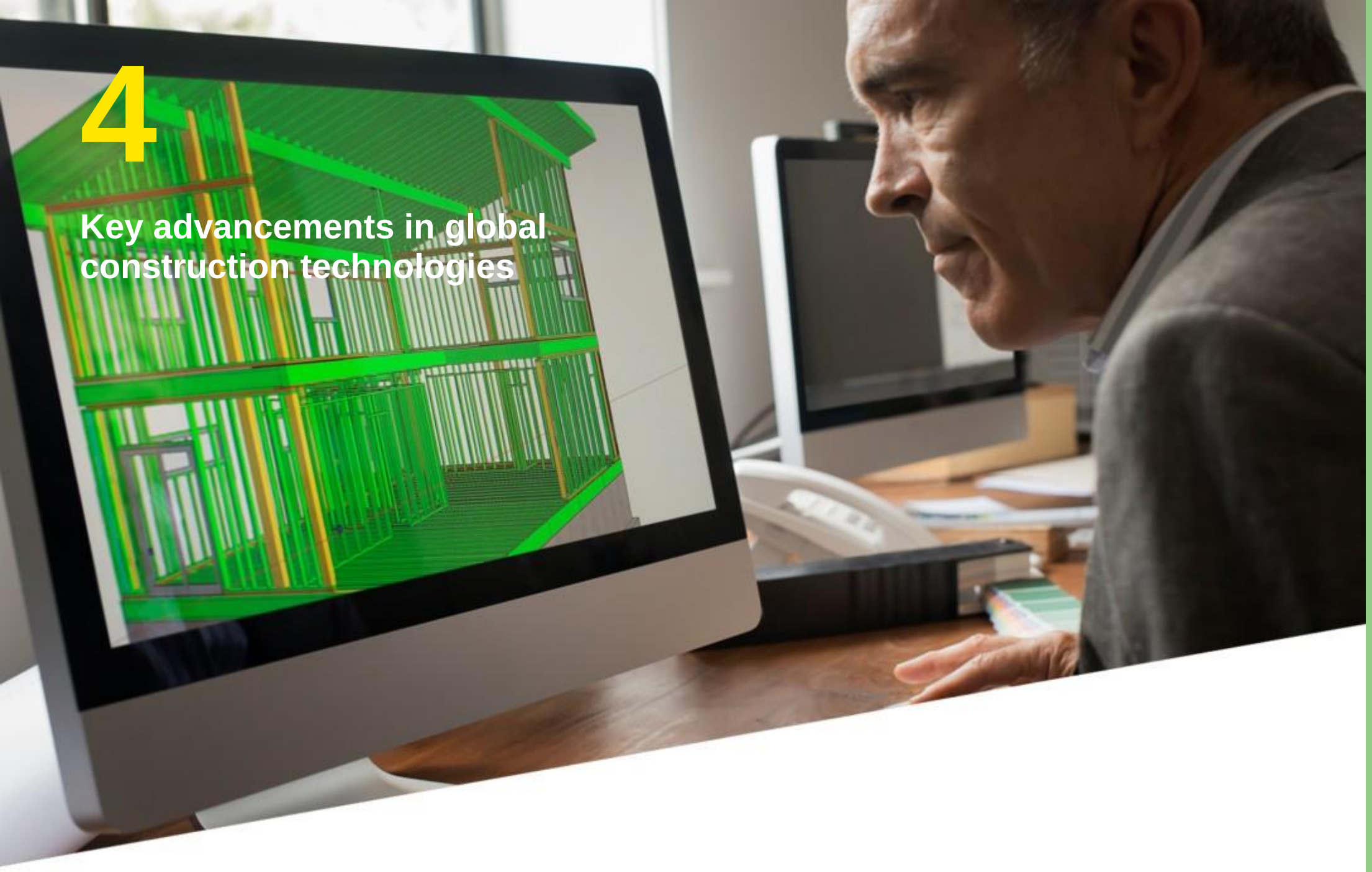
> *If construction productivity were to catch up with that of the total economy, **the sector's value added would increase by an estimated $1.6 trillion**, adding about 2 percent to the global economy.*
>
> **McKinsey Global Institute, July 2017**

> *Had the Irish construction industry been as productive in 2017 as the average European construction sector, **gross value added in terms of profits and wages would be some €1.7 billion higher**.*
>
> **Build 2020: Construction Sector Performance and Capacity (June 2020, DPER)**

> *For every €1m of additional output generated by the construction industry, **€0.68m of GVA is contributed to GDP**.*
>
> **EY Economic Impact of Construction for CIF (July 2019)**

4

Key advancements in global construction technologies



4 Key advancements in global construction technologies

Key observations

The proliferation of new technologies which are being adopted across the globe at a rapid pace throughout the project lifecycle is evident from the literature.

Automation is to be found in almost every repetitive process in the industry supply chain with an increased take-up of industrial manufacturing and modern methods of construction to compensate for declining on-site construction productivity.

By incorporating and expanding these technologies, the global industry is providing more intelligent planning of construction, supply chain management and delivery.

Despite this proliferation, commentators in the construction sector have suggested that the cornerstone for construction technology will be BIM as it can enable firms to expand with additional digital solutions e.g. Digital Twin and obtain greater functionality over time.

A number of IT and software companies have recognised the demand for digitalisation in the construction industry and are expanding their service offerings to provide solutions for many of the processes used in the construction supply chain.

This advancement of construction technologies is also helping to solve some structural and building performance issues which have emerged in many parts of the world.

Digital transformation is helping to address trust, risk and cost issues by, for example, using unique product identifiers based on global standards to track and trace building materials throughout the supply chain.

Those construction companies across the world who are pursuing the above technologies are helping to overcome a number of construction challenges, notably speed of deliverability, economic viability, quality and the enhancement of sustainability. Some countries are more advanced than others in this regard.

4 Key advancements in global construction technologies

Analysis and studies globally point to the continuation of the digital evolution (or revolution) and investment in technology to improve efficiency

There is no doubt that the maturing of technology and the emergence of so-called "exponentials" * has the ability to fundamentally redefine the world in which we live. Pre-2020, the adoption of these new exponential technologies was sporadic or disparate at best.

In 2020 as Covid-19 took root everything changed. A catalyst for digital adoption was born and with it new challenges arose including remote working, supply chain resilience and the use of collaboration technologies to enable everyday operations. Perhaps more profound was the pandemic's impact on our societal thoughts to technology and our reliance on data transparency, insights and information to enable our next best action in fighting the virus – a reality which was played out before us every evening on news broadcasts. The result is that we emerge from the pandemic in a changed state – we have got used to data insights, we expect technology to enable operations and we have developed new behaviours to reflect the same e.g. online shopping and courier tracking. In addition our lockdowns stalled construction whilst in many sectors jobs grew and the need for housing, key infrastructure and amenities increased. The question for the sector is will the catalyst remain a beacon for digital change and transformation or will we alternatively see a return to a siloed normal state?

Our analysis and studies across the globe point to the continuation of the digital evolution (or revolution) and investment in technology to improve efficiency, aid the adoption of modern methods of construction and to provide transparency for building management and the measurement of performance indicators including sustainability. Indeed at EY's 26th Annual Engineering & Construction Finance Conference in November of 2020 participants were polled and the following insights were highlighted:

- 31% of respondents were exploring options towards investment in analytics and business intelligence.
- 29% of respondents spent more than 5% on Construction Technologies as a percentage of total revenue.
- Building Information Modelling (BIM), Internet of Things (IOT) and Artificial Intelligence (AI) were the top three construction technologies invested in during the last three years.
- 78% of respondents had invested in construction technology over the last 6 months
- Project risk mitigation was viewed by 49% of respondents as the most useful output of data analytics, followed by project finances at 32% of respondents.
- 100% of respondents indicated an increase in cyber incidents during the Covid-19 pandemic.

Whilst this is compelling and welcomed, the bigger challenge is that of appreciating which technologies to leverage, where to start, what to prioritise and how to develop the future of construction in the context of technology change and its associated impact. The key will be the ability to create and develop a digital strategy which forms the nucleus for industry and firm development. For this reason we are seeing that firms, not just in construction, are progressing the three key actions outlined below:

1. Creating a digital vision and roadmap: A formal roadmap helps in identifying technologies, hiring talent and determining success factors and performance metrics.

2. Prioritising and starting small: Not every technology needs to be disruptive at a large scale.

3. Managing risk: Identifying and monitoring risks to implementation; ensuring the focus and vision stays on track.

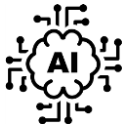
Building digital talent, integrating across the business ecosystem and evaluating return on investment will be key areas of consideration throughout the digital journey, yet in the rush to modernise systems and operations, organisations introduce multiple vulnerabilities across their businesses and have exposure to a growing number of cybersecurity threats.

* See page 43 for an overview of exponentials, i.e. technologies.

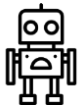
4 Key advancements in global construction technologies

Digital innovations and megatrends continue to evolve and shape the construction industry

There is a proliferation of new technologies which are emerging and are being adopted across the sector globally. Despite this proliferation, commentators in the construction sector have suggested that the cornerstone for construction technology will be Building Information Modelling (BIM) (see page 44) as it can enable firms to expand with additional digital solutions, such as Digital Twins (see page 45) and obtain greater functionality over time.



Artificial intelligence (AI)
Machine learning used for computing systems that exhibit some form of human intelligence. They are characterised by interacting in ways that seem 'natural' to humans while simultaneously learning from those interactions.



Robotics process automation (RPA)
Robots are machines designed to collaborate with humans and are capable of doing complex tasks and actions programmed by a computer to reduce cost and save time.

Internet of things (IoT)
The network of physical devices, vehicles, buildings and other items, embedded with electronics, software, sensors, actuators and network connectivity that enable these objects to collect and exchange data.

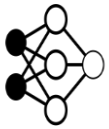
Internet of augmentation (IoA)
The concept of enhancing, augmenting or even re-designing humans on top of an IoT network – the next layer of data integration.

Geo-enabled technologies
Utilise cameras and sensors to obtain data, measurements and quantities over the lifecycle of a project (drones, remote sensing).

Smart buildings to smart cities
Smart buildings are constructed to allow owners and operators to better understand occupant needs and behaviors. This enhances both well-being and productivity while simultaneously saving operational costs and increasing building efficiencies.

Cloud-based
Field crews, construction managers, engineers and designers are connected in real time, allowing the various project execution members the ability to make revisions and work through difficult situations.

Industrialised construction
Process in which the structural parts or modules are manufactured in a factory-controlled environment, transported to the construction site and assembled there.



Machine networks
Machines that are wirelessly connected allow the project and home offices to monitor maintenance, fuel, performance and regulatory compliance.

Digital twins
Digital twins are links between real world assets and digital representations that are continually updating and utilising real time or uploaded data.

3D printing
The process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes, which means an object is created by laying down successive layers of material until the object is created.

Blockchain
An open public database where transactions are stored in virtual blocks. These blocks are connected together in a chain, creating a complete history of all transactions that have occurred within a particular network.

Data lake management
Integrate, organise, administer, govern and secure large volumes of both structured and unstructured data to deliver actionable fit-for-purpose applications.

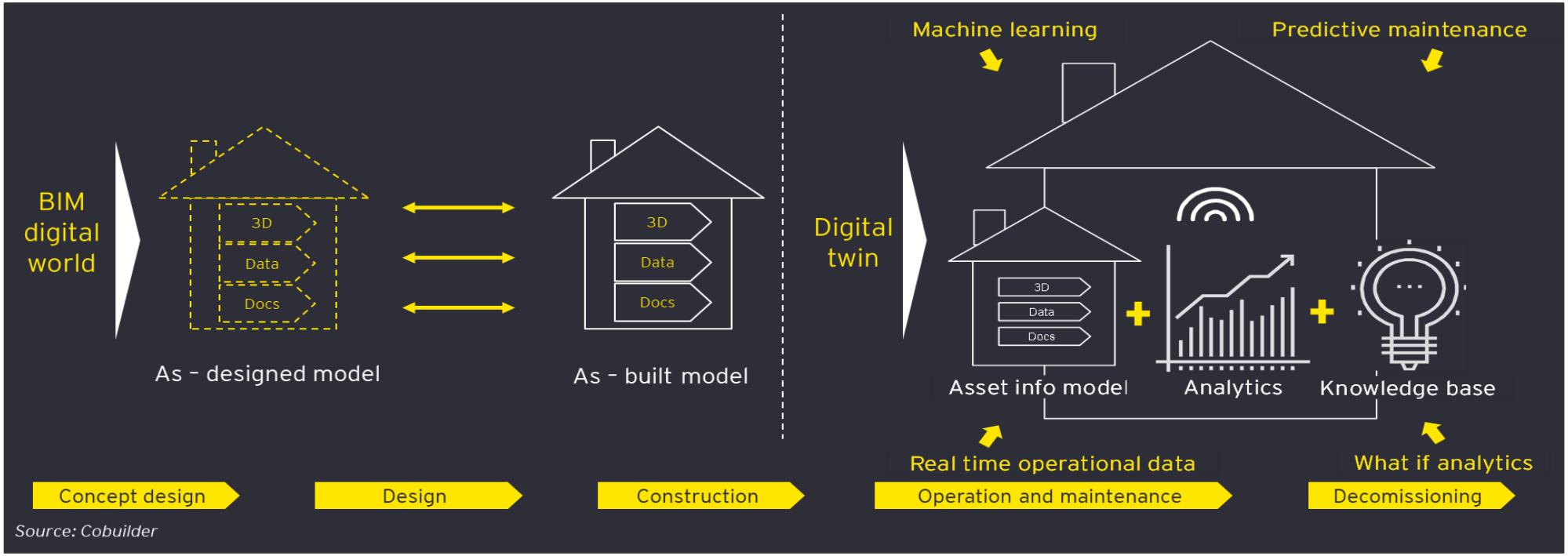
Virtual network
All devices, servers, **virtual** machines and data centers that are connected are done so through software and wireless technology.

Augmented and virtual reality
Interactive experience where augmented or virtual objects are simulated and portrayed in the real world.

4 Key advancements in global construction technologies

BIM is regarded as the enabler of Digital Twins. A Digital Twin is “a virtual representation of real-world entities and processes, synchronised at a specified frequency and fidelity”.

Building Information Modelling (BIM) is the process and digital representation used for modelling and management of the physical and functional characteristics of a construction project or facility. BIM can be used as the baseline technology and is traditionally focused on static asset information. It can then be incorporated into other processes or tools, such as digital twins, that enable active and dynamic solutions.



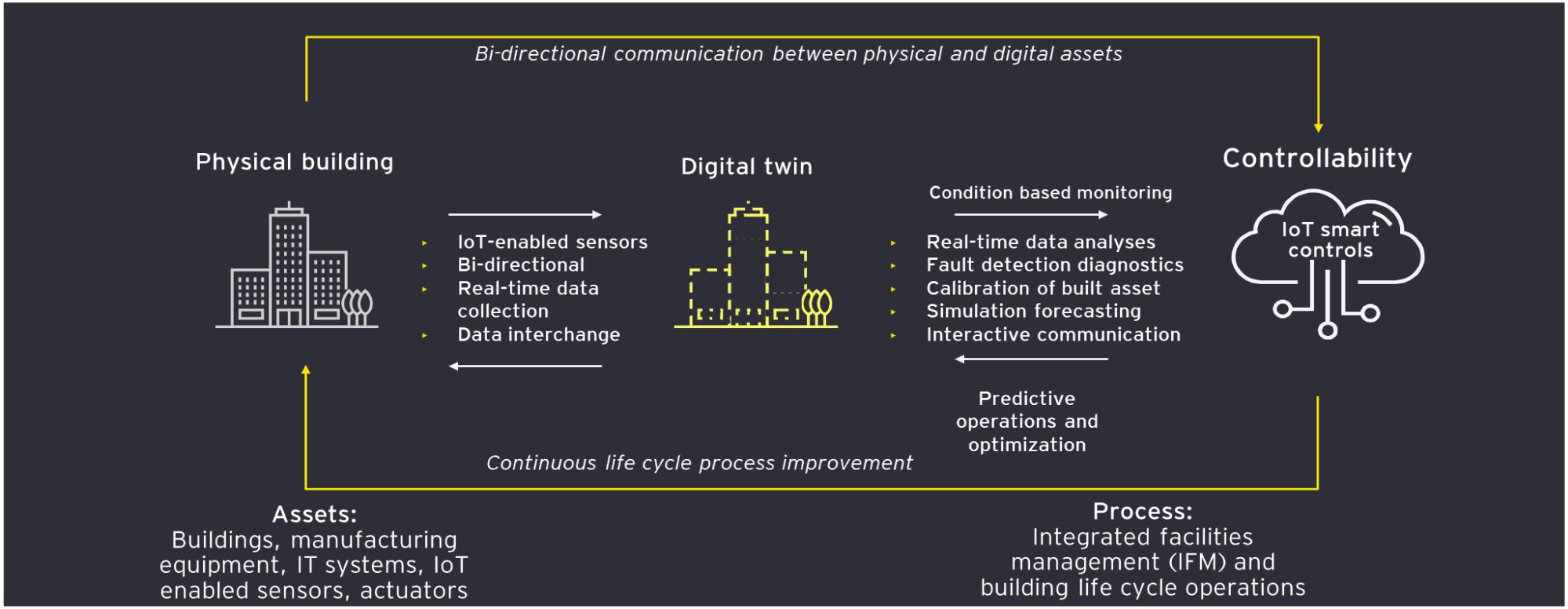
As mentioned above, BIM is regarded as the enabler of Digital Twins. The Digital Twin Consortium defines a Digital Twin as “a virtual representation of real-world entities and processes, synchronised at a specified frequency and fidelity”. The Digital Twin incorporates design, construction, geo-spatial and operational data to represent the asset and its connected systems. They utilise IoT-enabled sensors that feed into AI and Machine Learning (ML) models to collect and process real-time asset data. These models analyse and learn from previous performance as part of an Internet of Abilities (IoA) strategy to provide predictive analytics. Finally the Digital Twin Provides the ability to calibrate building operations to maximise efficiency.

Digital twins were anticipated by David Gelernter's 1991 book Mirror Worlds. It is widely acknowledged in both industry and academic publications that Michael Grieves of Florida Institute of Technology first applied the digital twin concept in manufacturing. The concept and model of the digital twin was publicly introduced in 2002 by Grieves at a Society of Manufacturing Engineers conference in Troy, Michigan. Grieves proposed the digital twin as the conceptual model underlying product lifecycle management (PLM).

4 Key advancements in global construction technologies

Digital twins are expected to revolutionise many industries. Construction and real estate are potential beneficiaries from its continued adoption.

Digital Twins have since been created and used at scale. One of the most publicised project was that by Dassault Systems in 2018 to build a Digital Twin for the city of Singapore. Global growth and adoption is expected to continue with the global Digital Twin market expected to attain a value of €35 billion by 2025.



While digital twins are expected to revolutionise many industries, construction and real estate is particularly positioned to benefit from its continued adoption. How digital twins are used and their resulting returns, will depend on the stage of the real estate life cycle at which the digital twin is implemented.

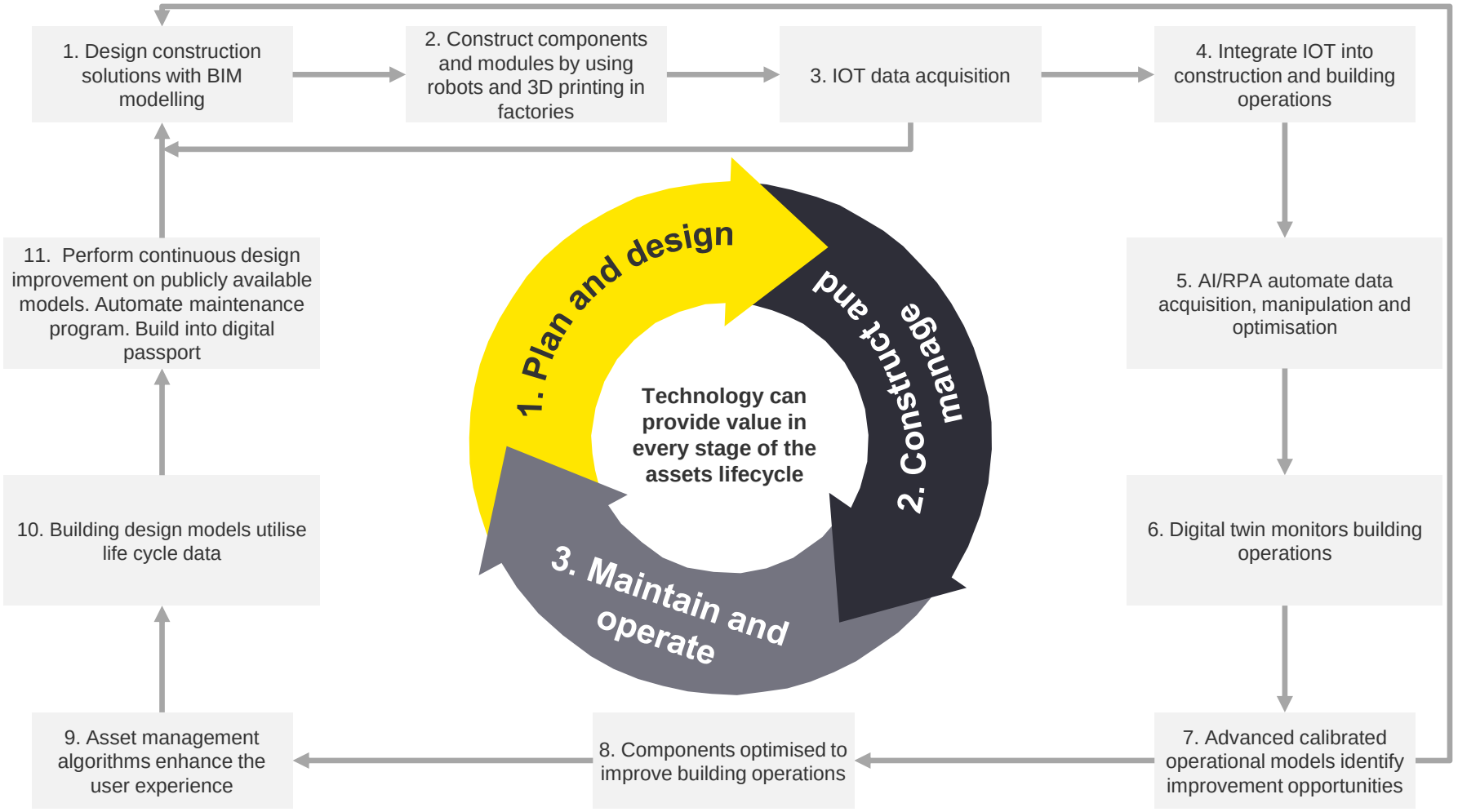
BIM and Digital Twins in the context of the Building Lifecycle

1. **Planning & Design** – use BIM to model structures before they are built. Streamlining project timelines and worker efficiency through Robotics Process Automation (RPA) and AI technologies
2. **Build Efficiently** – use drones and IoT sensors to capture real-time project progress. Monitor equipment in order to decrease downtime and use RPA to automate payment applications and invoice review
3. **Maintain & Operate for Less** – leverage a digital twin to model and adapt how humans interact with the building. Capture data from IoT devices to better understand how the building is being used. Use RPA to decrease costs related to lease administration and enable continuous data-driven improvement from machine learning to optimise predictive maintenance

4 Key advancements in global construction technologies

Adopting new technologies has resulted in the ability to map, manage and effectively deliver the complete project and asset lifecycle

Adopting these technologies and their capabilities has resulted in the ability to map, manage and effectively deliver of the complete project and asset lifecycle. This is creating a new operating paradigm which will be monitored and refined for adoption in Ireland.



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National trends in construction technologies

5 National trends in construction technologies

Key observations

Digital technologies are disrupting the way the Irish construction and built environment sector works. The rapid pace of change is already seeing some leaders in the construction industry embrace digital transformation to deliver construction projects in a better, more streamlined and efficient way. Many are working with international clients and are well regarded in terms of their building processes and quality and their ability to deliver on time and within budget.

However, it is clear from the EY surveys that the adoption rate amongst Irish construction firms are low in regard to the three broad areas of Modern Methods of Construction (MMC), Digitalisation and Technology and Innovation.

The research shows that there are significant challenges around the adoption of MMC (financing challenges, upfront capital costs, need for specialised labour) and digital adoption in Ireland. There would seem to be a lack of understanding of what constitutes digital adoption and how it can be employed in the construction process. Most of the focus is on Building Information Modelling (BIM) which has been a feature of the industry for over a decade. However, Ireland does not have a BIM mandate and is currently at 2D and 3D in terms of BIM adoption.

The primary barriers for firms to BIM implementation in Ireland were seen as a lack of in-house expertise (74%), no client demand (67%) and a lack of training (67%). The absence of an established contractual framework for working with BIM was also seen as a critical barrier. The challenge is to not only increase the level of BIM adoption, but to also grow the level of BIM maturity.

The EY survey of firms suggests that there is a significant lack of knowledge and understanding about construction specific technologies and how technologies can be implemented within day to day projects. The evidence from the EY survey of firms, is that, on average, 40% of firms in the industry are not using any form of automated technologies within their current projects.

However when asked about the culture within their firm, 38% of respondents stated that there was a ‘great’ or ‘very great extent’ to which they felt their firm was likely to engage in innovation. However only 29% of respondents felt that there was adequate training for new technologies.

The built environment and construction industry is in a position of considerable responsibility and influence, in terms of delivering a more climate resilient economy. The EY surveys indicate that over the next ten years 80% of firms and 88% of the key stakeholder groups believe that sustainability and energy will be of ‘great’ or ‘very great’ importance.

A number of recommendations arise for the Centre based on the review of current adoption levels:

- There needs to be an integrated BIM mandate (1D up to 7D) to drive BIM standards throughout the industry supply chain for projects above a certain threshold, to be determined.
- To ensure that the services provided by the Centre filter down to all enterprises in the domestic construction sector, regardless of scale, appropriate measures should be put in place to support domestic firms on their innovation journey.
- The Centre must also reflect the varying levels of digital maturity between stakeholders and sub-sectors in the industry.
- The centre should establish a Sustainability Action Plan within the first 90 days to ensure it remains focused and held accountable by ensuring that every action undertaken is concerned with building a sustainable environment within the industry.
- The Centre needs to develop a “good practice” process library for core commoditised industry processes to enable firms of varying size and scale to adopt and deploy these “good practice” processes to maximise output.
- To enable automation, enhanced use of data and process execution between parties, the Centre should create a technology “reference architecture” which will serve as a blueprint or roadmap for the technology evolution of the sector. This will highlight the centralised infrastructure that is required in a shared services model for commoditised processes in construction, the integration layer that is required to enable firms of all sizes and maturity to access this infrastructure as well as the governance, security and data protection requirements to enable this capability.

5 National trends in construction technologies

Digital technologies are disrupting the way the Irish construction and built environment sector works

Digital technologies are disrupting the way Irish construction and the built environment sector works. If the sector is to attract the next generation of professionals, become more environmentally sustainable and seek out better value-for-money for the taxpayer, it is crucial that the government and the industry stakeholders continue to embrace change.

Emerging trends suggest that firms in the sector are embracing this technological change to boost productivity. Their actions can be broadly categorised under the following headings:

1. Modern Methods of Construction
2. Digital Adoption
3. Technology and Innovation

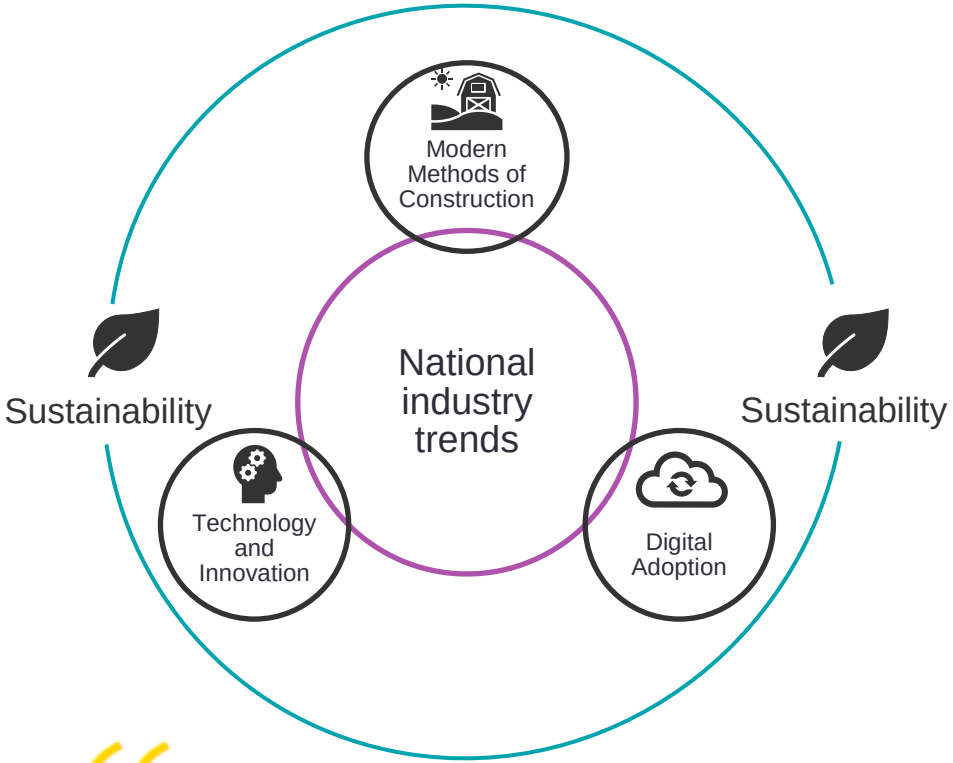
Sustainability underpins all three areas and is a key focus for the construction sector and will be even more important in the future.

Digital technologies seek to improve productivity by increasing the value of output, reducing costs, making the sector more climate-resilient and developing human capital.

Some of the benefits of embracing digital technologies include but are not limited to:

- Boost productivity
- Provide more sustainable buildings
- Help to attract the next generation of tech savvy construction workers
- Safer operations
- Better accuracy
- Better communication
- Less errors
- Provide better value for money for the tax payer

This chapter considers how these trends are developing throughout the Irish construction and built environment sector.



Digital transformation should not focus only on technology. We need to think about the actual endgame. In order to compete for and maintain customer engagement, we need to think about what we want to transform the overall experience into. Only then can we question how technology can play a role to optimise the return-on-experience, and decide on the tools and technologies to support, manage and sustain this digital transformation."

Dr Noel Carroll, Lecturer - Business Information Systems, NUI Galway

5 National trends in construction technologies

Modern Methods of Construction have the potential to improve the speed of construction of new homes by 30%, with a potential 25% reduction in costs

Modern Methods of Construction (MMC) is an umbrella term that can have different meanings for different people. MMC is used to describe a range of offsite manufacturing and onsite techniques that provide alternatives to traditional house building. MMC can include residential property units being constructed from factory-built volumetric modules to the use of innovative techniques that can be used to lay concrete blockwork onsite.[1]

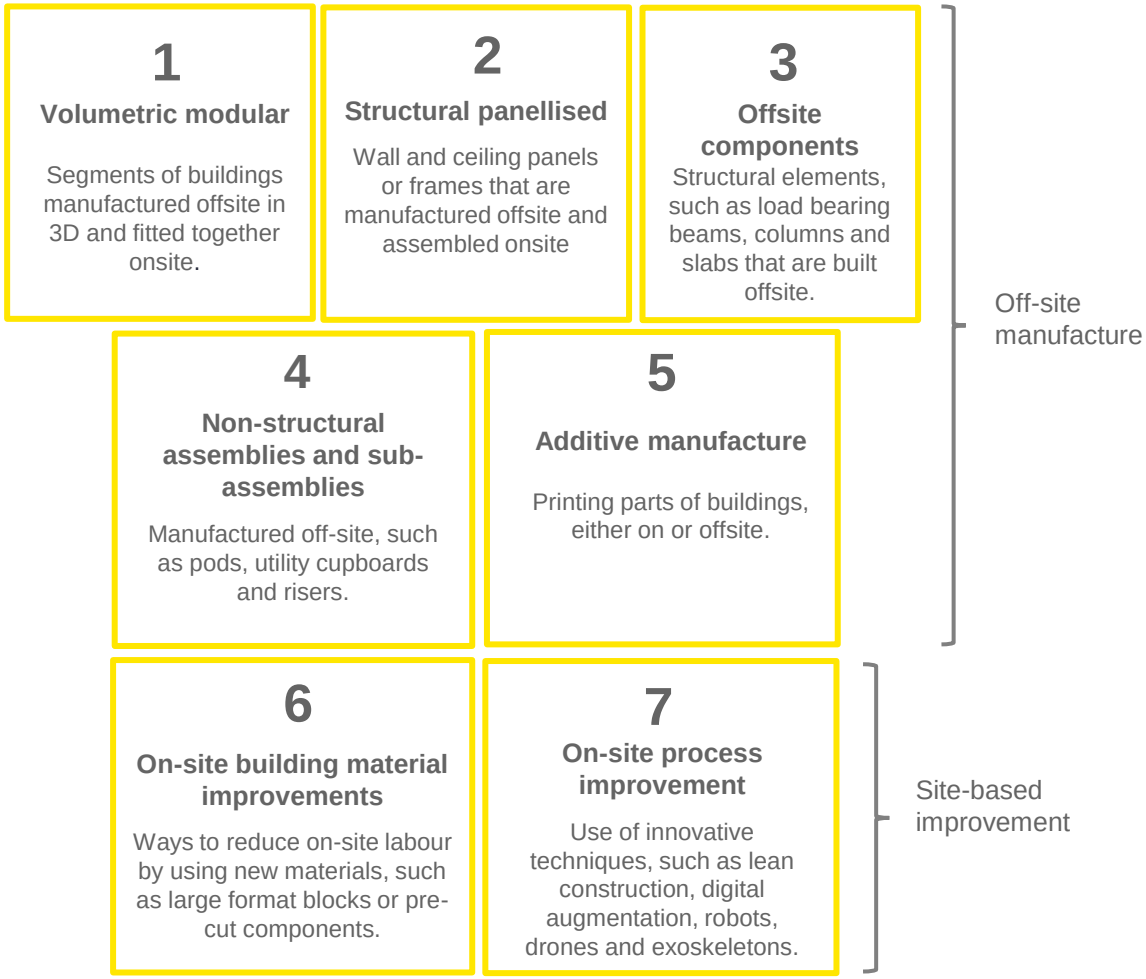
The UK's Ministry for Housing, Communities and Local Government published a definition framework in 2019, which focused on the MMC techniques used in residential unit delivery. It sets out seven categories for defining MMC (see opposite), the first five of which use off-site construction.[2]

Research has suggested that there has been increased interest in MMC, with developers engaging in project trials and going on to make increasing use of the different systems available. The 2017 UK Government White Paper expressed support for the use of MMC, which is expected to help solve the UK's housing crisis and achieve a significant increase in housing output. The UKG White Paper suggested that MMC had the potential to improve the speed of construction of new homes through the adoption of innovation by 30%, with a potential 25% reduction in costs, as well as the potential for advances in improving quality and energy efficiency. [3]

Anecdotal evidence suggests that MMC in the UK constitutes 6-10% of construction sector output and is projected to rise to closer to 20% over the next ten years.[4]

One of the key themes to have emerged from a number of one-to-one interviews as part of Action 3 – which seeks to establish a MMC Working Group – has been a lack of understanding of what constitutes MMC. [5]

Modern Methods of Construction used in housebuilding – Category Definitions



> *MMC is an enabler, not an outcome… As with all change, integrating MMC is neither a silver bullet nor without disruption. Adopting and integration innovation to deliver sustainable benefits is rarely a matter of technological substitution – it requires new points of team engagement, interrelationships and activities."*
>
> **A Report on MMC prepared by Akerlof for Enterprise Ireland**

5 National trends in construction technologies

The utilisation of MMC throughout the Irish construction industry remains relatively low

Where we are now: MMC adoption in the Irish construction sector[6]

In order to ascertain the level of MMC adoption within the Irish built environment and construction sectors, the EY survey of firms asked a number of questions. Firstly, 7.4% of the firms that responded to the firms' survey regarded Off-Site Manufacturing/Modern Methods of Construction (OSM/MMC) as being their main activity.

The survey about the extent to which the firms used 19 different MMC techniques (Appendix 6a). Firms were asked to rank their use of MMC techniques from 1. 'Not At All' to 5. 'Very Great Extent'.

The most common response for each technique was 'Not At All', suggesting that most firms are using more traditional methods of construction and are not ready to embrace MMC.

Figure 12 outlines the top 5 techniques which received the highest shares of 'Not At All' responses. Given that none of the OSM/MMC respondent firms were large firms, the share of firms regularly employing MMC is likely to be significantly higher, as a number of large contractors tend to use MMC as part of their main activity of being a 'main contractor'.

Of those firms who declare OSM/MMC as their main activity:

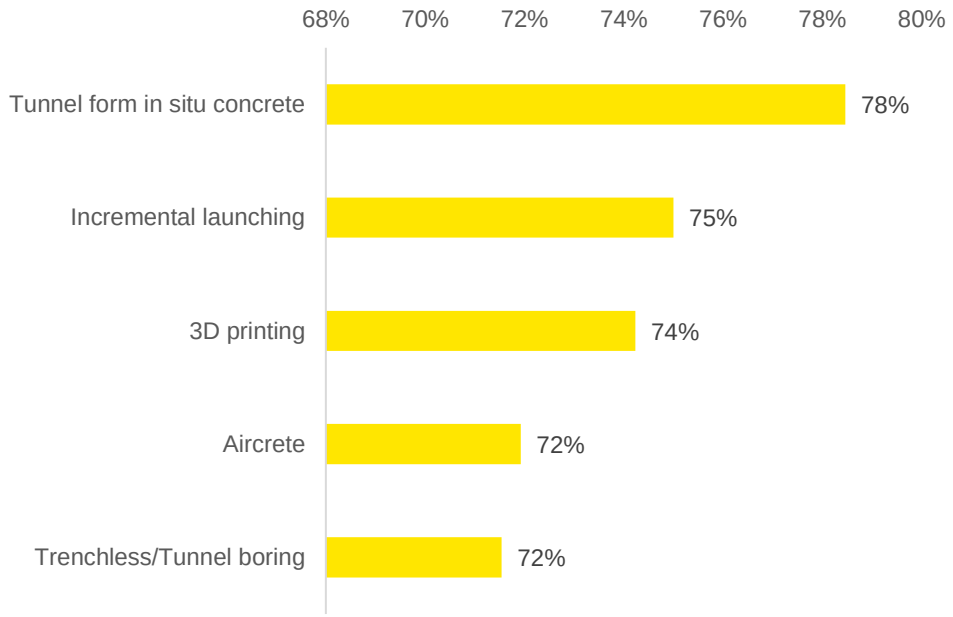
- 85% use panelised systems to a great extent or a very great extent
- 65% use sub-assemblies and components to a great extent or a very great extent
- 55% use hybrid systems (i.e. integration of volumetric and panelised systems) to a great extent or a very great extent

In terms of the different elements/facilities that might be provided by a Construction Technology Centre, 61% of firms described the extent to which 'modular assemblies' could assist them as moderate or above.

In this respect, 'modular assemblies' ranked 9th of 12 potential elements. Unsurprisingly, large companies (>250 employees) were more in favour of 'modular assemblies' being provided – 83% of these firms ranked the extent to which modular assemblies could assist them as moderate or above. On the other hand, this figure fell to 44% among micro firms.

The survey results and a review of the literature indicate that the utilisation of MMC in the Irish built environment and construction sector remains relatively low.

Figure 12: The top 5 techniques which received the highest shares of 'Not At All' responses



The following were the top three most common MMC techniques employed by those large firms that classified their main activity as 'main contractor':

- 93% use pre-cast concrete to a great extent or a very great extent
- 57% develop bathroom/kitchen pods off-site to a great extent or a very great extent
- 50% use slip form to a great extent or a very great extent
- 50% use panelised systems to a great extent or a very great extent

5 National trends in construction technologies

ESS Modular is just one of the leading companies in Ireland using MMC to deliver works

The case study below demonstrates just one of the leading companies in Ireland utilising Modern Methods of Construction (MMC) to win and deliver high quality works within Ireland and further afield.

Founded in Dublin in 1989, ESS Modular has three decades of experience delivering award-winning buildings using modern methods of construction (MMC). Backed by Enterprise Ireland, ESS Modular has more than doubled its workforce over the last 12 months, adding a total of 110 new employees across its five sites in Ireland and the UK. [7]

Following growth in orders and turnover, the company announced the doubling of its UK footprint with the new presence opening in Manchester which created an additional 70 jobs.

The company's off-site process involves the manufacture of buildings in a controlled environment while siteworks are completed at the project site. This approach allows for much greater speed, cost certainty, precision and quality control.

State of the art 40-bed ward extension to open at South Tipperary General Hospital

A recent ESS Modular project was a state of the art 3,300 square metre, 40-bed ward extension at South Tipperary General Hospital. The new development is the largest modular ward extension in Ireland and consists of a two-storey accommodation block linked to the main hospital. It features 40 en-suite bedrooms, reception and lounge areas, kitchen facilities, staff changing rooms, store rooms and drug preparation facilities.

Using a precision manufacturing process, ESS Modular manufactured the new building off-site, significantly reducing the time required on site. The new hospital facility was delivered in less than 12 months.

Design

The modular ward extension was designed by ESS Modular who partnered with O'Connell Mahon Architects and Arup Consultants to bring the works from planning stage through to detailed design, contractor tender and construction.

The design brief specified the need for a naturally ventilated building and with this in mind, all bedrooms were designed on the building perimeter and fitted with large openable windows, with the main clinical rooms centrally located and fed from an Air Handling Unit. The new building is split into two blocks which works with the geography of the site and allows for direct access from the corridor of the new building on ground floor to the central corridor and stairwell of the main hospital.

Site Works

In addition to the delivery of the new building, ESS Modular was also responsible for all ground works which featured a site clearance, a reduced level dig, radon and under building drainage, building of a 140m retaining wall, foundations, connection of mains water, gas and electric connection, provision of a 171m^3 attenuation tank and soft landscaping. [8]

> *"The use of off-site, modular construction methods brings multiple benefits. Buildings can be completed up to 50% faster than traditional constructed projects, be more energy efficient, and is increasingly recognised as having huge environmental benefits due to the increased focus on quality control in a factory environment."*
>
> **ESS Modular**

5 National trends in construction technologies

The majority of the industry believe that MMC will be of 'great' and 'very great' importance over the next 10 years

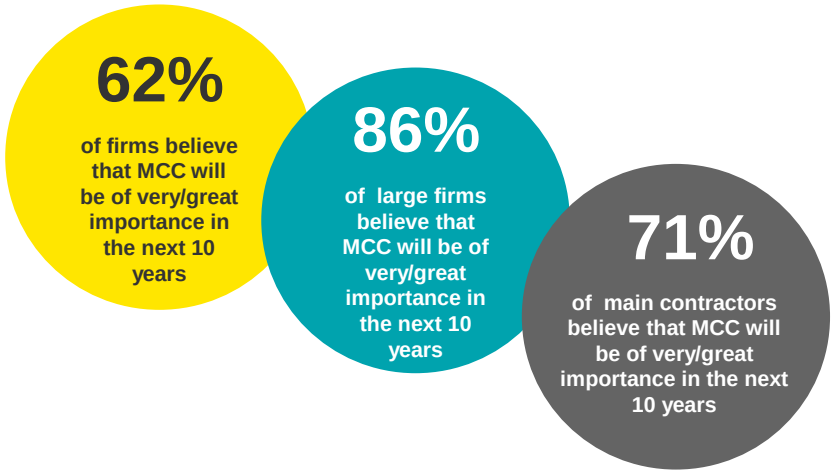
In regard to the future use of MMC, 62% of firms surveyed believe that modular construction will be of great importance or of very great importance in the next 10 years. The perceived future importance of MMC was stronger amongst larger firms with 86% of firms highlighting the importance of MMC to the future of the industry.[9]

Research from property agent Savills Ireland, suggested that the proportion of homes built in Ireland each year using MMC will rise from 6–10% in 2020 to 20% over the next 10 years.[10] The research suggested that these increases in MMC adoption are likely to occur for the following reasons:

1. Labour shortages in the construction sector, and
2. To make the construction sector more climate resilient.

The Covid-19 pandemic has changed the way firms work throughout the world with the construction sector not being immune from this change. A survey of over 250 chartered surveyors highlighted that 58% of firms were more likely to consider modular construction for their future projects as a result of Covid-19.[11]

On a global scale, the modular construction market was estimated to be valued at $102 billion in 2018 and is projected to grow at a compound annual growth rate of over 5.5% to surpass $142.5 billion by 2024.[12]



Ireland is currently experiencing a significant housing shortage. An increased demand for housing, an expanding population, rising rental costs and an undersupply of new housing completions are the key challenges for the residential property market. According to Deutsche Bank, Dublin is one of the most expensive places to rent.[13]

The impact of the Covid-19 pandemic and the shut down of the market has exacerbated the delivery of new supply. As with previous monthly reports, the Ulster Bank Purchasing Managers Index (PMI) report for September noted ongoing supply-side challenges, partly linked to the pandemic and to Brexit. Firms reported difficulties in sourcing material and staff, with the rate of input cost inflation remaining near record levels. The rise in input costs in September was only fractionally softer than the record high reached in July. Steel has been the item most widely reported to have increased significantly in price.[14]

The Housing for All Plan has projected that an average of 33,000 homes are required each year until 2030.[15] With just 113,000 new homes delivered over the past decade, there is also a significant pent-up demand which needs to be accommodated. Based on an average of 33,000 required per annum, this suggests that the economy needs around 547,000 homes over the next decade.

MMC and off-site construction can help address this shortfall more speedily, while also delivering well designed and high quality buildings, cost savings and higher productivity.[16]

The potential benefits of MMC are substantial with

- A 20%–60% reduction in construction programme time
- A 20%–40% reduction in construction costs
- A 70%+ reduction in onsite labour, which creates improved outcomes in health and safety for workers
- Greater programme certainty

The extensive benefits of MMC are continued on the next page.

5 National trends in construction technologies

Modern Methods of Construction have a wide range of benefits including increasing productivity and tackling labour shortages

Labour imbalances and safety

MMC can help to tackle the labour force imbalances inherent within the built environment and construction sector. In 2006, construction accounted for around 11% of employment in Ireland. However, after the global financial crash, its share declined to just over 4% in 2011 and 2012 before rising to a little over 6% in 2019 (CSO 2021).[17]

These fluctuations in employment levels mirror the cyclical nature of the Irish economy, with the associated job insecurity acting as a disincentive for younger people to start working the sector. In 2006, 47% of construction sector employees were over the age of 35. This increased to 70% by 2016. Furthermore, women constituted just 8.5% of those employed in construction in Q4 2019 – the most recent quarter for which data was not impacted by Covid-19. By contrast, 46.0% of those employed across all sectors were women.[18]

Even before the onset of Covid-19, skills shortages constituted the single largest factor holding back construction output. For example, in a SCSI/PWC survey, over 80% of survey respondents reported shortages of plumbers, carpenters, bricklayers and quantity surveyors. In addition, over 60% could not get enough electricians and civil engineers, despite attempts to source labour from abroad.[19]

Covid-19 exacerbated these skills shortages. During the first lockdown, which lasted seven weeks from 27 March 2020, EY estimates that 89.1% of those directly employed in construction in Q2 2020 (128,500) or almost 9 out of every 10 workers in the industry were on some form of pandemic related payment. EY forecasts that the Irish construction sector will not regain its Q4 2019 employment levels until 2024, given the strong possibility that many workers within the sector may have returned to their country of origin when the pandemic struck.[20]

Off-site manufacturing can be part of the solution to addressing this demographic imbalance and skills shortage within the industry for the following reasons:

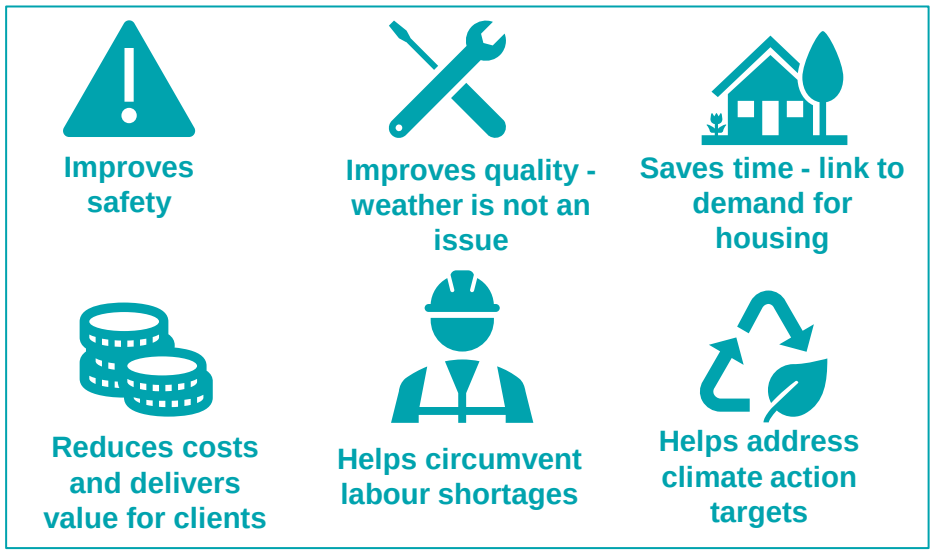
- An increasing proportion of factory based work and standardised hours could encourage more people into the workforce
- A larger proportion of the workforce is factory based, working at safe heights in controlled environments
- Factories provide stable employment and can be situated in areas with higher levels of unemployment to generate employment opportunities.

Furthermore, the increased prevalence of MMC will be conditional on a steady demand pipeline of projects to ensure its financial viability. It is therefore possible that this increasing demand certainty will entice more people to build a career path and take up apprenticeships within the fields of MMC.

In a separate report on the adoption of MMC in the UK market, a range of benefits of MMC transformation are noted under the following headings:[21]

- **Human** – high quality employment opportunities; safer working environments
- **Social** – positive public perception of construction; a more diverse workforce
- **Environmental** – supports carbon zero, reducing embodies and operations emissions; reduces waste and traffic movements;
- **Manufacturing** – improves productivity and delivers efficiency gains; accelerates delivery timescales
- **Financial** – reduces risk due to improved certainty in time and cost

Benefits of MMC



5 National trends in construction technologies

Modern Methods of Construction have significant environmental benefits

Environmental Benefits

The need for a greener approach to building is well acknowledged.

The potential environmental benefits are equally significant. It has been estimated that 12.2% of Ireland's CO_2 emissions are from the manufacturing and construction industry. Between 1990 and 2018, it is estimated that CO_2 emissions from the manufacturing and construction sector increased by 19.6%.[22] Research by WRAP reports (wrap.org.uk) that MMC can reduce energy consumption by 67% and reduce waste onsite by 70 – 90%, in addition to reductions in deliveries to site of 90%.[23]

For instance, Boyd et al, (2012)[24] term the lean processes employed in off-site manufacturing as critical to efficient utilisation of resources. The study notes that the prefabrication of building components provides an opportunity through which materials can be re-used and recycled, thus reducing wastage. Moreover, the modern OSM systems are said to have been built using a lightweight steel frame, which consumes less energy than other components such as concrete.

Mainstreaming sustainable modern methods of construction was identified in the survey of firms as the top challenge regarding sustainability that should be prioritised in a Construction Technology Centre.

'Sustainable, modular construction and standardised building elements' were identified by firms as the most important area of circular built environment research that should be undertaken by a Construction Technology Centre.

This was echoed in a similar survey of 100 key stakeholders as part of Action 2, where 'Sustainable, modular construction and standardised building elements' were deemed the most researched topics within the area of 'circular built environment' in order to achieve disruptive innovation in the construction sector for sustainability and climate action.[25]

65%

of stakeholders surveyed believe that mainstreaming sustainable MMC should be prioritised by a Construction Technology Centre

Figure 13: The top 5 challenges from the firms' survey regarding sustainability that should be prioritised in a Construction Technology Centre

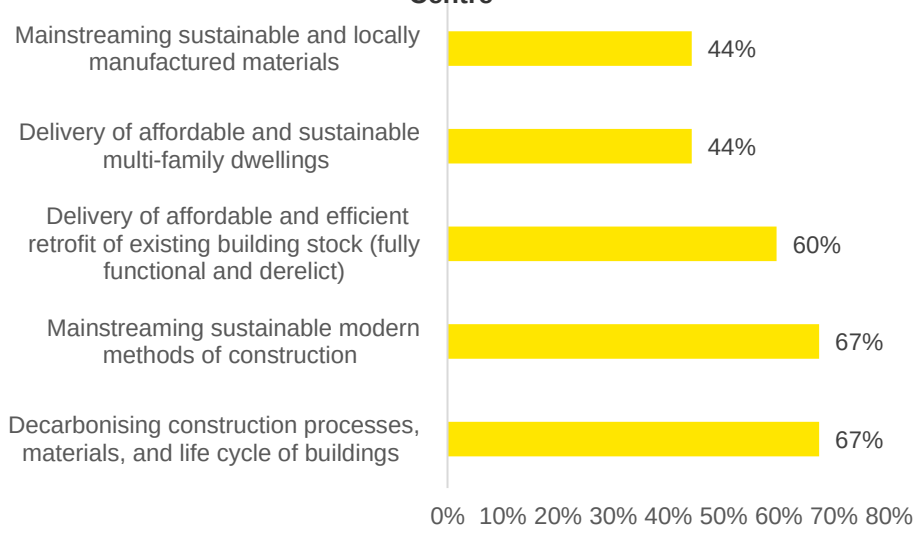
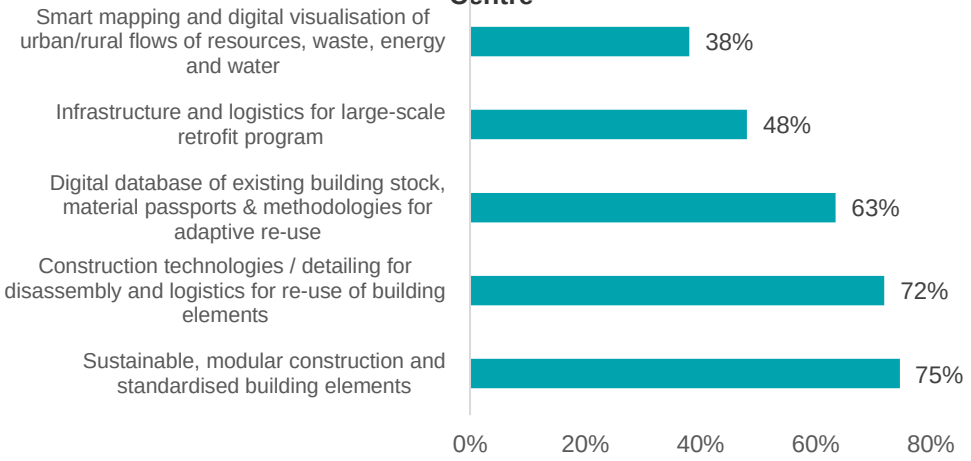


Figure 14: Areas of a circular built environment research that the firms' survey reported should be undertaken by a Construction Technology Centre



Customer demands for higher efficiency, reliability and quality

There has been an increased need for modern methods of construction, where much of the construction process is carried out in a factory-controlled environment, thus reducing the requirement for skills on-site. According to Kamar et al., (2011) [26] the off-site production of building components enhances quality and helps in reducing the risks attributed to on-site quality management. Kamar and his colleagues observed that, though quality management is still critical on the construction site, it could be improved by having some of the site-based work performed off-site.

A report presented by the Health and Safety Executive indicated that deadly accidents on construction sites are more than five times more likely to occur than in factory settings. [27]

There is also the added benefit of cost efficiency when adopting a modular approach. This is achieved by standardising certain building materials and designs. The modular method also employs economies of scale, where building materials that are mass-produced can be made at a lower cost.

Modular construction costs are often lower than for traditional construction projects due to fewer resources and less time required to complete a project. Construction lives by the idiom 'time is money'. When something needs to be retrospectively fixed or changed, a loss is incurred.

Barriers to Adoption

Whilst research has highlighted that there are multiple benefits to adopting the use of MMC within the Irish construction sector, there are a number of barriers to its adoption which may prohibit firms and the industry fully embracing the range of innovative techniques that embody MMC (e.g. OSM, rationalisation of processes and materials).

Some research claims that the prefabrication process is more expensive than the traditional method. A study conducted by Davis Langdon revealed that off-site manufacturing has a cost premium of between 10% and 25% [28], others argue that, though there is a premium in cost, the enhanced speed of construction and increased quality compensate for the loss of money (Pan and Sidwell, 2011) [29]. They also observe that most prefabricated components are designed in a manner that they can quickly be repaired and maintained, thus offering long-term benefits in terms of maintenance cost.

According to MTech Consult Limited (2009)[30], MMC require developers to purchase all relevant materials before kick starting a project, which necessitates high up-front costs. In particular, increments in cost of employing MMC have been associated with increase in execution time, which are the two most cited challenges of OSM systems.

Other significant challenges around the adoption of MMC which can arise along the construction supply chain are the following:[31]

- Financing challenges, as lenders may see it as a new method of construction with a limited track record, resulting in a hesitancy to commit. This has the potential to result in working capital issues for contractors.
- There are significant capital upfront costs involved with the factories required for MMC. There are also the costs of developing the architectural design and manufacturing processes. Certain oversized vehicles are also required to transport the prefabricated modules to site.
- Related to the above are the logistical controls required to ensure timely and effective deliveries throughout the supply chain. MMC requires efficient management and coordination of both the factory and the construction site.
- Specialised labour is required to operate the specialised equipment and assemble the prefabricated components.

Among the challenges to adoption of MMC are:

- The lack of a steady pipeline of projects required to ensure financial viability
- The switch from being a contractor to being a manufacturer and the implications this has for funding and risk

Some companies manage the risk involved by forming strategic alliances and collaborative partnerships with producers, other by developing 'knowledge factories' as a priority to investing in production. The latter involves developing new competencies, skills and roles in BIM and DfMA (Design for Manufacture and Assembly), a design approach focused on ease of manufacture and efficiency to assemble and deliver improvements. The latter is a well established approach used in the automotive and consumer product industries.

5 National trends in construction technologies

Digital Adoption is changing the way in which the industry builds

What is digital adoption?

The second of the two pillars to be assessed is digital adoption. Digital Adoption includes but is not limited to[32]

Additive manufacturing (3D Printing)	Robotisation	Drones	3D Scanning	Internet of Things (IoT)	Sensors
is the process of creating an object by solidifying a raw material (e.g. plastic, metal, wood or concrete) under the control of a computer using a Computer-Aided Design (CAD) or BIM file to guide the 3D printer nozzle. 3D printing minimises material waste, reduces the duration of the construction phase as well as labour accidents.	in the construction sector consists of the use of devices with robotic arms which operate repetitive processes such as laying floor tiles or bricks, lifting heavy objects and placing them in exact coordinates. Bricklaying robots, welding robots and self-driving heavy machinery make construction safer, faster while reducing construction costs.	are unmanned aerial vehicles equipped with high-resolution cameras and other scanning equipment. Drones can scan large areas or different directions/angles of an object simultaneously. Drones provide live streaming videos/photos for BIM use. Thus, allowing for reality-capture solutions and real-time comparison between planned and implemented solutions. If coupled with IoT, 3D models generated by drones would allow for a better monitoring and inspection of construction projects.	is the process of creating a 3D model of a real-world object or construction by scanning it from all possible angles. This process can be used in the construction sector for creating 3D models of existing buildings and infrastructures for which there is no digital information. The use of 3D scanners is, quite often, enabled by the use of drones. The 3D images captured by 3D scanners are incorporated in BIM for further elaboration, thus, allowing for an accurate intervention on existing buildings and infrastructures.	is the concept of connecting to the internet household appliances, devices, sensors, vehicles, etc. Thus, allowing for communication, remote control, exchange of data, etc. IoT is, currently, closely related to sensors as in most cases it requires some form of data provided by the sensors. However, as mentioned earlier, IoT could also be coupled with drones and 3D scanners which would lead to a better monitoring and inspection of construction projects.	offer the possibility of continuously collecting data and monitoring the performance of an aspect of a construction (e.g. electricity consumption, indoor air temperature, CO2 concentration). The use of sensors facilitates the transition from planned maintenance towards predictive maintenance leading to cost reductions and reduced disturbance for the users.

All of these digital technologies are slowly being adopted in the construction industry throughout Europe. However, there is a lack of understanding of what constitutes digital adoption and how it can be employed in the construction process. BIM is often at the forefront of conversations around digital adoption within the industry and has been a feature of the industry for over a decade. BIM tends to be the ingredient that links all of the other digital technologies together.

5 National trends in construction technologies

Digital Adoption: BIM is a collaborative system which facilitates knowledge sharing among stakeholders from conception to demolition

What is BIM?

Building Information Modelling (BIM) is a collaborative system that helps industry professionals in designing, delivering and maintaining assets throughout the entire lifecycle. It enables project stakeholders to access an integrated platform to input, analyse and process real-time data in a three-dimensional digitalised environment. As the successor to traditional computer-aided design, BIM systems allow 3D object data to be shared among project partners, as well as the possibility to share information on programme and scheduling (4D), cost control (5D), sustainability (6D) and ongoing life cycle asset operation and maintenance (7D).

In a fragmented sector like the Irish sector, comprising many players of varying sizes and skillsets interacting at different stages along the project lifecycle, BIM can provide a common information environment to facilitate cross-party engagement and a more integrated approach to project management. A key output of the BIM process is the Building Information Model - the digital description of every aspect of the built asset from information assembled collaboratively and updated at key stages of a project.

There are many benefits to BIM enablement, particularly in terms of enhancing information exchange. Aspects such as building models, project images and planning approvals can all be shared among relevant stakeholders at the beginning of a project, in order to finalise the design prior to going on-site. This approach minimises the risk of errors and eliminates any additional waste and cost arising from ad-hoc design changes on-site, thereby reducing the design phase of a construction project by 30% and its design cost by 8%.

BIM is also the key to further technological enablement. For example, BIM is founded upon the objectives of the lean construction approach to reduce wastage and increase productivity and cost efficiencies. Furthermore, modularised buildings rely on accurate information from BIM models to produce 3D objects and scheduling data that allow for accurate production and just-in-time delivery of modules from factories to construction sites. Digital twins improve the analytical capabilities of BIM, by visualising the real-time status, working conditions, and position of physical assets to allow every piece of a building to be measured and understood, as part of the whole life asset operation and management.[33]

> *BIM is the biggest enabler for us… Getting it right first time is key, reducing that 20 per cent capital cost that everyone is focusing on.*
>
> **Georgina Quigley, CEO - ACB Group**

Where is Ireland at now?

Prior to publication of the international BIM standard ISO 19650 (2018) when BIM was in its infancy with only three levels of BIM, the convention was BIM Level 1, 2 and 3 - thus the UK BIM Mandate required the use of 'BIM Level 2' as mandatory for all major public projects from April 2016. During the next phase of the UK strategy, construction firms were required to work towards BIM Level 3 on the whole lifecycle management of assets by 2025. The use of BIM 'levels' was based on the UK PAS 1192 standards.

Ireland now proposes to move well beyond that UK ambition based on ISO 19650 (2018) by seeking fully integrated BIM modelling of projects. In addition, the UK PAS standards are now withdrawn. ISO 19650 is now the internationally accepted standard of good practice. This seeks to define the BIM levels more logically as 'Dimensions' or 'D' for short. The international standard is now BIM 2D and BIM 3D which are simply 2 dimensional and 3 dimensional BIM replacing BIM Level 2 and Level 3 respectively on up to BIM 7D.[34]

Ireland is currently at BIM 2D and BIM 3D.

It is acknowledged that BIM is not new and some leading companies have been doing it for many years. The National Development Finance Agency (NDFA), for example, which procures and delivers Public Private Partnership (PPP) projects has been using BIM on PPP projects for a decade.

5 National trends in construction technologies

Digital Adoption: 65% of firms believe that BIM will be of great importance to their business over the next 10 years

BIM adoption levels in Ireland

Since 2015, there have been regular surveys to monitor the level of BIM adoption in Ireland, the first of which was initiated by the Construction IT Alliance (CitA) and Enterprise Ireland in 2015, sampling the 100 most influential leaders in Architecture, Engineering, and Contracting (AEC) across the State. It found that 67% of the industry sampled possessed confidence in their skills and knowledge to deliver BIM.[35] Follow-up surveys in 2016 and 2017 [36] revealed that this confidence had risen to 76%, among relatively similar sample groups.

A 2019 NBS (National Building Specification) and CitA survey of design professionals reported that 76% of respondents had adopted BIM in Ireland, three percentage points above the corresponding level in the UK. [37] However, Ireland remained at an earlier point in its BIM journey with fewer Irish respondents reaching 2D BIM on projects, relative to their UK counterparts. The level of BIM adoption among small Irish firms (those employing less than 15 people) was significantly below the national average, while BIM was used less often on one-off new houses, extensions, conversions, or alteration-type projects. This development is concerning, given nine out of ten respondents expected to be using BIM within the next one to five years.

Most recently, a study conducted by TU Dublin in 2020 of the Architecture, Engineering and Construction sector found that 42% of respondents saw BIM as strategically important to their business, while a further 32% were aware and regularly used BIM.[38]

There was a large cohort across organisations of all sizes in the EY survey that expected BIM to be of strategic importance for their businesses over the next decade.

The survey found that 65% of firms saw BIM becoming a crucial part of their business model over the next 10 years.[39]

Figure 15: How important will the following be for your business over the next 10 years

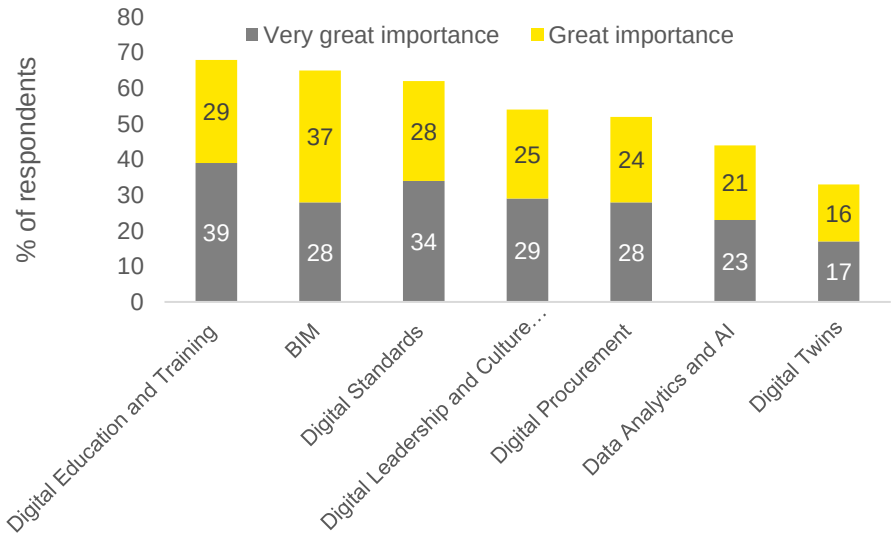
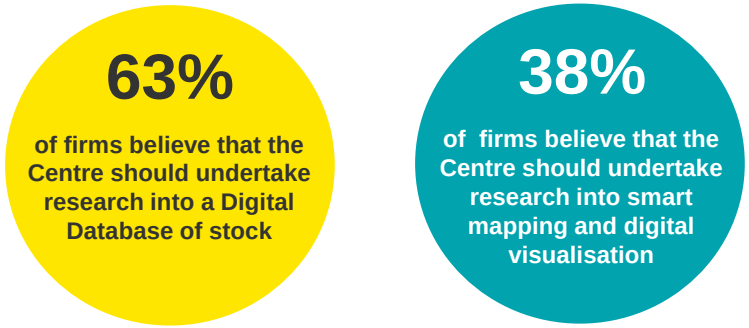


Figure 16: What research should be undertaken by a Construction Technology Centre?



5 National trends in construction technologies

Digital Adoption: BIM challenges

Challenges

McAuley et al (2020) outline a list of BIM-related publications, resources, activities, events and initiatives that have either been issued or organised in Ireland which have facilitated the digital transition in recent years.[40]

There appears to be mixed results in regard the level of BIM adoption within the Irish construction and built environment sector. The earlier studies from CitA reported high levels of adoption, albeit across small samples of leading professional firms, while the survey for this DDN study is showing more modest levels across the entire industry. This is the challenge to increase the levels across the entire construction supply chain over the next decade.

There is a concern that the growth in the level of BIM adoption may stall unless the challenges to its widespread implementation across the Irish construction and built environment sector are addressed.

Firstly, the level of BIM adoption among smaller firms (i.e., less than 15 people) working on smaller projects (e.g. extensions, conversions) is significantly below the national average. Even when all parties to a project use BIM, there can be differing levels of maturity; for instance, one stakeholder might be using BIM 1D which contains a mixture of 3D and 2D information which cannot be shared digitally and therefore information gaps arise when other stakeholders use BIM 2D. Therefore, the challenge is to not only increase the level of BIM adoption, but to also grow the level of BIM maturity.

Central to tackling this challenge is the recent appointment of a consortium of higher education institutions led by TU Dublin and industry leaders to undertake a five-year project to embed and upskill the construction industry in BIM, supported by international benchmarking (Action 7). Not only will these training programmes include 3D design, but they will also consist of 4D and 5D workflow to better manage scheduling, programme and cost control, 6D to monitor carbon foot-printing and 7D to measure the whole life attributes in asset management BIM 2D adoption, which facilitates collaboration through an information exchange process in which each party is capable of exporting their 3D models to a common file format.[41]

One of the highest-ranked barriers to BIM implementation repeatedly identified by the BIM adoption surveys and in consultations for this study was a client's unawareness of the value proposition of BIM. One suggestion to tackle this issue is for the government to introduce a BIM mandate, which would require BIM to be applied on all publicly funded projects, as is the case in the UK. All respondents to the 2020 AEC survey by MacAuley et al believed a mandate was required to assist in driving BIM usage throughout the private sector and show effective leadership.

However, the respondents acknowledged that certain outstanding issues had to be tackled prior to the introduction of a BIM mandate. At the time of the survey, the primary barriers to BIM were cost, lack of demand and insufficient training. The highest-ranked concern involved a lack of awareness of the value proposition of BIM with a need for a cost analysis of the benefit of moving towards BIM processes

The primary barriers for BIM implementation in Ireland were seen as a lack of in-house expertise (74%), no client demand (67%) and a lack of training (67%). The absence of an established contractual framework for working with BIM was also seen as a critical barrier.[42]

> *A step-change is required and it is those companies that are willing to commit to transforming their businesses within a generation who will be in a position to build their prosperity in a new landscape full of new markets and new approaches."*
>
> **UK National Federation of Builders Major Contractors Group, 2019**

5 National trends in construction technologies

Technology and Innovation adoption within the Irish Construction sector remains weak with firms' awareness of existing support being relatively low

The Construction Industry Institute based at The University of Texas defines construction technology as "the collection of innovative tools, machinery, modifications and software used during the construction phase of a project that enables advancement in field construction methods, including semi-automated and automated construction equipment."[43]

The use of technology during the construction phase has become more popular over the last 10 years with the use of mobile apps, autonomous heavy equipment, drones, and augmented and virtual reality becoming more commonly used. A report from Jones Lang LaSalle, Inc. released in 2020, reported that the growth in global construction technology on the ground, fuelled by demand because of the pandemic, far outstripped even the most optimistic forecasts. It reported that venture capital firms invested $2.87 billion in the top ten global construction technology start-ups in 2020, led by firms like Katerra (Modular), Procore (Digital Collaboration) and 3D Robotics (Drones).[44]

Current use of technology in Ireland

The EY survey of firms shows that 40% of firms in the industry are not using any form of automated technologies within their current projects. Aggregating the 'very great', 'great extent' and 'moderate extent' responses in the firms' survey for the current use of automated technologies, the most commonly cited technologies that are currently being used within the sector are Document Management Systems (60%); e-Procurement (57%); Mobile technologies or mobile platforms to manage projects in real time reporting (50%); and locating and tracking resources indoors using technologies such as laser scanners, video cameras, ultra-wide band (UWB), and wireless local area network (LAN) instead of manual methods (45%).

This would suggest that there is a significant lack of knowledge and understanding about construction specific technologies and how technologies can be implemented within day to day projects.

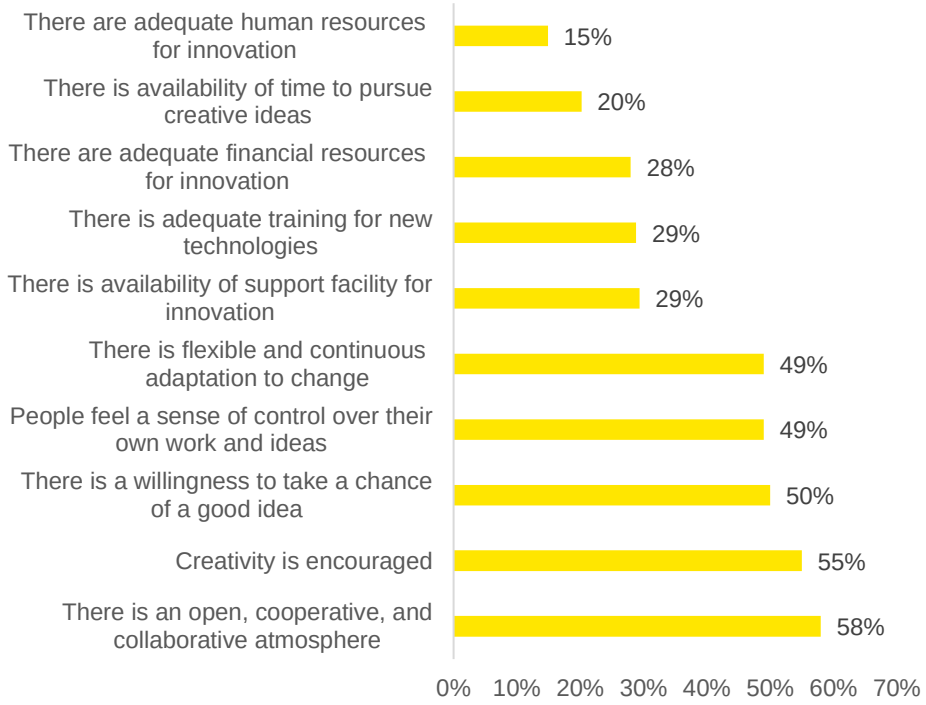
However, when firms were asked about the culture of their firm, 38% of respondents stated that there was a 'great' or 'very great extent' to which they felt their firm was likely to engage in innovative ways. As shown in Figure 17, 58% of respondents stated there was an open and collaborative atmosphere within their firm; however only 29% of respondents felt that there was adequate training for new technologies.[45]

Separately, when firms were asked about their awareness of Innovation Vouchers which are provided by Enterprise Ireland to support investment in innovation practices, 52% of Irish firms stated that they were not aware of them.

The following were the top three most common information sources cited as being important for firm's innovation:

- Self-research via internet search engines - 61%
- Suppliers of equipment and materials - 58%
- Competitors or other businesses in the industry – 51%

Figure 17: To what extent are the following statements about the overall culture of the firm true



5 National trends in construction technologies

The adoption of technology and innovation within the construction sector could increase productivity and improve safety on site; however firms are not investing in technologies due to lack of time, resources and incentives

Benefits to technology and innovation adoption

Research has suggested that there are numerous benefits to using technology and innovation in the construction industry[46], for example:

- Artificial Intelligence (AI) and machine learning systems can help businesses transform large quantities of data they have collected over the years on a range of projects to forecast and predict future outcomes on projects and gain a competitive advantage when estimating the cost of projects during the bidding process.
- AI can improve productivity by reducing time wasted when moving around the construction site to retrieve tools, materials and equipment to perform certain tasks. Workers are tracked throughout the day using smartphones or wearables.
- As construction technology adoption continues to ramp up in the construction industry, one area getting a lot of attention is improving safety. Technology solutions are making it easier to properly train and monitor workers to prevent accidents and reduce the rate of serious injuries and worker deaths.
- Site sensors can be deployed across a construction site to monitor things like temperature, noise levels, dust particulates, and volatile organic compounds to help limit exposure to workers.
- Robots are good at doing repetitive tasks such as bricklaying. Once set up, bricklaying robots can work continuously to complete tasks faster than human workers without needing to take breaks, thereby increasing productivity.

Challenges to technology and innovation adoption

Whilst there is a range of benefits to technology and innovation adoption within the construction industry, there are also a number of challenges which can prevent firms from adopting such technologies.

Evidence from the EY survey of firms (Figure 18) shows that having other priorities is the key deterrent preventing firms from implementing new technologies in Ireland. The day to day running of the business, lack of time and lack of financial incentives are amongst the challenges to technology adoption within the sector. There is an opportunity for a Construction Technology Centre to assist firms in breaking down these barriers, as shown in Figure 19.

Figure 18: To what extent could the following challenges exist while implementing new technologies (very great and great extent)

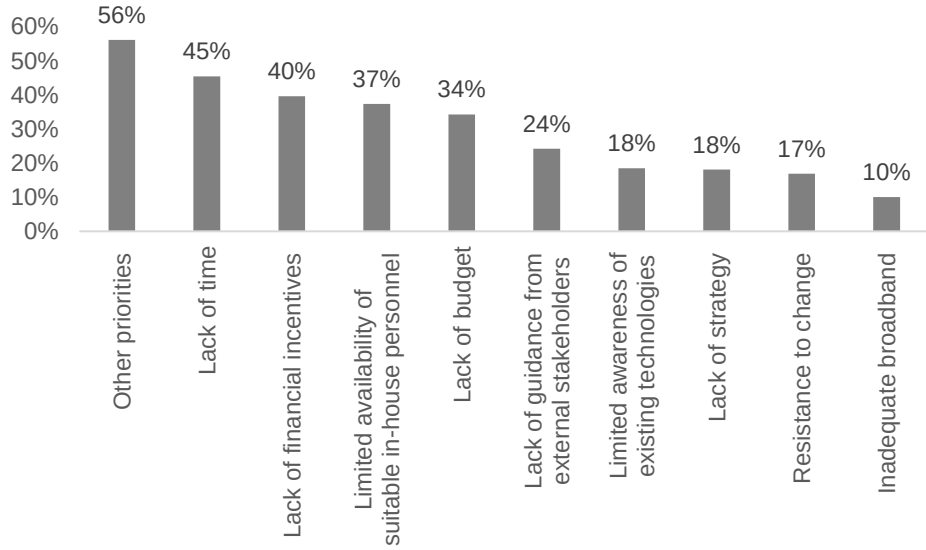
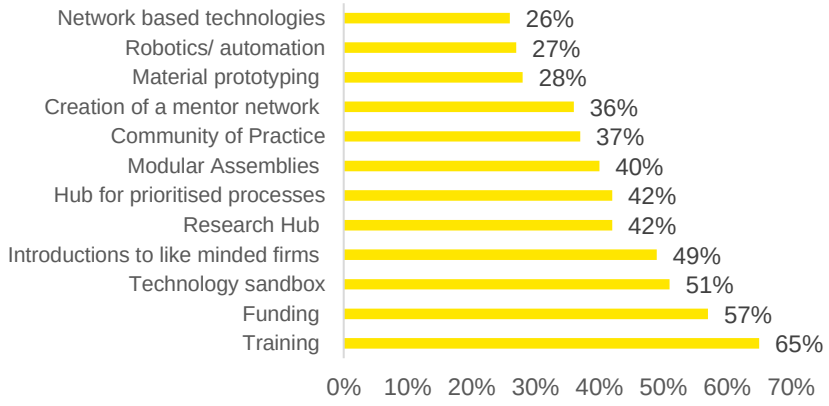


Figure 19: To what extent could the following elements of a technology centre assist your firm (very great and great extent)



5 National trends in construction technologies

Sustainability has to underpin the future of construction activities, while being attentive to environmental and circular economy imperatives

In 2019, the Government's Climate Action Plan noted that:

> *"The accelerating impact of greenhouse gas emissions on climate disruption must be arrested. The window of opportunity to act is fast closing, but Ireland is way off course."*

The construction and built environment sectors are, by their nature, significant users of the Earth's natural resources. Buildings and their construction are responsible for 39% of all carbon emissions in the world, with operational emissions (from energy used to heat, cool and light buildings) accounting for 28%.[47] The remaining 11% comes from embodied carbon emissions, or 'upfront' carbon that is associated with materials and construction processes throughout the whole building lifecycle (including extraction, manufacture, transport, construction and end of life). In Europe, when their full life cycle is taken into account, buildings are responsible for:

- Half of all energy use
- 40% of all greenhouse gas emissions
- Half of all raw material extraction
- A third of all water use

In addition, Construction and Demolition (C&D) waste, which includes any kind of waste created in the construction process (e.g., soil or stone), represents one third of all waste produced within the European Union. Indeed, C&D waste is the largest waste stream produced in Ireland, comprising 6.2 million tonnes of Ireland's 14 million tonnes of overall waste total in 2018 (44%), after jumping by almost a third vis-à-vis 2017 due to the sharp increase in construction activity.[48]

Consequently, a huge culture shift is needed towards actions and policies that tackle the full life cycle of buildings and their impacts. All the actors along each stage of the construction and built environment value chain must be incentivised to co-ordinate their efforts and embrace the possibilities for decarbonisation to reduce the negative environmental impact of their activities.

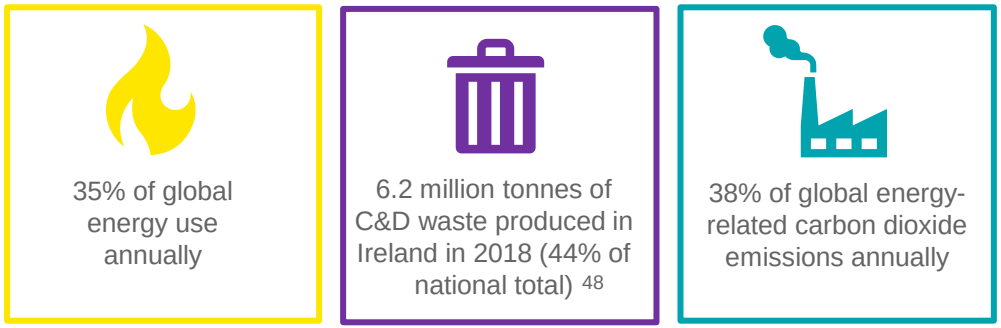
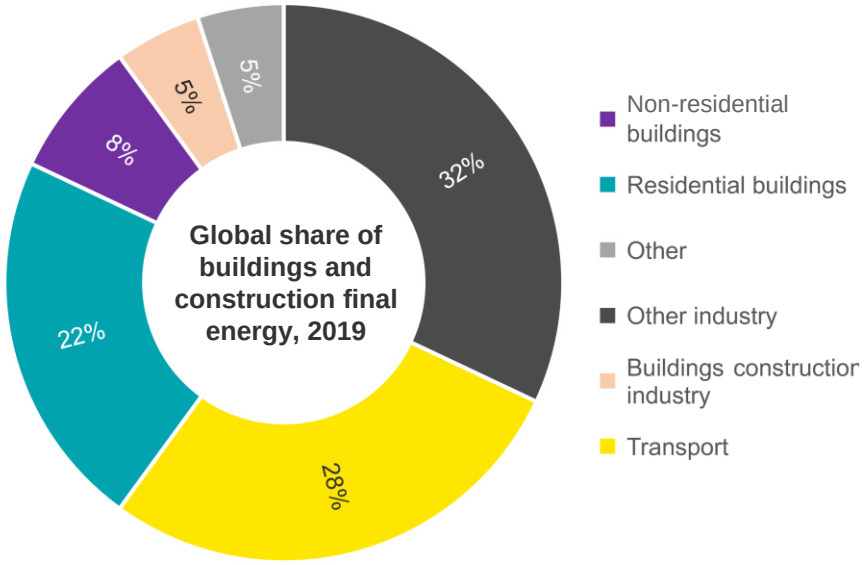


Figure 20: Global share of buildings and construction final energy, 2019



Source: European Commission

5 National trends in construction technologies

Government and societal attitudes to the importance of the climate are changing; the built environment and construction industry is in a position of considerable responsibility

In recent years, climate resilience has moved centre stage on both a political and societal level. The Paris Agreement (2015) demands that the built environment and construction sector decarbonise globally by 2050, if it wishes to succeed in its objective of limiting the rise in global temperatures this century to well below 2 degrees Celsius above pre-industrial levels.[51]

In March 2021, the Government published the Climate Action and Low Carbon Development (Amendment) Bill which declared that

> "*the State shall, so as to reduce the extent of further global warming, pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy."*

If enacted, this Revised Bill would represent a significant step-change in the governance arrangements for delivering on Ireland's legal obligations under the Paris Agreement and EU law to decarbonise the economy and pursue the transition to a climate neutral society. One of the key elements of the Bill, from a built environment and construction sector perspective, is the proposed introduction of carbon budgets which will introduce limits on the total amount of greenhouse gas emissions permitted during a budget period.

In summary:

- Each carbon budget would refer to a period of five years, with the first such carbon budget covering the period from 1 January 2021 to 31 December 2025.
- The first two carbon budgets would have to provide for a reduction of 51% in the total amount of greenhouse gas emissions by 31 December 2030 as against the amount reported for the year ending 31 December 2018. Given it is estimated that emissions fell by only 6% in Ireland in 2020, despite a Covid-19-induced collapse in economic activity and mobility, the impacts of this shift in climate action policy will be felt across the entire Irish economy and society.
- The Government will be responsible for setting an emissions ceiling for different sectors for the five year period within the limits of the carbon budget.[52]

In Ireland, a 2020 opinion poll found that 7 in 10 respondents "feel that a failure to act on climate change is a failure to act in the best interests of the people of Ireland." In addition, almost two-thirds of respondents agreed with the view that:

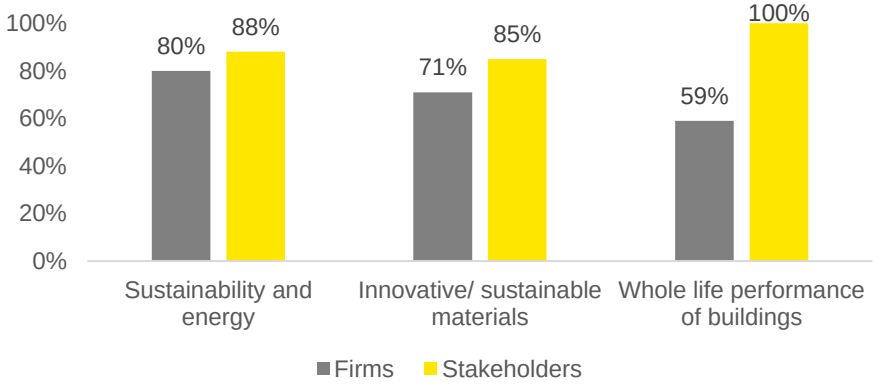
> "*In the economic recovery after Covid-19, it's important that government actions prioritise climate change".*[53]

It is clear that the built environment and construction industry is in a position of considerable responsibility and influence, in terms of delivering a more climate resilient economy. However, with this great responsibility comes great opportunity, and the survey results indicate that over the next ten years: [54]

- 80% of firms believe that sustainability and energy will be of 'great' or 'very great' importance.
- 71% of firms believe that innovative/sustainable materials will be of 'great' or 'very great' importance
- 59% of respondents believe that the whole life performance of buildings will be of 'great' or 'very great' importance

When asked similar questions, 88% of the key stakeholder groups reported that sustainability and energy will be of 'very great' or 'great importance' over the next 10 years.

Figure 21: How important will the following factors be to your firm/ clients over the next 10 years?



5 National trends in construction technologies

In order for industry to improve sustainability levels in construction, a Construction Technology Centre should prioritise the main challenges to be addressed for decarbonisation and sustainable MMC

The future of sustainability in construction industry

Research suggests that over the next number of years, the industry and Government will need to make some significant changes to ensure that sustainability is at the forefront of decisions. In order for the industry to move forward and improve its level of sustainability, any challenges which prevent the industry from adapting and moving forward will need to be addressed.

When firms were asked what the top challenges are in regard to climate change resilience that a Construction Technology Centre should research to drive innovation for sustainability and climate action in the construction sector, they responded as follows:[54]

- 78% of firms called for research on innovative materials to reduce impact of climate change.
- 60% of firms reported that research should be undertaken on a national database on buildings in need of climate change adaptation – flood protection, façade upgrade for warmer climate.
- 58% of firms called for research into digital mapping and visualisation of climate change impact, including urban heat island pockets, storm water flood risk and stress on infrastructure, should be undertaken.
- 58% of firms believe that research into integrated climate change mitigation with urban design and planning should be undertaken.
- 42% of firms reported that research into digital mapping and visualisation of green infrastructure in cities and towns should be undertaken.

When firms were asked about the top challenges facing sustainability in the construction sector, which they believe a Construction Technology Centre should research, the following top 5 challenges were prioritised:

1. Decarbonising construction processes – 67%
2. Mainstreaming sustainable modern methods of construction – 67%
3. Delivery of affordable and efficient retrofit of buildings – 60%
4. Mainstreaming sustainable and locally manufactured materials – 44%
5. Delivery of affordable and sustainable multi family dwellings – 44%

Figure 22: The top areas of circular built environment research that should be undertaken by a Centre

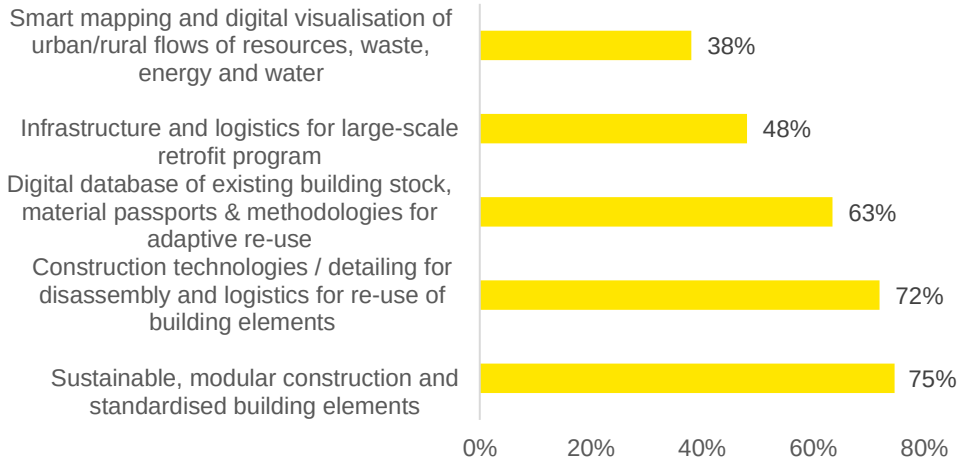
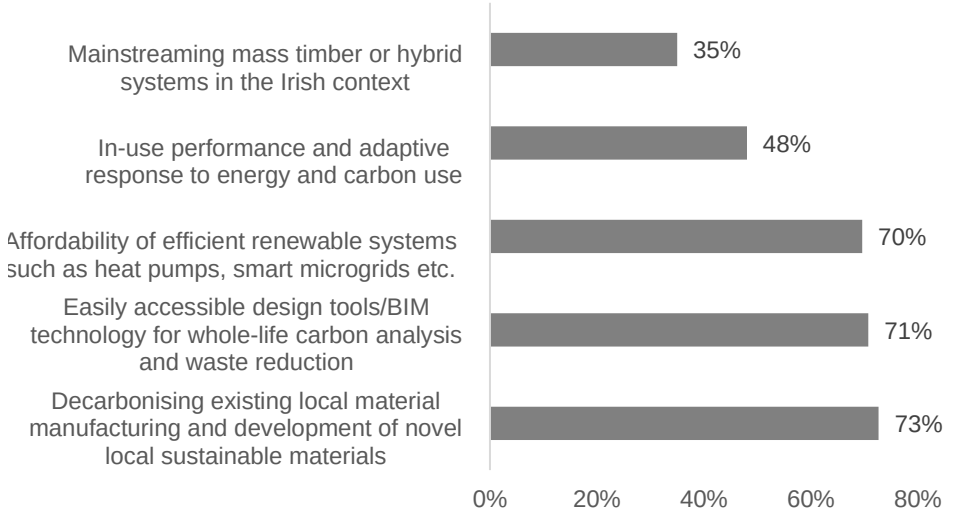


Figure 23: The top areas of decarbonisation research that should be undertaken by a Centre



5 National trends in construction technologies

Current take-up of construction specific technologies remains low; however evidence suggests there is an appetite to innovate

The adoption of technologies within the construction sector has the potential to significantly increase the productivity of the industry as well as improving the sustainability of the industry.

Research would suggest that Ireland's adoption of construction technologies is low. However, the results from the EY survey of firms and industry stakeholders point to an appetite within the industry to move toward a more productive, digitised, innovative and sustainable industry that works for all, and also addresses historic challenges to prevent them from reoccurring in the future.

Whilst there are intervention packages in the form of Enterprise Ireland Innovation vouchers to support innovation research in the industry, the EY survey of firms shows that there is a major lack of awareness and take-up of such supports within the industry. The current package of interventions is also more confined to enterprises engaged in export activities, who tend to be the larger firms. Whilst export activity is fundamental to the growth of the economy, it is those domestically focused firms that will predominantly be required to tackle national challenges such as the housing supply crisis, retrofitting on the building stock and the sustainability of infrastructure and buildings.

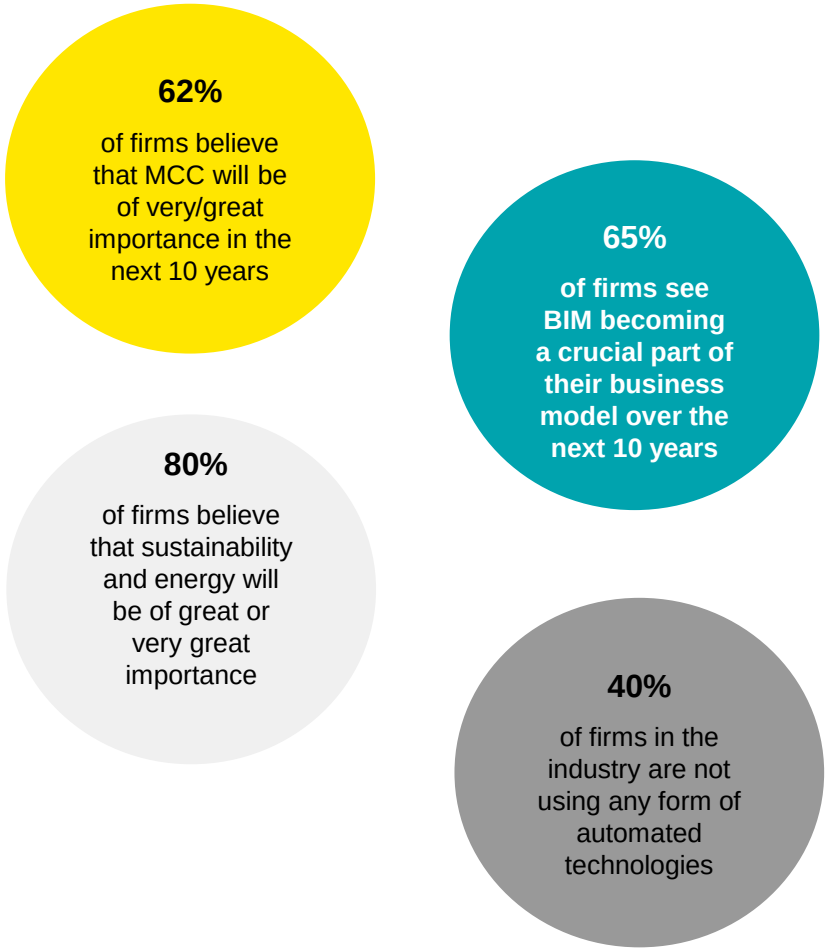
Evidence from the survey suggested that the majority of firms, 60%, within the industry are willing to collaborate with other organisations for research, development and innovation. Further to this 73% of firms stated that they had at least some capacity to allocate funding to undertake collaborative research, development and innovation.

The EY surveys suggests that there is a gap in the market for interventions/incentives to address the take-up and use of construction technologies within the industry. There is a willingness amongst firms to collaborate and an understanding of the important role that technology will play in the next 10 years within the industry and built environment sector.

The establishment of a standalone Construction Technology Centre could assist the Irish industry in becoming more productive and sustainable whilst assisting the industry in tackling legacy issues that have held back the industry from making its full contribution to economic growth and competitiveness.

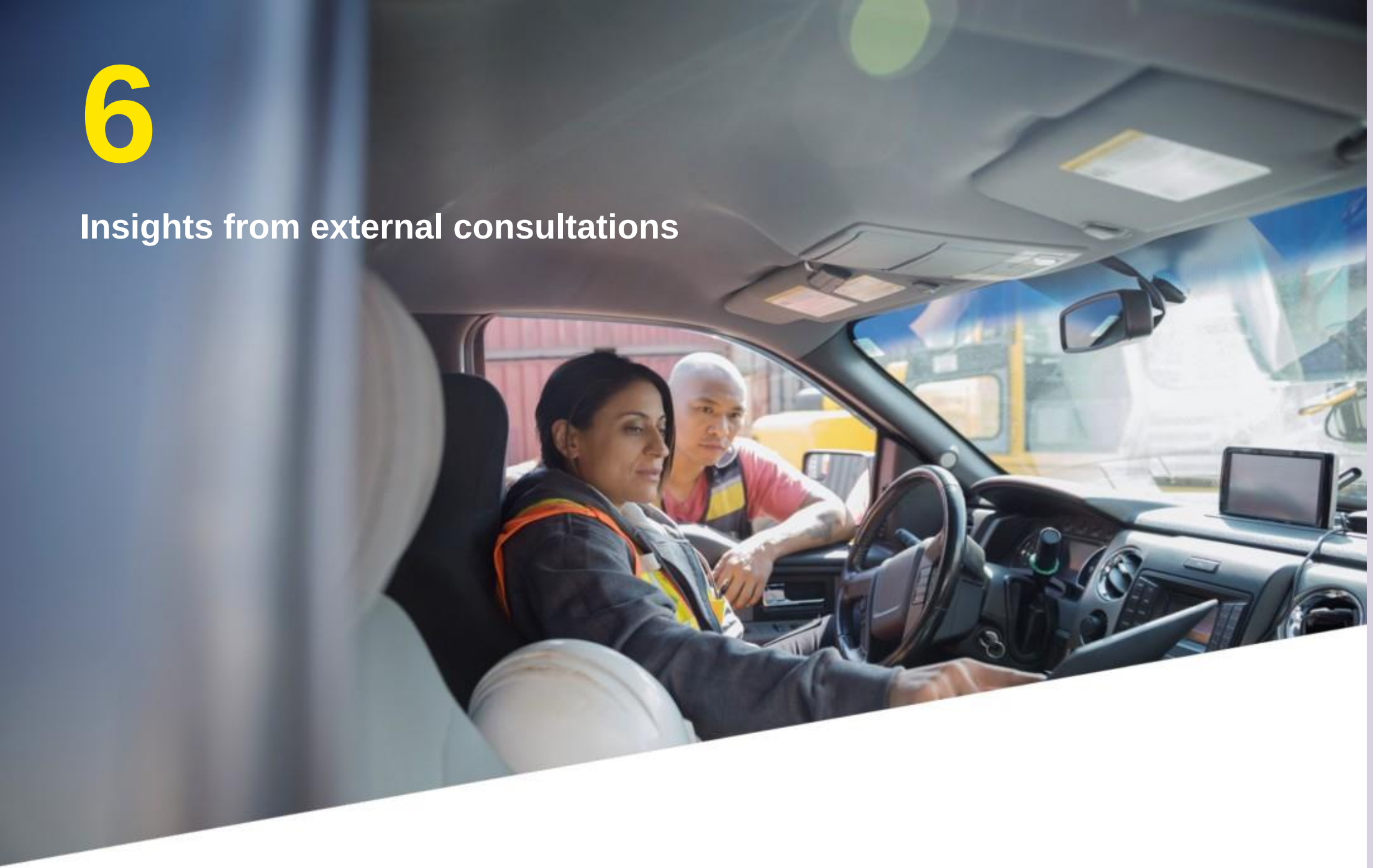
This section reported on the results of the EY surveys of firms and stakeholders to understand the current state of play with respect to the four pillars which are the subject of this study, including sustainability. In the next section, insights gathered from the focus groups are provided.

Selected findings from EY survey of firms



6

Insights from external consultations



6 Insights from external consultations

Key observations - summary of key themes (1/2)

1 Government can be a driving force

- Government is a key client of the sector.
- Financial and regulatory incentives by government are required to instigate change.
- No government mandate for BIM adoption exists in Ireland.

2 Public procurement

- Public procurement rules reward the bidder with the lowest price that takes on the most risk.
- This approach fosters a race-to-the-bottom culture.
- Contracting authorities could do more to embrace flexibility.
- Public procurement procedures must incorporate building life cycle metrics.

3 Online information resource

- Too much information is scattered across too many locations online.
- Collate this information within a “one-stop shop” online information resource.
- The Construction Technology Centre could play a role in the delivery and upkeep of this resource.

4 Assurance framework

- All public agencies with responsibility for compliance and standards were disbanded some years ago.
- Legacy issues of mica and pyrite now beset the industry.
- An assurance framework is required to rebuild trust in the sector.

5 Off-site manufacturing

- Clients are seeing the benefits of OSM delivery.
- Some challenges remain.
- There are significant up-front cost.
- A strong pipeline of sustained demand for modularisation is required.
- For viability, repeatability at scale is required

6 Climate action

- 67% of all Irish emissions are derived from the construction industry.
- Procurement processes do not give sufficient weight to embodied energy or the circularity of materials.
- Could suppliers employ Environmental Product Declarations (EPDs) to convey their product’s environmental performance?

6 Insights from external consultations

Key observations - summary of key themes (2/2)

7 Social value

- Many potential developments do not succeed because of inadequate engagement with existing communities.
- Construction with communities rather than for communities.
- EU universal design standards will have to be implemented by 2025.

8 Education and training

- Not enough information sharing currently.
- Many firms don't know where to go to find education resources relevant to them.
- A Construction Technology Centre could act as a go-to hub where best-practice ideas are shared.

9 Clients drive innovation

- Given most firms do not have the internal resources to innovate themselves, client requests are the primary innovation driver.
- However, clients often do not understand the capabilities of the different technologies available to them.

10 Understanding clients' needs

- Some participants questioned how hard firms try to understand their clients' needs.
- Firms need to listen more to their clients' needs, as opposed to applying what worked best on another job.

11 Time to innovate

- The industry is very fragmented with over 96% of firms employing less than 10 people.
- Firms often neither have the personnel, time nor the financial resources to take the risk required to innovate.

12 Challenges

- A Technology Centre must be industry-led and collaborative in nature. Would it be successful in a competitive market, such as construction?
- Does the fragmented nature and short-term focus of the construction sector make it ill-suited to a Technology Centre?

6 Insights from external consultations
Consultation process overview

What did the external consultations consist of?

The external consultations consisted of focus group sessions with three different groups - firms, stakeholders and government departments. Each group will play a vital role in any industry led and collaborative solution to address the research, development and innovation needs of the Irish construction and built environment sector. Due to Covid 19 restrictions, all focus group sessions took place virtually.

Who was consulted?

The three groups consulted were as follows:

1	2	3
Government Departments and State Agencies	**Stakeholder Groups representing those operating in the construction and built environment sector**	**Firms operating in the construction and built environment sector**
Date: 28 July 2021 Participant List: See Appendix 3	Date: 23 August 2021 Participant List: See Appendix 3	Date: 24 August 2021 Participant List: See Appendix 3

Why were the consultations completed?

A Construction Technology Centre will be industry-led and collaborative in nature. The purpose of the focus groups was to gather a spectrum of informed opinion from those that regularly engage with and/or operate within the industry and would be expected to engage with the Centre.

Furthermore, these insights would seek to clarify and authenticate the findings of the Detailed Description of Needs surveys and ensure that all those who wished to engage with the project could be brought on the journey from the outset. Technology Centres are delivered with industry, hence the consultations aimed to establish channels of communication that can be built upon between all relevant parties.

How were the focus groups structured?

1. The Chairman of the Construction Sector Innovation and Digital Adoption Group provided a briefing on the context and rationale for the Detailed Description of Needs study in terms of delivering Action 4 (of the 7 Priority Actions).

2. EY provided some insights as to the key challenges facing the construction and built environment sector on a national and global scale, before presenting some high-level analysis of the survey responses. This presentation culminated in a series of possible themes to be discussed by the relevant focus group participants.

3. A facilitated discussion followed, whereby participants provided their insights as to what the construction and built environment sector needs to drive innovation and digital adoption, as well as considering what role, if any, a Construction Technology Centre might play in facilitating this transformation.

6 Insights from external consultations

Key themes identified in the external consultations (1/6)

Some common subject areas which emerged across the three focus group sessions are examined in greater detail below.

Government and State Agencies have a significant role to play in driving innovation and digital adoption…

A knock on impact of clients being the primary innovation driver in the industry is the role that Government Departments and State Agencies play, with the firms' survey revealing that 29.1% of firms' turnover is generated by public sector clients.

It was remarked that no government mandate for BIM adoption exists in Ireland. Others mentioned that because spending time and money to develop innovative solutions is so inherently risky, financial and regulatory incentives for clients by government are required to instigate change. The successful implementation of health and safety regulatory reform in the 1980s and 1990s was provided as an example of government leveraging its authority to drive transformational advancements in the sector. These sentiments are bolstered by the EY survey, where firms ranked the need to comply with regulations as their primary innovation driver.

> *"The industry is slow. We're not the fastest if we're not forced into it. If we're forced into it, we will act. Look at modular housing, data centres, off-site manufacturing…a lot of it can be driven by government and government can then force everybody's hand in that respect."*
>
> **In reference to the role of Government Departments and State Agencies**

…while public procurement processes need to be reformed

Participants raised the following issues with regard to public procurement:

1. Public procurement rules often result in selection criteria rewarding the bidder with the lowest price that takes on board the most risk. Moreover, innovation and digital adoption are not sufficiently rewarded, enabling a race-to-the-bottom culture to develop within the industry. However, the Office of Government Procurement's (OGP) decision to give greater weighting to innovative practices in a recent tender process was welcomed.

2. Currently, the requirement for planning permission to be sought before a contractor is selected makes it challenging to reward innovation amongst contractors.

3. A key challenge going forward will be to align public procurement procedures with building life cycle metrics and assessment tools.

> *You know that with anything you do, any time that you invest into it [an innovation] is at risk because there's no guarantee of any benefits coming out of it because you've priced the job and you've complied with a procurement package and the specifications associated with it.*
>
> *By basing it [the procurement process] purely on price, you're not going to get anything new happening."*
>
> **In reference to adhering to a procurement outline and the agreed cost**

6 Insights from external consultations

Key themes identified in the external consultations (2/6)

A "one-stop shop" online information resource needs to be created and maintained

There is a quantum of knowledge and data that may be useful to the Irish construction and built environment sector. Notwithstanding their lack of time and personnel, firms often do not know where to look for this information. For example, it was noted that there are over 1,000 monitoring and evaluation standards and at least 40 different regulatory bodies, with no one central hub to collate the information. Furthermore, the firms' survey revealed a low level of awareness about innovation supports, for example, over half of all respondents were not aware of the Innovation Vouchers available from Enterprise Ireland.

An online database or "one stop shop" of all relevant information and regulations would be extremely beneficial to those working in the sector. It was suggested that the responsibility for the delivery and upkeep of this online resource could fall under the umbrella of a Construction Technology Centre.

The 'one stop shop' could also provide a glossary of terms to inform the industry about, for example, the different dimensions of BIM and the range of specific construction technologies which are being adopted in the global construction industry and are expected, according to the EY firm's survey, to become very important for firms over the next decade.

> *It's that knowledge sharing. Where's that library of relevant information? Where is that research place that you can go and press a button on a website, and it tells you exactly where you can find the information [you need]? Because everything is interpretation now and that takes up too much time in the industry".*
>
> **In reference to a knowledge sharing resource that could empower a more research-focused industry**

A renewed focus on standards and compliance is required by the sector

It was noted that all public agencies with responsibility for compliance and standards were disbanded 20 years ago, leaving the industry to self-regulate. Legacy issues of mica and pyrite now beset the industry, alongside a race-to-the-bottom culture on price and standards.

Therefore, it was suggested that the industry needs to develop an assurance framework that would give confidence to all products and materials that contribute to the built environment, underpinned by the testing and certification of components and systems (in both a physical and digital environment). This renewed focus on standards and compliance would demonstrate the quality of the end-product to the customer, while having the potential to open up additional funding opportunities for the industry. A Construction Technology Centre could play a role by monitoring international best-practice assurance initiatives and feeding its findings back to industry to ensure that the framework is continually updated.

> *More critically, that [assurance framework] will also feed into financial institutions, because if you can develop that framework and work with financial institutions, it should be possible to open up opportunities to access finance guarantees and insurance-based products that will support the wider rollout [of innovation].*
>
> **In reference to the link between an assurance framework and funding opportunities for the industry**

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6 Insights from external consultations

Key themes identified in the external consultations (3/6)

Despite its benefits, more can be done to **drive Off-Site Manufacturing** adoption

Firms that have invested heavily in Off-Site Manufacturing (OSM) in recent years noted that clients like its accelerated delivery timelines and associated cost benefits. For data centre and manufacturing plant clients, the controlled OSM environment facilitates a higher quality end-product that minimises the risk of down-time for clients on their sites, which can be very costly.

However, the adoption of OSM is not without its challenges. There is a significant up-front cost to building a manufacturing facility, which requires a strong pipeline of sustained demand for modularisation from clients. OSM production requires scale of repeatability to be financially viable (e.g., a reduced number of house types in residential developments), whilst balancing the need for architectural variety. In addition, OSM factories will have to be adaptable to the changing nature of demand. This demand is for housing currently but will change over time. Lastly, the building performance specifications required by clients are often better aligned with traditional methods of delivery. Clients currently do not understand that modular building specifications are just different but not inferior to those delivered using traditional methods.

> *"MMC shouldn't dictate what the architecture landscape looks like,… We need to maintain the variability in design that we have, but there does need to be some scale to it. So you can design as many house types for as many scenarios as you want…but there needs to be an element of repeatability to make it economically viable."*
>
> **In reference to the need for repeatability to make OSM financially viable**

More work required to enable a faster move to a decarbonised built environment

The State will need the Irish built environment and construction sector on-board to achieve its climate action targets. With this mind, some of the points raised were as follows:

1. Given Ireland's emissions targets, the challenge over the coming years is to figure out how to build as little as possible whilst serving the need for new housing and delivering on Government's retrofit programme.

2. It was reported that procurement processes do not give sufficient weight to embodied energy or the circularity of materials. The sector lacks a specific emissions target, although some of the larger firms have published their own.

3. In some countries, such as Norway and Denmark, suppliers provide Environmental Product Declarations (EPDs) which transparently communicate the environmental performance or impact of any product or material over its lifetime. This makes it possible for contractors to compare the impacts of different materials and products in order to select the most sustainable option. The adoption of a similar approach could prove beneficial in Ireland?

4. The Construction Technology Centre could have a role in encouraging the re-use and recycle of aggregate materials that would help with reducing emissions levels.

> *"[In the next 10 years] we will need to be halving our carbon emissions while doubling our housing output. So we're going to have to find a way to square that circle through total optimisation of delivery of homes and buildings that goes well beyond just materials, but we have to do the materials too."*
>
> **In reference to the climate action challenges facing the sector**

6 Insights from external consultations

Key themes identified in the external consultations (4/6)

The social value of our built environments should not be forgotten

It was acknowledged that the social impact of the Irish built environment and construction sector was equally as important as its environmental and economic impacts. For example, many potential developments do not succeed because of inadequate engagement with existing communities. It was acknowledged that the sector needs to become more skilled in bringing communities with them when projects are being developed.

In addition, safe, sustainable and pleasant places to live, work and meet others help to create vibrant communities – and the Government's retrofit initiative will play a key role here. The survey analysis undertaken as part of Action 2 was discussed, where 'Smart Mobility and Multi-functional/Adaptable Streets' emerged as the most important area for research under the heading of 'Social Value and Community Wellbeing'. Lastly, significant work is going on at EU level with regard to universal design standards which, by 2025, will have to be implemented in Ireland. It was suggested that a Construction Technology Centre could have a role in championing these new standards.

> *"One area in which I think the Research Centre could do a lot of work is in the area of how to engage with communities, how to bring them with you…we should be looking at construction with communities rather than construction for communities."*
>
> **In reference to the social value that a Construction Technology Centre could provide**

Education and training central to any transformational change

Many representatives commented on how 'Relevant Training/Continuous Professional Development' emerged from both surveys as the most important element to be provided by the Construction Technology Centre. For instance, BIM requires highly-skilled workers at all stages of delivery. While some SMEs are aware of recent advancements in digitalisation, they find it hard to figure out what developments are relevant to them. It was suggested that a Technology Centre could fill this gap, with sector-specific information and advice.

It was also proposed that the Centre could become a hub where firms could go to engage with expert advisors and harness the knowledge-sharing capacity of those Irish built environment and construction firms that are world leaders in their chosen fields (e.g., data centres, pharmaceutical plants). Open data sharing would be crucial to facilitate this collaboration. Others urged for the pain points of SMEs to be identified, with training sessions then provided to develop practical, sector-specific solutions. Two key challenges for the Centre were highlighted, namely the need to tailor the training to each cohort of technological maturity and the need to ensure that the training future-proofs the industry in the medium to long term.

> *"I think education is going to be a huge thing here at every level whether it's for clients or for design teams, constructors or operators."*
>
> **In reference to the potential role of education in driving transformational change**

6 Insights from external consultations

Key themes identified in the external consultations (5/6)

Ultimately, clients are driving innovation in the sector…

Many firms agreed that the client is the primary innovation driver within the industry, leading to a situation where if the client doesn't ask for an innovative solution, the solution will not be developed. For example, it was noted that the Irish construction sector is extremely well-regarded internationally in the delivery of data centres and pharmaceutical facilities because their clients prioritise quality and on-time project delivery, as opposed to the lowest cost.

However, multiple speakers noted that clients in Ireland are not fully aware of the value-add that different technologies provide. From a BIM perspective, it was reported that clients often lack sufficient understanding to provide a very clear and specific scope, and thus the potential benefits of the software are reduced. Furthermore, it was mentioned that clients only see the up-front costs to delivering a building with very little consideration given to the life-cycle of a building and how it would perform in ten or twenty years' time. Could there be a role for the Construction Technology Centre in educating the clients, the ultimate end-users?

> *"People working in an SME are working flat out on what they have to do so they don't have the time to be going [researching] unless something is handed to them on a plate or demanded from the client…SMEs are not going to look into something unless they have to or unless they've been told by somebody else."*
>
> **In reference to the key role clients play in instigating change**

> *"Training needs to go to our potential clients to tell them what we can do….. Sometimes they do not understand what's possible."*
>
> **In reference to the need to educate end-users**

…although some firms think the industry itself could do more

Some firm representatives believe that Irish construction and built environment firms could do more to guide the discussion with their clients to understand their value drivers and go-to-market needs. Firms involved in the delivery of a building do not tend to be responsible for its performance and maintenance in the long-term. Therefore, it was noted many of the top 50 construction and built environment firms empower one individual to research the next innovation drivers in the short, medium and long term. This market-specific information is then fed back to management to enable them to have a more strategic knowledge of what their clients need.

> *"I just find that we're not fully aligned with our clients' drivers in many of the sectors…we don't really put ourselves in their shoes. We kind of nod and say, "oh well, that's what we did in the last job, so this is what they want in this job". We're not aligned to their drivers there."*
>
> **In reference to anticipating the future needs of clients**

6 Insights from external consultations

Key themes identified in the external consultations (6/6)

Most firms operating in the construction and built environment sectors do not have enough time to drive innovation

The construction and built environment industry is very fragmented, with over 96% of firms employing less than 10 people (Appendix 6a). Most SME representatives stated that they did not have enough personnel time or finances available to take on the risk associated with trialling innovative technologies. These sentiments echo those from our survey, where 'other priorities' (e.g. day-to-day running of the business) and 'lack of time' emerged as the top two challenges which exist for SMEs when it comes to implementing new technologies.

> *"Everybody is busy and it takes time to commit and people to commit to researching and testing solutions. And even at that you're not guaranteed what you're looking into is going to add value to your service or is going to provide what you need."*
>
> **In reference to finding time to develop innovative solutions**

Some challenges facing a potential Technology Centre were also outlined

While there was widespread agreement that an increase in productivity across the sector is essential, not all stakeholders believe that a Construction Technology Centre is the most effective means to achieve it. It was argued that Technology Centres work well in research-driven areas such as life sciences where products in five years' time do not exist today. By contrast, it was remarked that the construction sector is much more fragmented, with a greater short-term focus and an emphasis on completing one job and moving on to another. This led to question marks being raised over the amount of usage a Construction Technology Centre might get.

Collaboration between competing firms was also raised as a concern. Firms compete to win projects and some participants questioned what role a collaborative centre would have in such a competitive market. However, other speakers differed, believing that no one firm has copyright over non-competitive information, (e.g., CE marking). A culture of knowledge-sharing, facilitated by the Centre, could transform the industry and help smaller players, in particular, become more efficient – without infringing upon a larger firm's intellectual property rights. Indeed this view also emerged in EY's firms' survey, with 'Research hub for collaboration at the pre-competitive stage' ranking as the fifth-most important element that a Construction Technology Centre could provide.

> *"I've seen similar initiatives in the UK… they haven't done what it says on the tin in terms of Technology Centres. They have tended not to get the usage."*
>
> **In reference to the uptake that a Construction Technology Centre may get from industry**

> *"There are ways of doing MMC, there are ways of [adopting] technical and engineering standards, CE marking... We don't have a copyright on this stuff and therefore these should be freely available as a resource in my view, so then everybody can go off in their own spare time and research it and come up with the solutions."*
>
> **In reference to the role that a Construction Technology Centre could have in sharing non-competitive information**

7

Benchmarking of international construction research initiatives

7 Benchmarking of international construction research initiatives

Key observations

The research is informed by an international benchmarking analysis of seven institutions providing and encouraging the adoption of construction technology across the construction sector at an international level.

There are a number of key findings from the benchmarking exercise which are relevant and potentially applicable for the approach to be adopted in Ireland. Three important lessons that emerge for the establishment of a Construction Technology Centre in Ireland are:

- **Communication** and the need for clear guidance from the research institute on the available research/support for businesses. There is a need to promote what the centre can actually do to support businesses but there also needs to be a willingness from businesses to actually innovate.
- **Collaboration** between government, industry and academia, to ensure there is buy in across the board for the Centre to work and a positive impact on innovation within the sector.
- **Commercialisation** of some of the institutions' services and initiatives could be a way to maximise the services provided whilst also generating income to sustain some of the services.

The main sources of funding across all of the institutions examined tend to be a mix of national governments and/or EU and private sources. Initiatives examined across the UK have typically been allocated between €10 million (€11.79m) (Construction Scotland Innovation Centre) and €15 million (€17.67m) (Dudley Advance II) of public funding to being with over a multi-year period. Other funding is often provided by academic institutions or other project partners. The remainder of funding tends to be sourced via membership and/or commercialisation of the research.

Given the current fragmentation of the construction sector in Ireland, a large majority of target firms are currently outside the public research funding ecosystem normally available to IDA Ireland and Enterprise Ireland clients; with the exception of Innovation Vouchers from Enterprise Ireland (52% of firms are not aware of these according to the firms' survey), such initiatives have been largely confined to enterprises with an export dimension.

Other findings include that there is a requirement for appropriate benchmarks and key performance indicators, buy in from the construction industry and government and a willingness to collaborate. Resources must be tailored specifically to construction enterprises based on a clear definition of their needs.

When deciding the mix of funding for a Centre in Ireland, consideration should be given to the fact that in the region of ten government departments, who are the project promoters for the building and infrastructure projects in the National Development Plan 2030 (NDP), and Project Ireland 2040, the Housing for All Plan and the Climate Action Plan 2021, rely on the construction industry to deliver their capital projects, based on the Strategic Investment Priorities in the NDP.

7 Benchmarking of international construction research initiatives

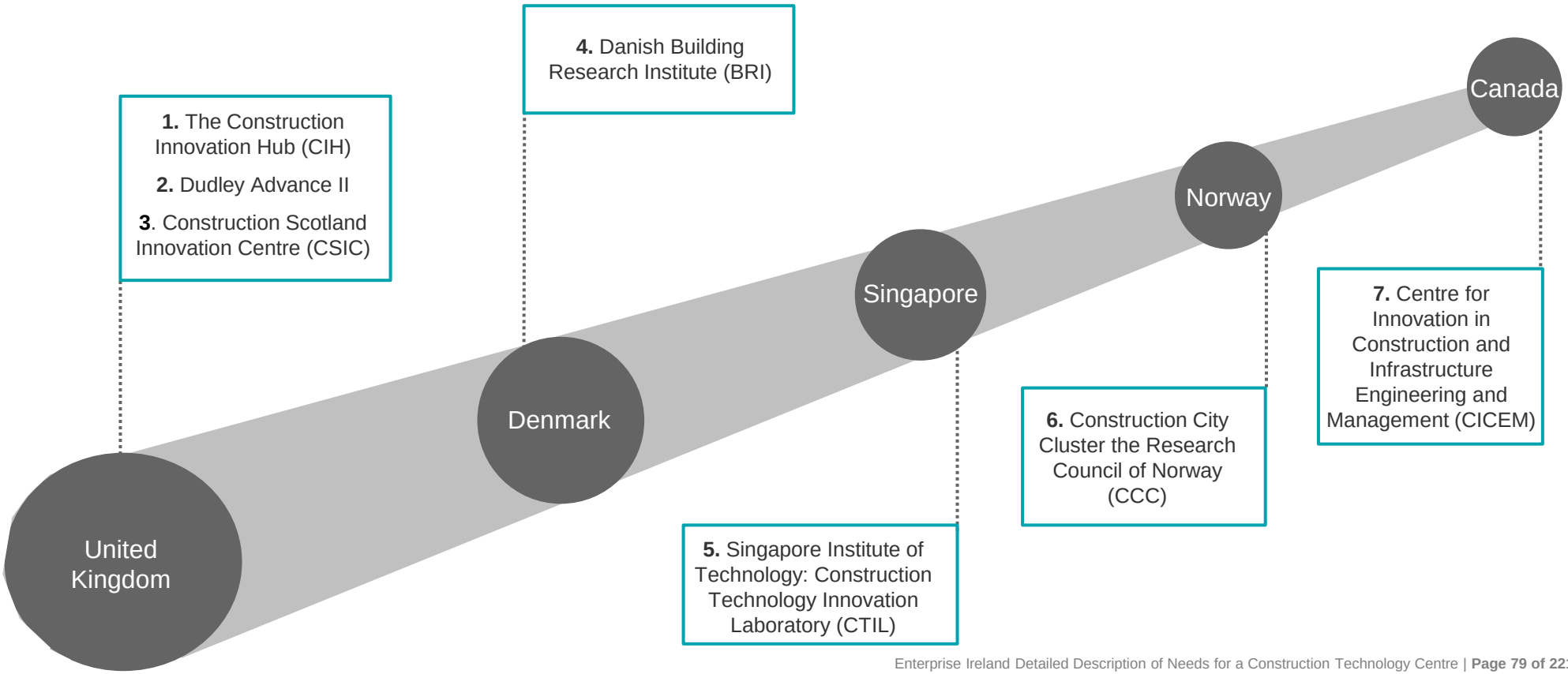
From an initial list of 20, we have reviewed seven construction research initiatives in five international jurisdictions to gather key learnings for the approach to be adopted in Ireland

Aim of the benchmarking exercise

The research is informed by an international benchmarking analysis of a number of international construction research initiatives and organisations that enable the development and adoption of construction technology. The exercise aims to identify potential approaches to construction/built environment research, development and innovation that would be applicable to the construction sector in Ireland.

Following engagement with the Steering Group, seven institutions were selected for the benchmarking exercise with the view being taken that these institutions are wide ranging and provide comprehensive intelligence on the RD&I capability initiatives at an international level.

The seven initiatives in the five jurisdictions selected for examination are set out below:



7 Benchmarking of international construction research initiatives

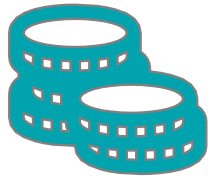
Each of the institutions are assessed against criteria established in collaboration with the Steering Group

Discussion of each category

The seven institutions are assessed under six headings listed below:

Structure

How the institution was established, the level of employment within the centre, the primary users of the centre and the maturity level of the institution.



Funding

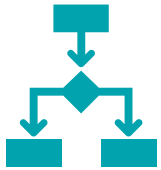
The main sources of funding, including national and/or EU, public and private sources.

Main activities

The mission of the centre, the key objectives, specific areas of research and interest.

Technology

What construction specific technologies are covered within the institution and to what extent does it have a sustainability agenda.



Governance

How the governance is organised, degree of commercialisation of the centre and Intellectual Property management.

Collaboration

The level of collaboration and engagement with businesses, academia and government.

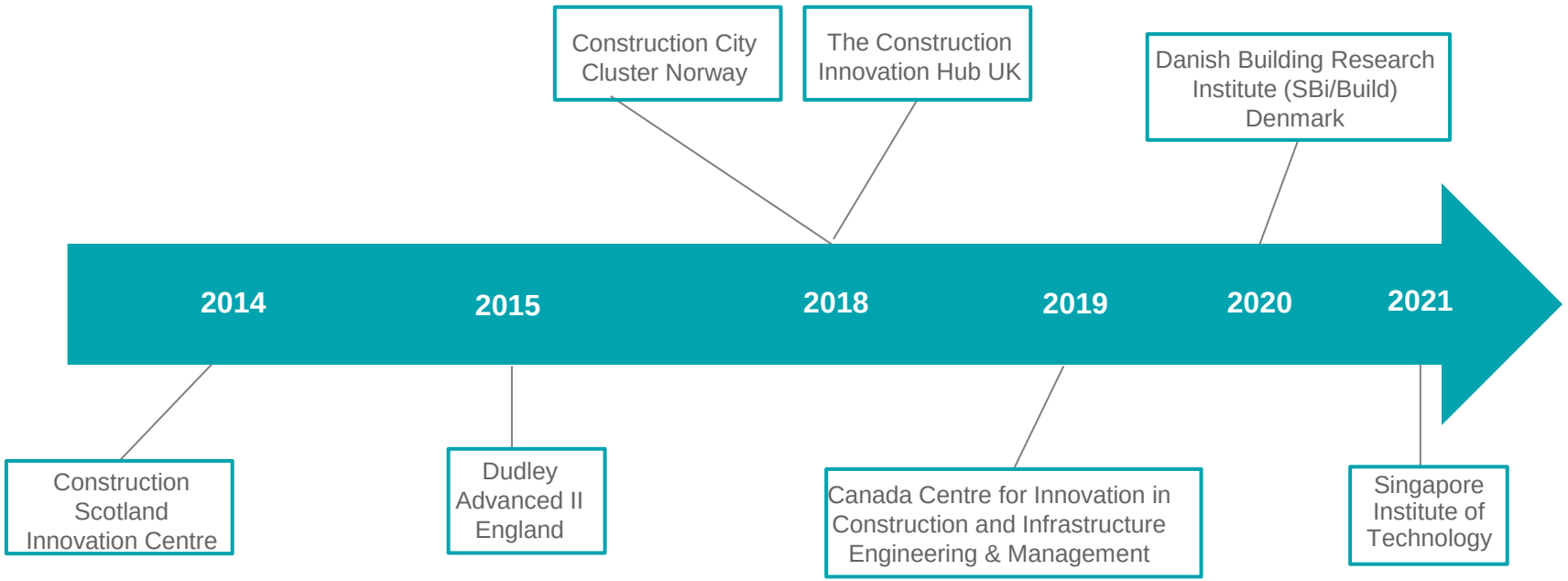
7 Benchmarking of international construction research initiatives

Structure: A number of institutions originate from universities but collaboration across industry, academia and government is a high priority

Structure

The benchmarking found that most of the institutions are relatively young with the Construction Technology Innovation Laboratory in Singapore being the most recent, as established in January 2021.[1] The relative youth of the institutions highlights that the advancement of construction technologies within the industry, at an international level, is still in its infancy and not yet the industry norm. However, the recent development of such centres demonstrates that collaboration is a high priority internationally and that the importance of technology advancement is reflected in the level of research funding invested by research institutions, businesses and government.

A common theme across the institutions is their relationship with academia, with a number of the institutes originating from universities. All of the institutions appear to have been formed with the intention of either industry and/or academia being the primary users. The Centre for Innovation in Construction and Infrastructure Engineering and Management (CICEM) in Canada stated, that the primary users of their services and labs are its members including its academic staff and their graduate students. The end users of the research output of CICEM are the industrial and governmental partners who collaborate with the CICEM on specific research projects.[2]



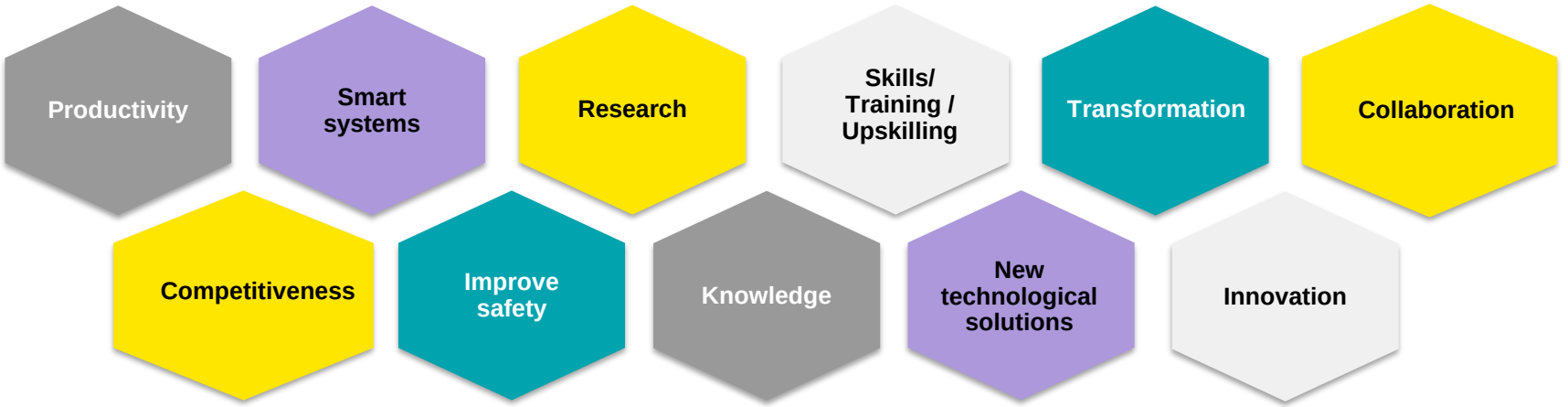
7 Benchmarking of international construction research initiatives

Structure: Institutions connect construction companies and the public sector with academics developing innovative solutions for the industry

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Structure	The CIH brings together BRE (an international, multi-disciplinary building science organisation), the Manufacturing Technology Centre (MTC) (a High Value Manufacturing Catapult centre) and the Centre for Digital Built Britain (CDBB)	Dudley Advance II is a centre of excellence created in partnership between Dudley College and leading construction companies.	The CSIC is a hub to connect businesses in construction and academics.	SBi is the Danish national building research institute. SBi merged with Aalborg University in 2007, forming Denmark's largest centre for the built environment, Build.aau.	The CCC is an innovation cluster in the Oslo region, consisting of 93 members from industry, start-ups, research and education.	The CICIEM is part of Concordia University in Montreal. CICIEM provides solutions that improve safety, productivity and competitiveness in the construction industry.	CTIL is a collaboration between the Singapore Institute of Technology and Who Hup Pte Ltd, one of Singapore's largest privately-owned construction and civil engineering companies
Academic Links	The CIH is a partnership between industry and government and the University of Cambridge	Dudley College of Technology	Edinburgh Napier University	Aalborg University, Copenhagen	None	School of Engineering and Computer Science at Concordia University, Montreal	Singapore Institute of Technology (SIT)
Employment	23	Unknown	44	250	Unknown	11	Unknown
Primary Users	Academia and Industry	Industry and students	Industry, Government and students	Academia and Industry	Unknown	Academia and students. End users: Industry and Government	Industry, researchers
Maturity	November 2018		March 2014	January 2020	Unknown	June 2019	January 2021

7 Benchmarking of international construction research initiatives

Main activities: A number of key themes frequently appeared throughout the mission statements and objectives of the seven institutions



Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Mission Statement	To deliver a world where the built environment improves quality of life, delivers greater social value, reduces environmental impact and is delivered by a world-leading, innovative and sustainable industry	Dudley Advance II was designed and built wholly around the future training needs of the industry, to provide unique facilities, latest technologies and the first-class trainers required to provide the next generation of skills and know-how	The Centres mission is to Champion innovation and linking together businesses, university experts, the public sector and the economic development networks, our industry-led team to support a culture of innovation that drives transformational change across the construction industry.	To be a driving force for collaboration in the building, construction and real estate industry, and develop research-based knowledge that improves buildings and the built environment and to subsequently disseminate this knowledge to the industry	To drive collaboration and new solutions in the construction industry and increase members' individual and collective competitiveness and to be a showcase for the benefits of industry co-location, and to share insights, and build the industry's international muscle	Embrace the principles of industry 4.0 leveraging smart systems such as remote sensing technologies and digital imaging among other things to improve safety, productivity and competitiveness in the construction industry	To leverage a symbiotic industry-academia partnership, and provide Singapore-based construction companies and SIT researchers with a platform to boost applied research efforts and develop innovative construction technologies for building structures and sub-structures

7 Benchmarking of international construction research initiatives

Main Activities: Common themes mentioned in objectives are driving technology and innovation, collaboration, training and disseminating research-based knowledge

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Objectives	► Ensure the voice of the industry is heard ► Encourage collaboration ► Ensure outputs drive transformation of the construction sector, and ► Provide challenge to objectives	► Bring first class construction training facilities to the region ► Offer employers the best opportunities to recruit, and ► Provide apprenticeships at advanced higher levels in a range of new apprenticeship standards (e.g. digital engineering, on-site assembly, sustainability)	► Uncover and develop with industry the value that lies in innovating ► Drive future demand for innovation support ► Empower industry to take ownership of the innovation process ► Align academic expertise and public sector agency support ► Bridge existing gaps by matching industry need to appropriate innovation support packages; and ► Deliver support from inception to commercialisation	► Promote development and innovation in construction work and the housing sector ► Create and disseminate research-based knowledge that improves construction work and the built environment	► Become the industry's most relevant forum for collaboration and new solutions ► Work to establish meeting places for the members ► Initiate collaborative projects within the Cluster that contribute to research, innovation, competence and business development	► Provide solutions that improve safety, productivity and competitiveness in the construction industry ► Promote large-scale interdisciplinary research, training of highly qualified personnel, technology transfer and interaction with industry.	► Promote technology innovation and collaboration among construction related companies/ partners ► Develop innovative and disruptive construction technologies ► Translate and adopt disruptive technologies from laboratories to construction sites ► Upskill construction professionals in specialist knowledge and skills

7 Benchmarking of international construction research initiatives

Main activities: there are some common areas of interest; with a strong focus on upskilling and training in the adoption of digital technologies

Main focus of activities

Across the seven institutions there is a degree of variance in the specific objectives of each institution. However, all seven institutions do have a clearly defined set of objectives that have been created to drive their focus on developing innovative and transformative solutions for the construction sector. The use of clear and defined objectives allows the institutions to ensure that the support and initiatives they design are aligned and focused on the needs of the industry.

While each institution has its own specialised areas of interest, there are common areas of interest, such as, in upskilling the industry and training apprentices in the new skills that will be important to fulfil the future needs of the industry.

CICIEM in Canada notably stated that it has an interest and focus on training highly qualified personnel along with the use of automation and robotics in construction and the use of big data analytics and data science.[10]

Construction City in Norway has invested in creating state of the art facilities to provide access to solutions, tools and services, such as the use of Virtual Reality and IoT sensors, to transform the sector. Its facility also has capacity to assist industry in testing new business models.[11]

Whist a number of the institutions have a clear focus on assisting industry and providing technological advancements that can improve productivity and safety, a number of other institutions are more academically focused. Those institutions that were more focused on supporting industry tend to undertake essential research on technological advancements and upskilling the existing and future workforce.

For example, Dudley Advanced II in England has developed a curriculum to train students in the following digital technologies:[12]

- Building information modelling (BIM)
- Home automation and building management systems
- Modern methods of Construction, for example, pre-fabricated modular construction techniques, fabrication and welding for off-site production
- Environmental technologies - sustainable construction methods and green technologies

The Construction Scotland Innovation Centre focuses on research that will boost the uptake of remote site inspections, equipment and machinery including a masonry casting press, cross laminated timber vacuum press, 3D printer, augmented and virtual reality headsets and an offsite manufacturing cell.[13]

The Construction Technology Innovation Lab in Singapore is focused on applied research to develop innovative construction technologies for building structures and sub-structures. The Centre, which was launched in January 2021, intends to focus initially on implementing innovative construction technologies for deep foundation and excavation, to achieve improvements in various construction areas such as water systems, piling systems and crack and corrosion-resistant concrete. The research projects will be carried out in consultation with construction companies and are intended to improve productivity, introduce safer construction technologies and increase durability and resilience of deep foundation construction elements.[14]

The next two pages provide an overview of the wide range of activities carried out by each institution.

7 Benchmarking of international construction research initiatives

Main activities: The institutes complete a wide range of activities including the provision of funding to develop and research solutions, training and educating students and the industry workforce, and providing laboratories for members

The UK CIH focuses on the development and promotion of technologies linked to their four key themes:

- **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.
- **Digital** – the promotion and demonstration of the potential and benefits of digital transformation and innovative processes, tools and technologies, including BIM.[15]

The goal is to provide facilities, the latest technologies and trainers required to provide the next generation of skills and know-how. Advance Dudley II provides:

- Training for apprenticeships at advanced and higher levels in a range of new and traditional trades.
- A range of shorter programmes aimed at upskilling the existing workforce in developing techniques such as BIM.
- 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 'digital centre' in which BIM and digital environment software packages are demonstrated and taught.[16]

The CSIC in Scotland links together businesses, academic experts and the public sector to support a culture of innovation by providing the following:

- 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.

They provide a 35,000 sq. ft. innovation factory (equipment available to hire, conference and training spaces) which is designed to support construction related businesses to collaborate and innovate. This facility can be used via a day rate or annual membership.

The CSIC have supported over 350 innovation projects, including funding/co-funding projects.[17]

The Danish BRI:

- Develops research based knowledge that improves buildings and the built environment.
- Three main research topics are:
  - Cities, housing and infrastructure
  - Energy, indoor climate and sustainability
  - Construction, construction technology and processes
- Research takes place both nationally and internationally in close collaboration with construction companies, organisations and public institutions.
- Offers their clients research collaboration opportunities and helps with the development, testing and evaluation of new solutions for construction businesses.
- Shares knowledge and findings on, for example, building technology, energy efficient construction, sustainability and housing.[18]

7 Benchmarking of international construction research initiatives

Main activities: The institutes complete a wide range of activities including the provision of funding to develop and research solutions, training and educating students and the industry workforce, and providing laboratories for members

Construction City Cluster

The Norwegian CCC:

- Offers a facility for research, innovation, expertise and collaboration for development across the construction industry and built environment.
- Accommodates businesses/ organisations/ educational institutions/ public entities, from start-up entrepreneurs to established industries.
- 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 IoT sensors and a makerspace with a 3D printer.

Members are from the entire construction, civil engineering and real estate industry as well as educational institutions and public sector. A range of membership options are available.[19]

Université Concordia University

CICIEM's research areas are the following:

- Automation and robotics in construction
- Sensing technologies and IoT applications in construction, infrastructure engineering and management
- Big data analytics an data science applications in the context of smart cities
- Industrialisation of construction
- Reliability analysis, condition assessment and rating of infrastructure for optimised maintenance and intervention plans and value-driven budget allocation

CICEM has several related research laboratories that support research and training in the above areas.[20]

SIT Singapore Institute of Technology

CITL:

- Provides a platform for Singapore-based construction companies and SIT researchers to carry out applied research and develop innovative technologies for building structures and sub-structures with societal and economic impact.
- Uses the latest technology to develop new innovative solutions, including to improve site safety an productivity, cost efficiency and reduce manpower requirements.
- Provides specialised training and support talent development to deepen knowledge and skills.

CTIL, SIT and industry partners co-fund the research projects.

CTIL also applies for external funding from government agencies to further develop projects in partnership with industry.

Intellectual property is jointly owned by SIT, Who Hup and industry partners.[21]

7 Benchmarking of international construction research initiatives

Governance: The majority of institutions are governed by a Board which is responsible for the overall strategy, performance and activity

Governance

The typical governance structures tend to be as follows :

- The majority of institutions are governed by a Board which is responsible for the overall strategy, performance and activity of the institution.
- A number of institutions have also established or are planning to establish an Advisory Board to oversee activity and provide external challenge where necessary to ensure that the institutions fulfil their objectives.
- A number of the institutions have included industry leaders within their leadership/ advisory boards in order to provide representation and to ensure that the needs of the industry are taken into consideration and that any objectives and initiatives are appropriate.

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Governance	The Board is responsible for the Hub's overall strategy and performance. The Industry Advisory Board is the voice of the construction industry for the programme, and makes sure the outputs of the programme reach businesses and drive the transformation of the sector.	Unknown	Led by a Governance Board, Innovation champions and technical experts. Partners include Scottish Funding Council, Scottish Enterprise, Highlands and Islands Enterprise, all Scottish Universities and college. Have strategic partnerships including construction innovation hub.	BUILD is headed by Head of Department. There are a number of independent research sections, each with its own head of research and a secretariat to carry out the administrative tasks of the Foundation. An Advisory Committee has not yet been put in place.	The Cluster's executive professional body is the "Professional Board". It consists of representatives from the membership category "Partner" and two representatives from the membership category "Member". It is responsible for the Cluster's strategy work and professional efforts.	There is an advisory board comprised of executives from Hydro-Québec, Canam Group, Hatch and S NC-Lavalin. The advisory board's primary role is to provide input on the development of a strategy for the Centre's future research. It also facilitates and supports efforts of members seeking collaborative research with industry.	Unknown

7 Benchmarking of international construction research initiatives

Governance: Intellectual Property in some cases is on the basis of a technology agreement between the parties concerned

Intellectual Property (IP)

The degree of Intellectual Property (IP) management within the institutions varied with a number of institutions not publicly detailing their IP management. The Danish Building Research Institute provides an opportunity for businesses to enter into a technology agreement with Aalborg University. The technology agreement was created with the aim of creating a positive outcome for both the Institute/University and the businesses involved. The agreement provides a license agreement which gives businesses the right to utilise the technology within their field, mostly on non-exclusive terms but with the opportunity to negotiate. It is essentially a sales agreement where the intellectual property rights are transferred to the businesses.[22]

The Construction Innovation Hub in the UK work with the UK Government and industry to ensure that clear rules are in place to both protect IP but to also enable a competitive and sustainable market to be established.[23]

The Singapore Institute of Technology: Construction Technology Innovation Laboratory, has stated that any IP will be jointly owned by the Singapore Institute of Technology, Who Hup Pte Ltd (the institute's innovation partner) and industry partners.[24]

The IP management approach at CICIEM depends on the nature of the collaborative projects. The IP shares are negotiated between the members of CICIEM (represented by the Office of Research of Concordia) and the industrial partners. In research contracts and some research grants, the IP is fully assigned to the industrial partners.[25]

7 Benchmarking of international construction research initiatives

Governance: Commercialisation is seen as a route to sustain services and generate income

Commercialisation

Regarding the degree of commercialisation throughout the institutes, the information was unavailable in the public domain for most of them. However, the Danish Building Research Institute and Construction City Norway appear to have some degree of commercialisation. For example, the Danish Building Research Institute published a pricing list connected to their collaboration, this includes rates for professors and researchers to provide services for businesses to provide knowledge and expertise. Construction City Norway have a programme available that provides businesses with the opportunity to rent out office space and conference space.

The benchmarking exercise suggests that commercialisation of some of the institutions services and initiatives could be a way to maximise the services provided whilst also generating income to sustain some of the services. For example, the Construction Scotland Innovation Centre offers a number of product development, manufacturing, robotics and visualisation equipment options that can be hired by businesses on a Pay-As-You-Go basis or as part of annual membership benefits.

The renting and use of equipment are beneficial for both the Centre and those involved in the industry. The Centre can cover some of the cost of running and purchasing equipment whilst also engaging the industry. Businesses, organisations and individuals can trial the equipment and use the equipment on an as needs basis before committing to such a large investment. This could be particularly favourable for those smaller businesses who may not have the capital levels to support such a long term investment, but the renting of the Centres equipment allows them to increase productivity and remain competitive.

By providing businesses with access to technologies that they may have not previously been able to access, especially those smaller businesses and start-ups, means that such an initiative could be successful in providing direct support to businesses whilst also encouraging them to use innovative methods of construction and to potentially invest directly in adopting the technologies provided. A number of more academically focused institutions have also made researchers and professors available at a consultancy style day rate in order to provide support to businesses and to assist them in their research and innovation.

Research Centre	The Construction Innovation Hub UK (CIH)[3]	Dudley Advance II England[4]	Construction Scotland Innovation Centre (CSIC)[5]	Building Research Institute Denmark (BRI)[6]	Construction City Cluster Norway (CCC)[7]	CICIEM Canada[8]	Construction Technology Innovation Laboratory Singapore (CTIL)[9]
Commercialisation	Unknown	Unknown	✓	✓	✓	✓	Unknown

7 Benchmarking of international construction research initiatives

Funding: National and/or EU, public and private are the main sources of funding

All of the institutions researched receive some form of public funding in order to undertake their respective activities and initiatives. The remainder of funding is sourced either via commercialisation or other sources. Examples of sources of funding for a select number of the benchmarked institutions are set out below.

Dudley Advance II (UK)[26]

- Funding received from Central and Local Government.
- A total of £20.5m was secured to build the new Centre for Advanced Building Technologies and Construction.
- This included £15m of public sector investment and £5.5m of private sector investment.
- Annual Turnover in 2017/18 of £41m.

Centre for Innovation in Construction and Infrastructure Engineering and Management (Canada)[27]

- The wider Concordia University which hosts the Centre, receives the majority of its funding from Government sources.
- 57% Federal Government
- 14% non-government agencies
- 10% external sources
- 14% provincial government, and
- 6% other government sources
- The Centre is funded by industries based on the scales of research projects and duration of projects. The industry contributions are mainly used to leverage the government funds through the funding agencies.

Construction Scotland Innovation Centre (CSIC)[28]

- The Centre was established in March 2014 and is connects 31,000 plus businesses with academic expertise.
- This partnership between industry, academia and Government, aims to be a catalyst to drive growth and profit in the construction industry in Scotland
- Initial funding of £7.5m was received in spring 2014, with an additional £2m for capital equipment subsequently obtained.
- Financed by Scottish Funding Council, supported by Scottish Enterprise, Highlands & Islands Enterprise and 13 of Scotland's universities.
- In 2019 the Centre received almost £11m of core funding from the Scottish Funding Council (£7.98m), the Scottish Enterprise (£2.5m) and Highlands and Islands Enterprise (£0.5m).
- The Centre also received £8m investment from industry and other project partners in 2019.

In the UK, the Governments' Construction Sector Deal was established in 2018 and consists of a partnership between the UK Government and the construction industry to provide funding for construction technology . The aim of the Deal is to transform the construction sector's productivity through the use of innovative technologies and a highly skilled workforce. The Sector Deal included a government commitment to invest £170 million into the Transforming Construction Programme, to develop and commercialise digital and offsite manufacturing technologies to produce safe and sustainable buildings. The project also invested £72 million in the Construction Innovation Hub.[29]

The EU have created a number of funding initiatives to encourage the firms across the EU to engage in innovation and research, and have highlighted Advanced Manufacturing as being a key enabler to support and promote business research and innovation in key enabling technologies.

For example the EU Horizon 2020 programme (now succeeded by Horizon Europe) had a €80 billion budget which focused on providing research and innovation funding for multi-national collaboration projects along with individual researchers and SMEs. To date, the programme has funded a number of projects related to future and emerging technologies including those relates to robotics and green technologies. The European Commission developed a Horizon 2020 Work Programme for the period covering 2018-2020. The work plan included research and innovation into the use of technology in construction. Examples include research into Energy Efficient Buildings (EEB) with funding available for the development of lightweight components for the construction of building envelopes with active/passive management of energy transfer.[30]

7 Benchmarking of international construction research initiatives

Funding: National and/or EU, public and private are the main sources of funding

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Funding	The Hub is Government funded with the aim of transforming the UK construction industry. Funded by UK Research and Innovation through the Industrial Strategy Challenge Fund. £72m Hub.	Funding received from the Black Country LEP and Central Government. Secured investment of £20.5m in the new Centre for Advanced Building Technologies and Construction Skills at Dudley College, including local public sector investment of £15m and private sector investment of £5.5m. Investment of £7.9m in the new centre at Dudley College (£4.2 in 2015/16) (Central Government)	Financed by the Scottish Funding Council, and supported by Scottish Enterprise, Highlands & Islands Enterprise and 13 of Scotland's universities.	Funded by the University, Government funding and commercialisation.	Recently allocated funding from Innovation Norway. Most of the research in the Construction sector is customer driven - often with government sponsoring 50%. The research institutes have also individual governmental base funding.	Around 57% of Concordia University's funding comes from federal government, 14% non-government agencies, 10% external sources 14% from provincial government 6% other government sources.	CTIL, SIT and industry partners co-fund the applied research projects. CTIL also applies for external funding from government agencies to further develop projects in partnership with industry.

7 Benchmarking of international construction research initiatives

Technology: Many institutions have a range of facilities and labs for researching and testing different construction technologies

Specific technologies covered by the institutions

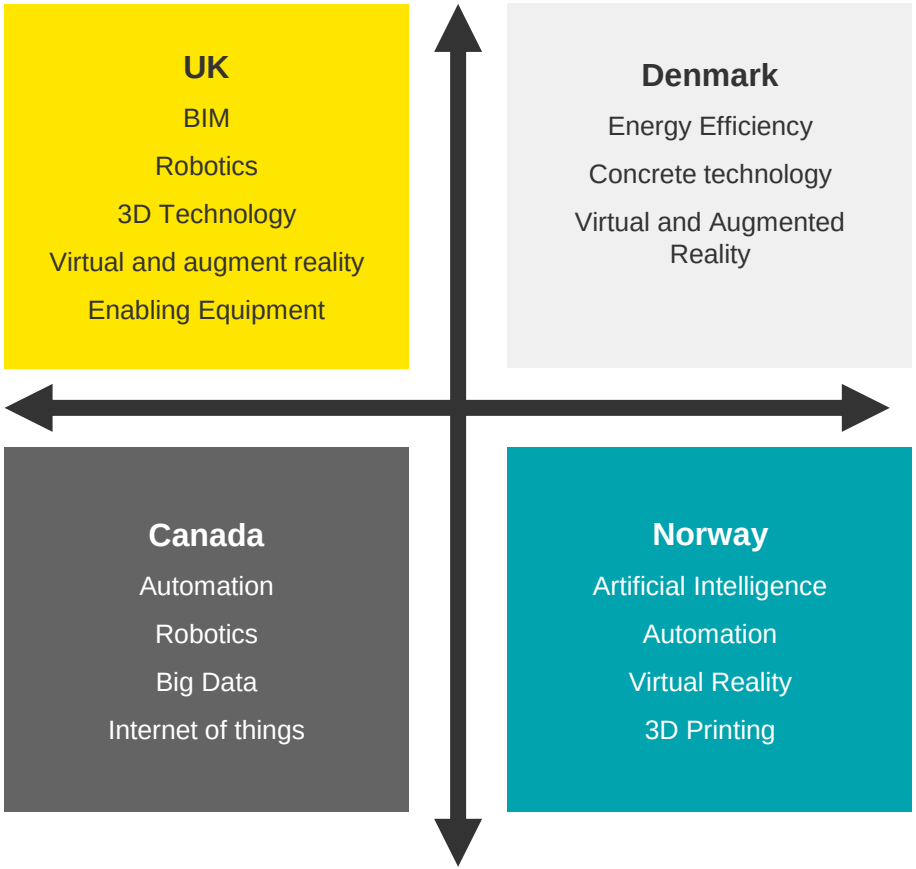
Over the last decade, governmental agencies across the world have expressed concerns in regard to the performance of the construction industry in terms of its ability and capability to improve productivity and innovate. This, along with the rapid emergence of new technologies has resulted in government bodies across the world focusing their attention on improving and increasing the use of technology within the construction industry.

Construction technology is often a term that is used to collectively categorise a range of technologies which are specifically used within the construction industry. Examples include smart machinery, automated robots, virtual reality, 5G and IoT. The aim of encouraging the use of construction technology is to improve working conditions, increase efficiency and productivity and improve health and safety.

Whilst the trends in the use of construction technology varies throughout the world (discussed further in Chapter 4), the benchmarking exercise did demonstrate a number of similarities in the construction technologies which institutions have chosen to focus on. Across the benchmarked institutions, the most frequently cited technologies are Virtual and Augmented Reality, Big Data and Automation.

The majority of organisations included within the benchmarking exercise have chosen to focus on the research and development of construction technologies. Many institutions have a range of facilities and labs for researching and testing different construction technologies as the summary table on the next page shows.

The image below highlights the key specific construction technologies that each of the institutions have chosen to focus their research and innovation projects on:



7 Benchmarking of international construction research initiatives

Technology: Many institutions have a range of facilities and labs for researching and testing different construction technologies

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Construction Technologies Covered	Focused on: ► Accelerating the pace towards greater digitalisation in the construction industry. ► Promoting the use of BIM within the construction industry. CIH has developed a platform construction system, which consists of a standardised 'kit of parts' that can be deployed across multiple building types. Their Assurance theme includes the development and roll out of the Construction Quality Planning Process and delivery of an online compliance tool.	Dudley Advance II has: ► A four-storey high 'hangar' where students are taught the practical know-how required for fabricating and assembling buildings ► A 'digital centre' in which BIM and digital environment software packages are demonstrated and taught. ► A 'carbon-friendly technology centre' where students acquire skills in the installation of air source heat pumps and photo-voltaic technologies, and ► A 'construction manufacturing and fabrication centre' to develop building engineering skills.	CSIC offers a range of product development, manufacturing, robotics and visualisation equipment, including: ► The gantry crane, forklift & hand tools ► Robotics (Collaborate tool, industrial robot) ► 3D Technology (Scanner and Printer) ► Virtual and augmented reality equipment ► Enabling equipment (Manual assembly table)	► BRI provides access to laboratory facilities, where laboratory technicians and researchers are ready to help. Research areas include: ► Building technology ► Indoor climate ► Energy-efficient construction ► Sustainability ► Urban development, ► Housing or architecture.	► Ongoing construction technology projects include: ► Artificial Intelligence ► Sustainable material use in the construction industry, and ► The testing of new collaboration tools.	► At CICIEM the technology researched includes: ► Automation and robotics in construction ► Big data analytics and data science applications. ► Industrialisation of construction, ► Reliability analyses, ► Condition, assessment and rating of infrastructure ► Sensing technologies and internet of things (IoT) applications in construction/ infrastructure engineering and management.	► CTIL is focused on implementing innovative construction technologies for deep foundation and excavation, to achieve improvements in various construction areas such as water systems, piling system and crack and corrosion-resistant concrete.

7 Benchmarking of international construction research initiatives

Sustainability: All institutions have a sustainability agenda as a priority

Sustainability

As might be expected, the majority of institutions researched have, as a priority, ensuring that their research and future development projects are focused on sustainability. A number of institutions such as The Construction Innovation Hub[31] and the Danish Building Research Institute[32] have chosen to put sustainability at the forefront of their actions by including it as a key objective.

The Centre for Innovation in Construction and Infrastructure Engineering and Management in Canada[33] follows the wider Sustainability Action Plan as established by Concordia University. The latter ensures that the institution is focused and held accountable in regard to ensuring that every action undertaken is concerned about its contribution to building a sustainable environment within the industry. The Centre has stated that sustainability and resilience of the built environment are among the core focuses of their research. They have formed a workgroup that is specifically focused on the 'circularity of construction' and seek smarter ways for the management of rehabilitation and construction waste. The workgroup held a workshop in May 2021 on 'Smart Management of Construction Waste' and brought together panellists from the industry, municipalities, and academia to share their best practices in this regard. Furthermore, the centre has a long history of research on planning, construction, maintenance, and rehabilitation for sustainable and resilient civil infrastructure. This covers a wide range of analytical and experimental studies on different aspects of physical infrastructure assets and the associated levels of service to better manage the economic, social, and environmental performance as well as react/adapt to manmade and natural disruptions.

> *"Create a world where our built environment improves quality of life, delivers greater social value, reduces environmental impact and is delivered by a world leading innovative and sustainable industry."*
>
> **UK Construction Innovation Hub**

7 Benchmarking of international construction research initiatives

Sustainability

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Sustainability	CIH's vision is a world where the built environment improves quality of life, delivers greater social value, reduces environmental impact and is delivered by a world-leading, innovative and sustainable industry. They aim to create better outcomes for current and future generations by driving the adoption of manufacturing and digital approaches that improve the delivery, resilience and performance of infrastructure.	Sustainability is at the core of the curriculum offered by Dudley Advance II. Environmental technologies with a focus on sustainable construction methods and green technologies is one of the five key areas of the curriculum.	Amongst its key areas of research is building sustainably. CSIC is focused on energy and decarbonisation, design for an ageing society, smart and sustainable materials and the circular economy. CSIC has supported collaboration and circular innovation in a number of sustainability driven projects such as the K-Briq by Kenoteq, which uses 90% recycled materials, producing just 10% of the carbon created by a traditional brick.	A key focus of the institute has been to research sustainable methods of construction along with research into how to promote energy savings in buildings. The Institute offers a course focused on Life Cycle Assessment (LCA), a method being used to asses the potential environmental impacts and resource consumption for products and services in construction.	The Cluster has completed a number of research pieces into sustainability within the construction industry. Construction City has been working with Norsk Gjenvinning to begin a project on the industrialisation of sustainable material use for the construction industry. The Cluster was recently awarded funding from Innovation Norway. The goal is to complete work that results in businesses using climate friendly and sustainable solutions in business.	The wider university has a Sustainability Action Plan with the aim of fostering an institutional culture that will position Concordia as a world leader in sustainability research with meaningful effects on society, and in sustainable research practices. CICIEM have three research centres focused on sustainability, including the Centre for Zero Energy Building Studies.	The wider Singapore Institute of Technology has undertaken a number of initiatives to reduce their carbon footprint. CTIL has established a stand alone Energy Efficiency Technology Centre that is focused on assisting businesses in becoming more energy efficient.

7 Benchmarking of international construction research initiatives

Collaboration: is seen by all institutions as fundamental to delivering their mission and objectives

Collaboration

Collaboration is considered fundamental to delivering on the mission and objectives of each institution. All of the institutions benchmarked demonstrated at least some level of engagement with government, academia and industry with some institutions engaging more than others. A number of institutions have decided to add industry leaders to their governance and advisory boards. The addition of an industry voice to the direct operation of a centre ensures that the goals and actions of the centre are directly aligned to the industry's needs and requirements.

All of the institutions also provide access to information and learning from their lead researchers to assist businesses. Other institutions have taken a more coordinated approach by establishing joint projects with businesses within the industry. For example, the CICIEM Canada,[34] provides industry with access to academics in order to learn what kind of Internet of Things (IoT) devices are needed and come up with ways to get the most out of allocations by municipal governments for maintenance, rehabilitation and renewal of civil infrastructure assets. The centre co-ordinates research projects and shares project data.

Dudley Advanced II in England has chosen to take a different approach in terms of collaboration with a key focus on training and upskilling industry employees. The centre also partners with industry and gives them the opportunity to contribute towards the college's curriculum. This ensures that students are trained in an appropriate manner that ensures that the needs of the industry are met.[35]

The Danish Building Research Institute[36] in Denmark focuses on collaboration with Government, industry and academics. They offer the following benefits through their collaboration:

- Companies and organisations, can use their own project cases in students' project work in e.g. construction, water, environment and transport.
- They can provide students with internships in businesses and organisations.
- They facilitate professional events where researchers present the latest knowledge in an area.
- Research collaborations ensure that companies, public authorities and the sector are constantly aware of the latest and best knowledge.
- They provide advice from researchers to industry. If a company lacks knowledge about a highly technical area, such as energy efficiency improvement, researchers can visit larger companies and interest groups to engage with employees about the latest developments and research in a given area.
- They provide research and share knowledge with Government.

The Construction Innovation Hub in the UK[37] have put collaboration with government, academia and industry at the core of their operations. To ensure their transformative programme delivers a lasting impact, the CIH is working with five government departments (Health, Justice, Education, Defence and Transport) to support their adoption of their Transforming Infrastructure Performance programme in favour of offsite.

7 Benchmarking of international construction research initiatives

Collaboration and engagement with businesses, academia and government is a key element of the work of the institutes

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Collaboration	The CIH works very closely with industry and academia to develop tools and technologies for the construction sector.	Dudley Advance II works with businesses and students. Dudley Advance II has been developed with input by employers for employers.	CSIC's Innovation Factory allows an open access, low cost and safe environment for collaborating partners to access state of the art equipment to drive industry activity in the circular economy.	The BRI places a high priority on cooperation with public authorities, companies, the sector and other research institutions.	CCC have a campus that can be used as a meeting place for hosting events, courses, and field trips – bringing together a unique cross-sector network of people and companies, collaborating to their mutual benefit. There is a membership fee.	One of the goals of the CICIEM is to collaborate with industry to learn what kind of IoT devices are needed and suggest how big data can help detect latent patterns in all the feedback.	CTIL works with construction companies and SIT researches complete applied research projects.
Government Collaboration	Funded by the UK Government's Industrial Challenge fund and is run by UK research and innovation (research councils, innovate UK and research England).			Research collaborations to ensure that companies, public authorities and the sector are constantly aware of the latest and best knowledge. Work to solve Government tasks and makes their knowledge available to ministries.		CICIEM works with Government to develop creative methods for condition assessment and asset management. It all leads to cost efficiency, value for money, and better safety and productivity on job sites.	

7 Benchmarking of international construction research initiatives

Collaboration: The level of collaboration and engagement with businesses, academia and government

Research Centre	The Construction Innovation Hub UK (CIH) [3]	Dudley Advance II England [4]	Construction Scotland Innovation Centre (CSIC) [5]	Building Research Institute Denmark (BRI) [6]	Construction City Cluster Norway (CCC) [7]	CICIEM Canada [8]	Construction Technology Innovation Laboratory Singapore (CTIL) [9]
Business Collaboration	The hub works with government, academia and the Construction Leadership Council to develop solutions that can be uses across the sector.	Dudley Advance II aims to assist businesses in the following: recruitment, upskilling their workforce, providing businesses with the ability to influence the curriculum and providing access to equipment and technology.	The CSIC works with businesses to understand their business and connect them quickly to the expertise and services they require.	Aalborg University aims to assist businesses to realise their entrepreneurial ambitions. AAU is seeking to create an optimal framework for starting knowledge-based companies through courses, workshops and advice.	Organisations based in Norway that supply products or services in the construction and real estate industry or that intend to can become a member.	Academics work with industry to learn what kind of IoT devices are needed and come up with ways to get the most out of allocations by municipal governments for maintenance, rehabilitation and renewal of civil infrastructure assets.	CTIL works with construction companies and SIT researches to complete applied research projects.
Academic Collaboration	The Hub has partnered up with Cardiff University and its Digital Compliance Network (March 2021) to develop a digital ecosystem to support construction firms in navigating complex regulatory landscapes.	The centre provides students with not just know-how but real industry exposure through Apprenticeship opportunities, guest speakers, site visits, mentors and real work-experience.	At CSIC, they link together businesses, academics and public sector.	Aalborg University's offer of cooperation includes cooperation with students on projects or internships, collaboration with researchers on research and development, rental of laboratories and equipment, technology transfer, and continuing training and participation in professional networks.		CICEM aims to train highly qualified personnel. It runs the largest graduate programme in construction and civil infrastructure in the country.	CTIL provides opportunities for SIT students reading the Bachelor and Master of Civil Engineering degree programmes to gain practical hands-on experience in industrial environments and be exposed to applied research and innovation projects.

7 Benchmarking of international construction research initiatives

Key observations for Ireland – communication, commercialisation and collaborations are key to the success of a centre

There are a number of key learnings and takeaways from the benchmarking exercise that could be applicable to the construction and built environment sector in Ireland. By examining what has worked well for other institutions helps identify potential aspects that Ireland could adopt to ensure an optimum outcome in a future construction technology centre.

Communication challenges between partners

Research has suggested that a lack of clear communication between the industry and relative institutions or research councils can result in frictions and a lack of productivity in terms of collaboration between both sides.

Research completed by BI Norwegian Business School at Uppsala University into 'Public Policy and Industry Views on Innovation in Construction' suggested that the perceived lack of domestic construction research programmes was jointly down to both industry and the research institution. Industry organisations believed that the lack of funding was as a result of governmental bodies' lack of interest in construction and their failure to understand its importance. The Research Council of Norway believed that the industry had shown a lack of desire to apply for funding and initiatives.

It appears that in the Norway case, there was a lack of communication between academia and business which resulted in challenges for both. This case presents the need for clear guidance from the research institute on the available research/ support for businesses and the promotion of activities. There is a need to promote what the centre can actually do to support businesses. There also needs to be a willingness from businesses to actually innovate.

Commercialisation

The benchmarking exercise suggests that commercialisation of some of the institutions' services and initiatives could be a way to maximise the services provided whilst also generating income to sustain some of the services. For example, the Construction Scotland Innovation Centre offers a range of services, including product development, manufacturing, robotics and visualisation equipment that can be hired by businesses on a Pay-As-You-Go basis or as part of annual membership benefits. This can also provide an opportunity to equipment suppliers who donate equipment to make sales to interested parties.

The Pay-As-You-Go option provides businesses, especially those smaller businesses and start-ups, with access to technologies that they may not have previously been able to access. This initiative could be successful in providing direct support to businesses whilst also encouraging them to use innovative methods of construction and potentially to invest directly in adopting the technologies provided.

A number of more academically focused institutions have also made researchers and professors available at a consultancy style day rate in order to provide support to businesses and to assist them in their research and innovation.

Collaboration

A critical element of the success of a centre will be the extent of collaboration between government, industry and academia. It will be important that there is buy in across the board for the Centre to work.

The benchmarking exercise has shown that whilst the majority of the institutions researched are relatively young, a number of initiatives appear to have been extremely successful in increasing the prevalence and use of technologies across the construction sector in the respective jurisdictions.

This indicates that the level of maturity of an institution does not need to deter its success and immediate contribution to the successful take up of technology. In order to achieve such success, it is vital that the right interventions and programmes are established and provided from the start as well as strong levels of communication and collaboration between industry and the institution.

The benchmarking research shows how building strong working relationships between professional institutions, academia and businesses can have a positive impact on innovation within a sector. In order to ensure that businesses are on board and invested in the technology centre, it is important that they are included within the establishment of any potential technology centre from day one. By ensuring the voice of the industry is heard, the centre will be able to harness the skills and experience of local businesses whilst ensuing that any initiatives such as grants are tailored to the needs of the construction industry in Ireland.

7 Benchmarking of international construction research initiatives

Key observations for Ireland – areas of focus for centre

In regard to **Training**, the Centre should provide accredited training in collaboration with local academics, universities, such as the following, which are provided elsewhere:

- 1 day or two day courses in accreditation BIM either funded by the centre or partially subsidised by the Centre
- Partnering with academics and industry experts to upskill the industry and increase productivity, similar to Dudley in England. This could be informed by the fact that Ireland is behind the UK in its level of BIM dimension. This could help businesses win larger contracts. Government stakeholders from procurement teams could also be involved to support their understanding of construction technology usage at a procurement level.

Introductions: The Centre should hold conferences to bring together likeminded businesses and key experts from other international centres, and have sessions to promote and get to know the Centre, thereby encouraging increased membership. Through a membership option, the Centre could encourage collaboration on bidding for projects across a range of disciplines. These initiatives would facilitate networking across the industry and introduce firms to other like-minded firms. With the increasing complexity of roles being created as a result of digitalisation and technology, this networking would also support the building of a workforce of T-shaped workers who have discipline-specific skills in at least one area and are knowledgeable or skilled in several others.

Technology sandbox: Provide the technologies for firms to try before they buy, by offering rental of equipment on a day rate. This would be especially helpful for those micro and small firms who do not have the resources; potentially a model similar to that used by the Scotland Innovation Centre. (See Case Study in Appendix 4, pages 180 and 181).

Research: Facilitate the research to be completed by academics, through linking academics with businesses etc. It is important that there is an element of applied research similar to that in Canada that will actually add value and be of benefit to firms.

Grants/vouchers: The Centre would provide a combination of grants/vouchers to partially fund projects and programmes, similar to the Construction Scotland Innovation Centre, which has supported over 350 innovation projects by working with industry, academia and the public sector to research new products, processes, businesses models and services across the sector.

Most domestic construction enterprises are not aware of, nor do they avail of, for example, Innovation Vouchers provided by Enterprise Ireland. These vouchers link enterprises with academics to research specific innovation, processes or building materials. Any Construction Technology Centre in Ireland must ensure:

- Its target clients include micro firms and SMEs in the domestic construction sector
- The required competencies that these enterprises need are catered for by the Centre
- The requisite State interventions are available to support these enterprises on their innovation journey.

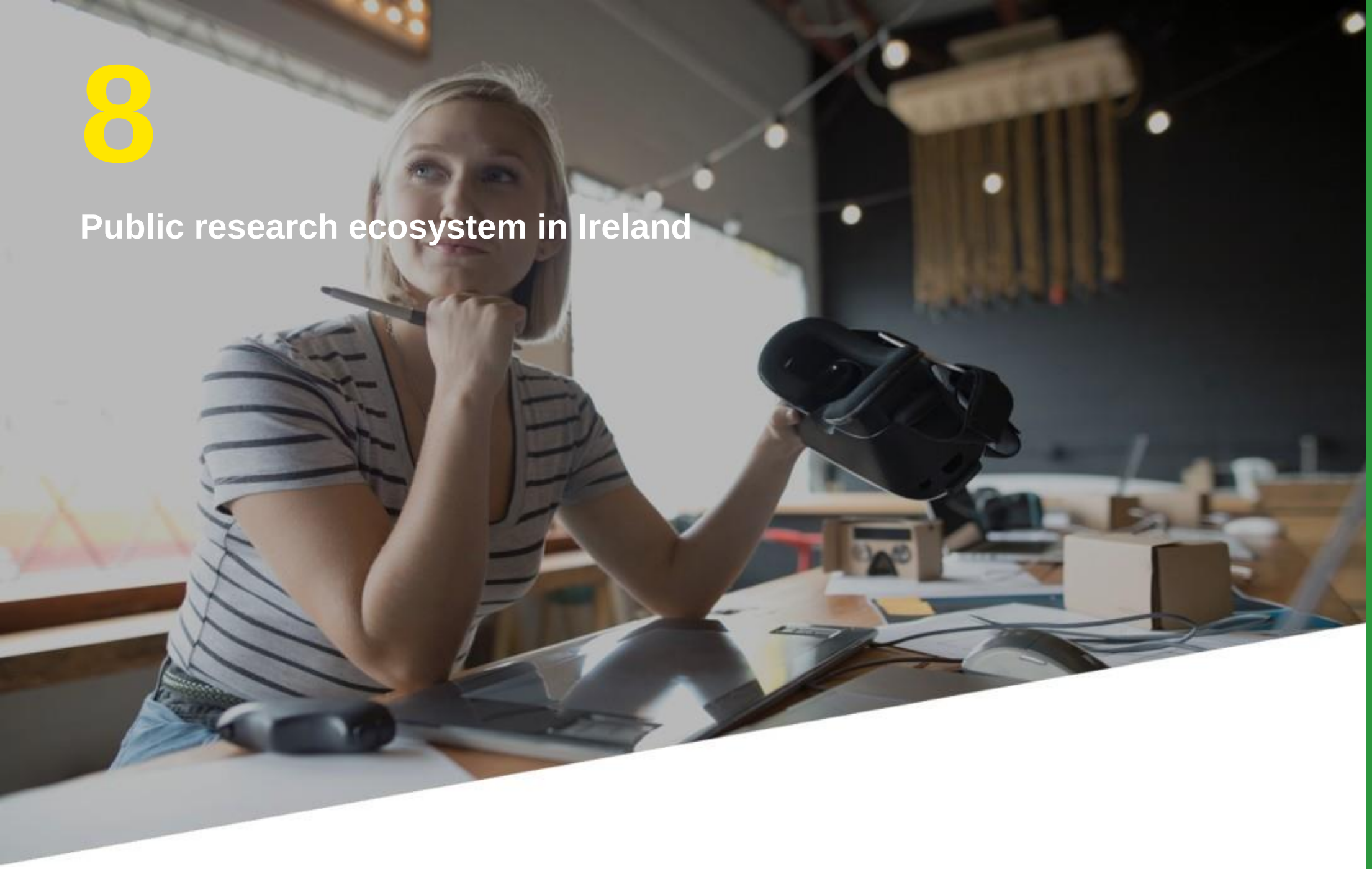
Conclusion

It is evident that, to ensure that initiatives are successful, there needs to be clear objectives and clear targets. The implementation of a business plan that will target key stages over a number of years with attention initially focused on a small number of priority areas is an important element of the journey. The target client has to be predominantly enterprises in the domestic construction sector.

Learnings include the requirement for a clear definition of needs, appropriate benchmarks and key performance indicators. Buy in from the industry and government and a willingness to collaborate can be achieved by ensuring that support and resources are tailored to the needs of construction enterprises.

8

Public research ecosystem in Ireland



8 Public research ecosystem
Key observations

The Irish public research ecosystem is complex with various institutions and agencies involved. Our research demonstrated that there is significant activity with various levels of funding and support available to assist enterprises in their RD&I efforts.

In order for the public research ecosystem to continue to assist Ireland in becoming and hub for innovation, it will be essential that their remains high levels of collaboration and communication between the actors involves (education, government, businesses and support agencies). It is also important that the levels of duplication remain as low as possible to ensure the most efficient and effective use of public money.

It is important to recognise the range of initiatives and supports which Government, Enterprise Ireland and IDA Ireland have put in place to encourage and promote RD&I activity within enterprises across the economy. The gross domestic expenditure on R&D (GERD) by Government was €4.02 billion in 2019. This represents investment incurred by resident companies, research institutes, university and government laboratories.

Ireland has created significant research capabilities in centres of scale and excellence. These research centres engage in collaborative research and partner with industry to address specific research and development needs. These centres also have significant experience in engaging in collaborative EU-funded research projects.

The ecosystem for construction RD&I comprises EI Technology Gateways, EI Technology Centres, Science Foundation Ireland centres, third level institutions and other training providers such as SOLAS and Skillnet. At present, there are various construction-related academic research projects taking place across Ireland each unique in their chosen focus. Four key institutions focus on construction innovation and research: University College Dublin, National University Galway, Trinity College Dublin and TU Dublin.

In establishing a Construction Technology Centre, it will be important to recognise and acknowledge the existing initiatives that are already doing great work to support the transformation of the industry, all of which are individually funded. These initiatives should be invited to become part of the competency of the Centre over time. This means that the Centre should act as a magnet to draw all of those early adopters in to ensure a collaborative role between them and the Centre. This could be achieved over time by having Service Level Agreements (SLAs) between the Centre and these existing initiatives.

Enterprise Ireland is responsible for the development and growth of Irish enterprises in world markets; its remit does not extend to domestic enterprises that do not export, which include the vast bulk in construction.

Notwithstanding the initiatives currently in place, the challenge will be ensuring the public research system caters for the domestic construction sector which appears to be behind the RD&I curve relative to other sectors. There is limited investment provided for these firms currently and a Centre will need to cater for these micro firms and SMEs to ensure they have the required competencies to support the transformation of the industry over the next decade.

As with existing initiatives across other sectors, this will require strong collaboration between the construction industry, Government institutions and the higher education sector to achieve the vision for the Centre. The provision of State funding to support the industry on its innovation journey will be critical to its success.

8 Public research ecosystem

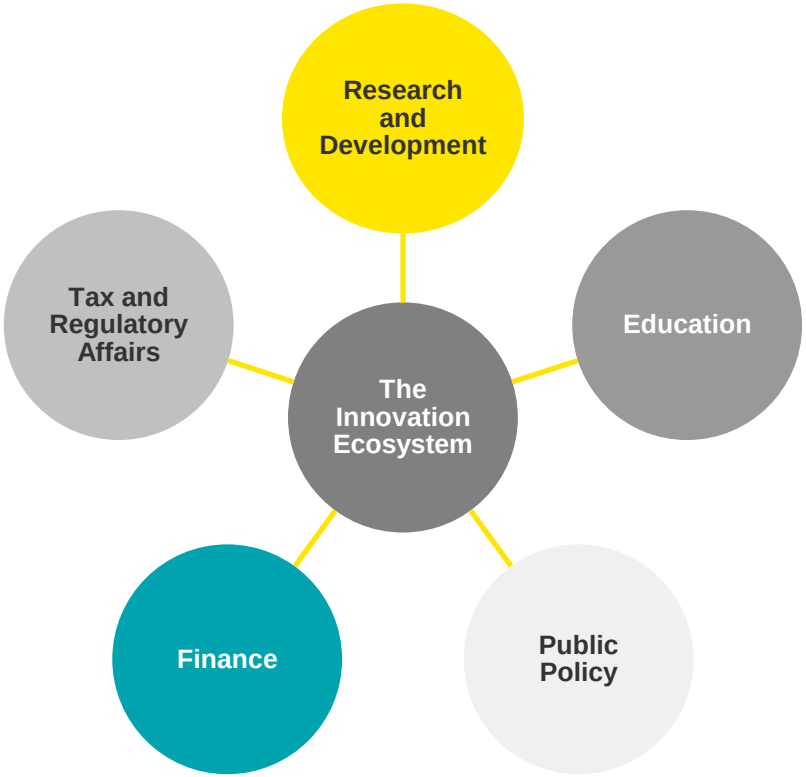
The Irish public research ecosystem is complex in nature, involving multiple actors with various roles in research funding

Introduction

Increasing the level of productivity within a given sector or economy by developing new ways of thinking increases the quality and quantity of the creation of goods and services that can boost the economic prosperity of a nation. Research, development and innovation (RD&I) in production, technology and processes can increase efficiency and effectiveness along with promoting sustainability within any given industry. The investment in RD&I can lead to increased competitiveness, more high value-added jobs and an increase in foreign direct investment, all of which can increase the prosperity and productivity of an economy. For an economy to prosper, it is essential that there are strong levels of RD&I collaboration across the economy amongst businesses, academics and government.

The Irish public research ecosystem is complex in nature, involving multiple actors with various roles in research funding. It is comprised of Government researchers and professionals working for government institutions engaged in the conception or creation of new knowledge, products, processes, methods and systems and in the management of the projects concerned.

It is widely recognised that RD&I active companies are key to sustainable, innovation led, economic development and employment in the economy. In order to encourage and promote RD&I activity within enterprises, the Irish Government provides a number of initiatives and supports. Fostering an Irish ecosystem that can compete with the best in the world is a critical element of the Irish Government's vision to make Ireland a global innovation leader. The Government aims to provide supports that are aligned with the evolving needs and challenges faced by Irish companies as their RD&I activities advance from concept through to market exploitation. Furthermore, the elements of the support ecosystem have been designed around a few key principles of successful RD&I. This means that, as far as possible, there is a high degree of consistency between incentives and supports in terms of eligibility, documentation and recording requirements.



8 Public research ecosystem

The R&D intensity rate for Ireland of 0.92% of GDP was below the EU28 average of 1.39%. Ireland was ranked 13th in the EU28 in 2015 & 2017, compared with 10th in 2013

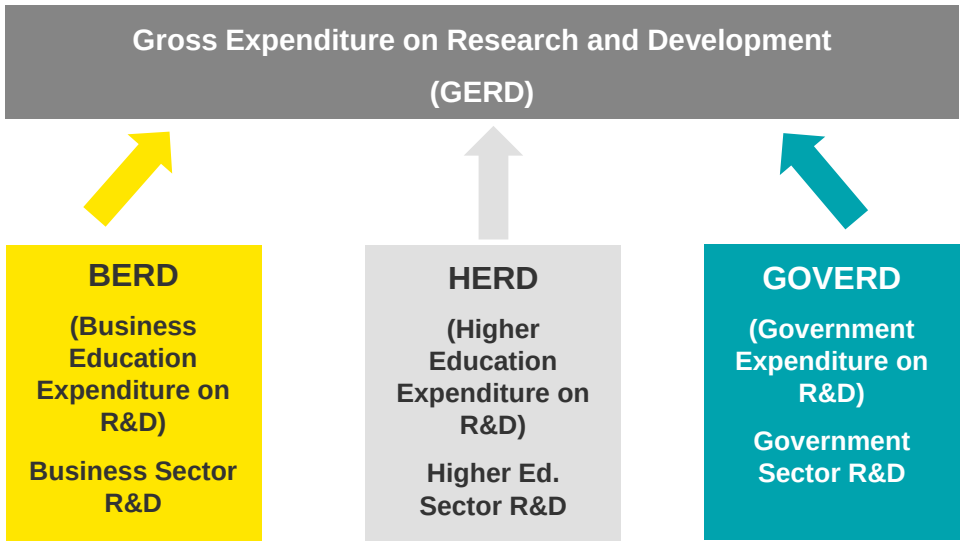
The Irish Government continues to invest heavily in RD&I with a number of high profile announcements, for example:

> *The Irish Government allocated €869.2m to research and development in 2020 with the aim of turning Ireland into a "global innovation leader.[1]*

> *The new Climate Enterprise Action Fund supports Irish companies to build the capabilities required to deliver sustainable products, services and business models.[2]*

> *Tánaiste announces €338,000 for new Technology Gateway to help business become more energy efficient (24th March) [3]*

The commitment to investment in RD&I is measured annually by the Department of Business, Enterprise and Innovation. Referred to as gross domestic expenditure on R&D (GERD), it captures the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc. in a country.



- In 2019, GERD in Ireland increased to an estimated €4.02bn, its highest level in 11 years, representing a 47.2% increase when compared to 2009 levels.
- The highest expenditure on R&D continues to be in the business sector (€2.91bn); higher education expenditure reached an estimated €952m, while the Government sector is the smallest with €164m of research expenditure in government institutions.
- Government has put in place a diverse range of policy measures to encourage greater engagement in RD&I between enterprises and the public research system in key technology areas. The public enterprise agencies act as a catalyst for consortia development aimed at capitalising on Ireland's potential to be at the forefront of the RD&I sector.[4]

The latest data available would suggest that the business sector has continued to increase its expenditure on R&D, despite the wider economy facing significant issues in 2020 as a result of the Covid-19 pandemic. In 2020, the CSO forecasted that €3.39bn was expected to be spent on R&D by businesses located in Ireland. Of this, an estimated €977m was spent by domestic businesses whilst €2.4bn was spent by foreign owned businesses. The CSO stated that when businesses were asked, they suggested that 89.3% of all their R&D expenditure was funded by the business itself via company/internal funds whilst the remaining 10.7% of expenditure was sourced externally.[5]

The Business Expenditure on Research and Development survey is carried out in all EU member states. The most recent data available from Eurostat is taken from the 2017-2018 survey and allows comparisons across the EU. R&D intensity for a country is defined as the R&D expenditure as a percentage of Gross Domestic Product. In 2017 the R&D intensity rate for Ireland, at 0.92%, was below the EU28 average of 1.39%. Ireland was ranked 13th in the EU28 for both 2015 and 2017, compared to a ranking of 10th in 2013. Sweden had the highest R&D intensity rate in the EU28 in 2017 at 2.40%, while Latvia had the lowest R&D intensity rate at 0.14% of GDP.[6]

8 Public research ecosystem

Research and Funding Bodies in Ireland

The table below shows Ireland's main sources of public funding for scientific research. They are concentrated in four main government departments and agencies: The Department of Enterprise Trade and Employment (Science Foundation Ireland, IDA Ireland and Enterprise Ireland), The Department of Education and Skills (Irish Research Council), the Department of Agriculture, Food and Marine and the Department of Health.[7]

Department of Agriculture, Food and the Marine	Enterprise Ireland	EPA	HEA	HRB	IDA Ireland	Irish Research Council
The Department of Agriculture, Food and the Marine's mission is to lead the sustainable development of the agri-food and marine sector and to optimise its contribution to national economic development and the natural environment.	Enterprise Ireland is the government agency responsible for the development and growth of Irish enterprises in world markets. It works in partnership with Irish enterprises to help them start, grow, innovate and win export sales on global markets. In this way, it supports sustainable economic growth, regional development and secure employment	The EPA was established in 1993 and is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. It is committed to protecting people and the environment from the harmful effects of radiation and pollution and plays key roles in environmental regulation, provision of environmental knowledge and advocacy for the environment.	Founded in 1968, the HEA is the independent statutory agency that allocates public funding to the higher education institutions in Ireland. It advises the Irish Government on higher education and research policy. The Authority also co-ordinates the system to meet agreed national targets in education and research.	The HRB works with other stakeholders to set a clear strategic direction for national health research. The organisation: • Funds high-quality, peer-reviewed research projects, programmes and infrastructures. • Supports researchers at early, mid and senior stages of their careers • Manages a series of national health information systems.	Ireland's research, development and innovation sector is driven by an exceptional level of collaboration between industry, academia, state agencies and regulatory authorities. IDA Ireland plays a leading role in RD&I development by funding suitable projects and identifying further support opportunities from partner organisations, such as Enterprise Ireland, Science Foundation Ireland and Sustainable Energy Authority Ireland.	The Council was set up to: • Support researchers across all disciplines to enhance the pool of knowledge and expertise available and accessible to address Ireland's societal, cultural and economic needs • Focus in particular on the education and skills development of excellent individual early-stage researchers (masters, PhDs and postdoctoral researchers) and to enable them to become independent researchers and thinkers early in their careers • Partner with employers to offer researchers a diversity of research careers • Fund research with a policy, societal or cultural focus, and partner as appropriate with government and other organisations including civic society to address their needs • Advise on national and international policy regarding graduate education and research, with particular attention given to the arts, humanities and social sciences (AHSS)

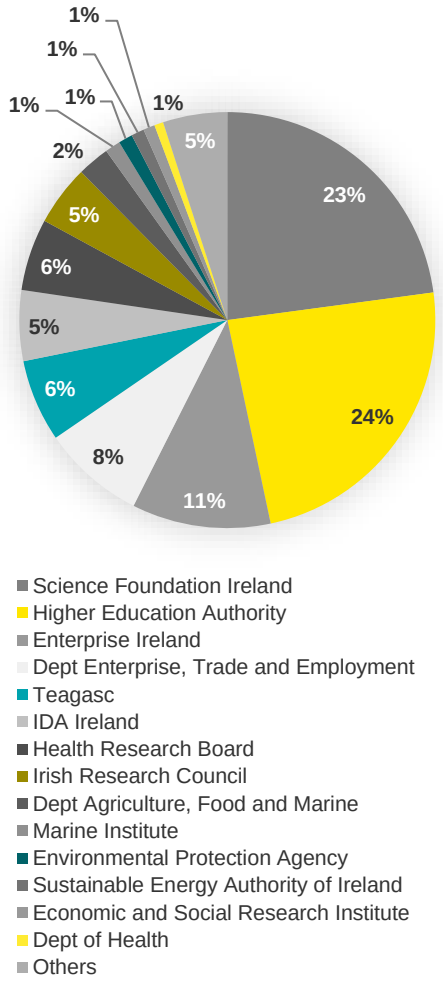
8 Public research ecosystem

Research and Funding Bodies in Ireland

Marine Institute	seai	Science Foundation Ireland sfi For what's next	Teagasc	KTI Knowledge Transfer Ireland	Horizon Europe
The Marine Institute is Ireland's national agency for marine research, technology, development and innovation. Founded in 1991, it promotes the sustainable development of Ireland's marine resources and co-ordinates national research strategy.	The SEAI is the national agency responsible for promoting Ireland's transition to a low carbon economy. It was set up in 2002. Every year, it allocates about €4m to energy research and related activities, which range from nurturing early-stage concepts through to full-scale deployment of proven solutions. The SEAI is instrumental in the development of energy research policy. It also conducts ongoing analysis of Ireland's energy options through world-class modelling, both directly and through academic institutions.	SFI is the national foundation for investment in scientific and engineering research. Founded in 2000, it invests in academic researchers and research teams who are most likely to generate new knowledge, leading-edge technologies and competitive enterprises in the fields of science, technology, engineering and maths (STEM).	Teagasc is an independent government agency that provides research support and education to the Irish agri-food sector. Founded in 1988, Teagasc sees collaboration and partnerships with industry as central to its strategy.	Knowledge Transfer Ireland (KTI) is operated by Enterprise Ireland in partnership with the Irish Universities Association. KTI takes a national perspective on the commercialisation of state-funded research.	Horizon Europe reflects Europe's commitment to finding answers to key societal challenges. Doing so effectively implies a close partnership between science and society, with both sides working together towards common goals. Broader engagement of the public with science and innovation will lead to greater public confidence to invest in ground-breaking research.

> *The primary rationale for Government investment in innovation is to develop a competitive knowledge-based economy and society and to drive innovation in enterprise, develop talent, and maximise the return on our investment for economic and social progress.*
>
> **Innovation 2020**[9]

Figure 24: Main Government Departments/Agencies with Spending on R&D as a % of 2020 total



8 Public research ecosystem

Enterprise Ireland is responsible for the development and growth of Irish enterprises in world markets; its remit does not extend to domestic enterprises that do not export, which include the majority of construction firms

The key sources of public funding for businesses

In regard to the local business sector, there are a number of sources of information, guidance and funding available for businesses. The three main sources are: Enterprise Ireland. IDA Ireland and Horizon Europe.

Enterprise Ireland

Enterprise Ireland is a government organisation which is responsible for the development and growth of Irish enterprises in world markets. They work in partnership with enterprises to assist them in starting, growing, innovating and establishing a presence in global markets. Enterprise Ireland aim to support sustainable economic growth, regional development and secure employment. The specific remit of Enterprise Ireland includes the commercialisation of state funded research and extends to stimulating RD&I collaboration between companies, both foreign and Irish-owned, with research institutes.

Programmes and interventions provided by Enterprise Ireland to promote collaboration between researchers, government and businesses include:

- Innovation Vouchers. Company applies and gets the €5,000 voucher and can cash it in for research at any public Research Providing Organisation (RPO) in the Republic of Ireland or Northern Ireland. 3 fully funded + 1 Co-funded Vouchers are available to a company i.e. up to €25,000 research available for €5,000 cost to the company.
- Innovation Partnership provides funding for Projects in RPOs up to €200,000; A minimum of 20% cash from the participating company is required.
- The Disruptive Technologies Innovation Fund (DTIF) is a €500m fund established under Project Ireland 2040 and is run by the Department of Business, Enterprise and Innovation with administrative support from Enterprise Ireland. DTIF supports innovation and provides opportunities for dynamic companies and researchers in selected sectors to translate their industrial research on disruptive technologies into commercial realities.
- The European Digital Innovation Hub programme, supported by Enterprise Ireland and the European Commission, to help both companies and the public service to embrace digitalisation and keep pace with technological change.
- Other support mechanisms include Knowledge Transfer Ireland, which works with business, investors, universities, Institutes of Technology, State research organisations, research funders and government agencies to maximise State funded technology, ideas and expertise for business to drive innovation and the Research and Development. KTI is located in Enterprise Ireland and funded by EI with co-financing from the Irish Universities Association (IUA).[10]

> *To make innovation work for us we have to **develop an ecosystem** in which each element, and each interaction, **supports innovation** across the economy and society. The key elements in such an ecosystem are; **entrepreneurs and enterprises** (indigenous and foreign-owned); **investment** in research and development; the **education system**, in particular, higher education institutions; **finance,** in particular risk capital; the **tax and regulatory environment**; public **policy** and institutions."*[11]
>
> **Enterprise Ireland**

ENTERPRISE IRELAND
where innovation means business

8 Public research ecosystem

It can be difficult for companies to navigate the ecosystem to find and access the supports appropriate to their requirements at any particular stage of development

The key sources of public funding for businesses

In regard to the local business sector, there are a number of sources of information, guidance and funding available for businesses. The three main sources are: Enterprise Ireland. IDA Ireland and Horizon Europe.

IDA

IDA was founded in 1949 and is now one of the most successful FDI development agencies in the world. Its current goals are very R&D-centric, focusing on attracting investors from a range of industry sectors who are seeking the best location for advanced manufacturing, global business services and R&D operations. IDA offer a range of supports including financial incentives to carry out in house R&D projects and collaborative projects with third level institutes and industrial partners. There is also a 25% tax credit available for companies engaging in R&D.

Ireland's RD&I sector is driven by collaboration between industry, academia, state agencies and regulatory authorities. IDA Ireland plays a key role in RD&I development by funding suitable projects and identifying further support opportunities from partner organisations, such as Enterprise Ireland, Science Foundation Ireland and Sustainable Energy Authority Ireland.[12]

EU Funding

There is also a wide range of EU funding instruments available to assist businesses in investment and research however businesses can sometimes find the application methods long and complicated.

Horizon Europe is the primary European funding program for research and innovation. Horizon Europe has a budget of €95.5 billion for the period from 2021-2027. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate.[13]

From Enterprise Ireland RD&I grants to Revenue tax incentives and European Funding initiatives ,the Irish RD&I ecosystem is made up of an integrated suite of supports for innovation-led Irish companies. However, it can be difficult for companies to navigate the ecosystem to find and access the supports appropriate to the requirements at any particular stage of development. To address this, Enterprise Ireland developed a guide to clarify some of the main qualification requirements for key State supports and to explain how they relate to different stages in the RD&I cycle. It also describes the integration that exists between the various support incentives.[14]

8 Public research ecosystem

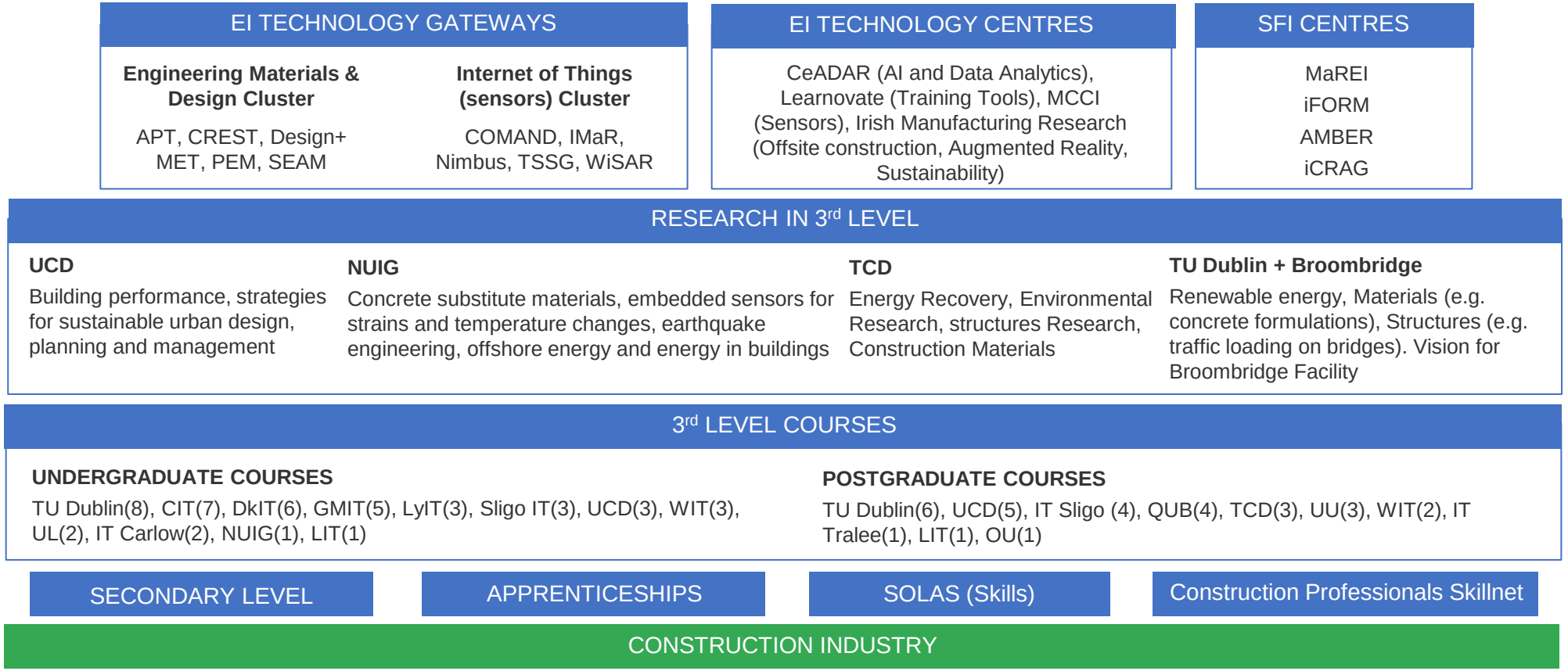
The Construction research, development and innovation ecosystem

The construction industry is recognised, by Enterprise Ireland, as a key sector and promotion of innovation in the sector is a key strategic goal.15 The ecosystem for RD&I, education and training comprises EI Technology Gateways, EI/IDA Technology Centres, Science Foundation Ireland Centres, third level institutions and other training providers such as SOLAS and Skillnet. The ecosystem illustrates the importance of the links between government, academia and industry.

The collaboration of all three actors will help the sector increase RD&I which will in turn boost the productivity and sustainability of the industry.

Construction, unlike manufacturing, ICT and MedTech is not accustomed to undertaking technical research. The challenge, therefore, will be dealing with a very fragmented construction sector which consists of firms which are not the typical clients of Enterprise Ireland and academic institutions.

Figure 25: Ecosystem 2020: National Construction Research, Development, Innovation, Education & Training



8 Public research ecosystem

The most popular construction courses covered at 3rd Level appear to be Construction Management, Quantity Surveying and Architectural Technology

The ecosystem begins with the education of those at the most junior level, secondary level and apprenticeships before moving to more focused education and training via 3rd Level courses. Research has suggested that at the time of writing, there are 44 construction related Undergraduate course in Ireland across 12 educational institutions. The courses range from Level 6 to Level 8 across the country's third level institutions. The focus of each course varies depending on the level and the institution, however the most popular courses covered appear to be Construction Management, Quantity Surveying and Architectural Technology.

Institution	Course	Level
Cork IT	Architectural Technology	7/8
	Civil Engineering	7
	Construction	7
	Construction Management	8
	Environmental Engineering	7
	Structural Engineering	8
Letterkenny IT	Civil Engineering	7
	Construction Management	8
	Quantity Surveying	7
Dundalk IT	Architectural Technology	7/8
	Building Surveying	7/8
	Construction Management	7/8
IT Sligo	Applied Construction Technology	6
	Construction Economics	6
	Construction Project Management	8
	Applied Technology	8
TU Dublin	Architectural Technology	8
	Auctioneering Valuation and Estate Agency	7
	Building Engineering	7
	Construction Management	8
	Geographic Science	8
	Property Economics	8
	Quantity Surveying and Construction Economics	8
	Timber Product Technology	7

Institution	Course	Level
UL	Construction Management and Engineering	8
	Materials and Architectural Technology with concurrent Teacher Education	8
Waterford IT	Architectural Technology	7
	Construction Management and Engineering	8
	Quantity Surveying	8
GMIT	Education Design Graphics and Construction	8
	Construction Management	7/8
	Quantity Surveying and Construction Economics	7/8
UCD	City Planning and Environmental Policy	8
	Engineering	8
	Landscape Architecture	8
IT Carlow	Construction	8
	Construction Management with Building Services	7
Limerick IT	Construction Management	8
NUIG	Project and Construction Management	8

8 Public research ecosystem

3rd Level Research - There are four key institutions that focus on construction innovation and research

Whilst 3rd Level educational courses are providing insight and knowledge, academic research focuses on specific research and innovative projects which have the potential to change and improve how the industry works. At present, there are various construction related academic research projects taking place across Ireland, each unique in its chosen focus. There are four key institutions that focus on construction innovation and research: University College Dublin, National University Galway, Trinity College Dublin and TU Dublin.

University College Dublin (UCD)

Researchers at University College Dublin (UCD) have been undertaking a range of research related to construction technology. The college have primarily been focused on; building performance, sustainable urban design, planning and management.

Recent research projects include:

- Building performance, strategies for sustainable urban design, planning and management.
- Flood-risk perception and behavioural responses to environmental and land use externalities caused by natural hazards and human activities.
- Cultural studies relating to building and landscape design, visualization and conservation studies.
- Soil mechanics and foundation problems, traffic and transportation studies, water and environmental engineering, computational modelling of civil engineering materials.
- Smart transportation/infrastructure asset management system capable of monitoring the condition of its critical infrastructure can plan preventive maintenance activities, e.g. bridge/road/rail damage detection and health monitoring (highway and railway bridges).
- Drone-based fly-by monitoring of bridge network resiliency with IR cameras, novel multi coil wireless recharging of remote sensors by drone to enhance the sensor node (mote) operational lifetime.
- Dynamic behaviour of wind turbines in terms of the dynamic response due to the mass damping effects.
- Harvesting of electrostatic kinetic energy (i.e. vibrations) to power wireless sensors.
- Multi-disciplinary research on next generation IoT and future (5G) communication networks including energy harvesting (sunlight, electromagnetic fields or ambient vibrations) for use with ultra-low power IoT sensor nodes; digitally assisted power efficient reconfigurable wireless transceiver architectures and related subsystems.

National University of Ireland Galway (NUIG)

NUIG construction research has recently focused on concrete substitute materials, offshore energy and energy in buildings. Specific examples have included:

- Concrete Research - OPC substitute materials (e.g. peat fly ash), embedded sensors to continuously monitor strains and temperature changes, earthquake engineering, offshore energy and energy in buildings.
- Environmental Engineering research includes the development of computer simulations for water/wastewater treatment, water re-use from wastewater and sludge; and wastewater treatment.
- Geotechnical engineering research on ground improvement, piling, micro-tunnelling and stabilised soil blocks.
- Transport Engineering research focuses on improved sustainability in the transport system - design of walking and cycling infrastructure; urban planning, pedestrianisation and shared spaces; permeability and connectivity of the built environment; and road materials testing.

Trinity College Dublin (TCD)

TCD research focuses on energy recovery, environmental research, structures research and construction materials. Examples include:

- Structural reliability (bridges, wind turbines) – foundations, impact of structural dynamics & vibrations, probabilistic analysis.
- Novel concrete reinforcement systems.
- Material research – biomaterials, mortars, concrete.

TU Dublin

TU Dublin construction research focuses on renewable energy, materials including concrete formulation and structures (e.g. traffic loading on bridges).

8 Public research ecosystem

Enterprise Ireland Technology Centres enable Irish companies and multinationals to work together on market focused strategic R&D projects in collaboration with research institutions

Enterprise Ireland Technology Centres

Ireland has created significant research capabilities in centres of scale and excellence. These research centres engage in collaborative research and partner with industry to address specific research and development needs. These centres also have significant experience in engaging in collaborative EU-funded research projects.

The Technology Centre programme is a joint initiative between Enterprise Ireland and IDA Ireland. It allows Irish companies and multinationals to work together on market focused strategic R&D projects in collaboration with research institutions. The 8 Technology Centres in the programme are resourced by highly-qualified researchers who provide a unique ecosystem for collaboration in areas identified by industry as being strategically important. In regard to the research and development of construction technologies, there are currently four centres which have links to construction technology research and development.[17]

CeADAR – Ireland's Centre for Applied AI

- A market-focused technology centre that drives the accelerated development and deployment of data analytics and machine intelligence (DA&MI) technology and innovation.
- Focuses on developing tools, techniques and technologies that enable more people, organisations and industries to use analytics and machine intelligence for better decision making and competitive advantage.
- Acts as the bridge between the worlds of applied research in data analytics and machine intelligence (DA&MI) and their commercial application.
- The primary outputs of the Centre are prototypes, and demonstrators, alongside contract research plus in-depth reviews of state-of-the-art technology.
- CeADAR is funded by Enterprise Ireland, IDA Ireland and by contract research. The Centre is headquartered in University College Dublin and is a partnership with the Technological University Dublin.

LEARNOVATE

- One of Europe's leading research and innovation centres in learning technologies. An industry-led technology centre funded by Enterprise Ireland and hosted by Trinity College Dublin.
- Connect world-class research with entrepreneurs at the leading edge of the global learning technologies sector.
- Has a core of technology-enhanced learning expertise and a wealth of experience in learning design, product design, user interface design, software development and business innovation including: Technology – AI, API's, NLP, Cloud, Machine Learning Design – Needs Analysis,
- Learnovate offers strategic research and innovation services to individual companies that develop learning technologies; and companies that acquire and use learning technologies. The centre's expertise and experience encompass a wide range of learning contexts including corporate learning, higher-ed learning, school learning, and non-formal learning.

MCCI – Microelectronic Circuits Centre Ireland

- MCCI is a technology centre focused on carrying out microelectronic circuit research for the benefit of industry and is a world leader in analogue and mixed-signal integrated circuit research.
- MCCI's visions emphasises high impact research outcomes, but beyond that the development of researchers into independent thinkers and future leaders in Irish companies and in the global semiconductor landscape.
- MCCI values the trusted networks of industry led collaborative research and commits to timely execution that benefits not only our industry partners, but which contributes fundamentally to a better, more prosperous society.

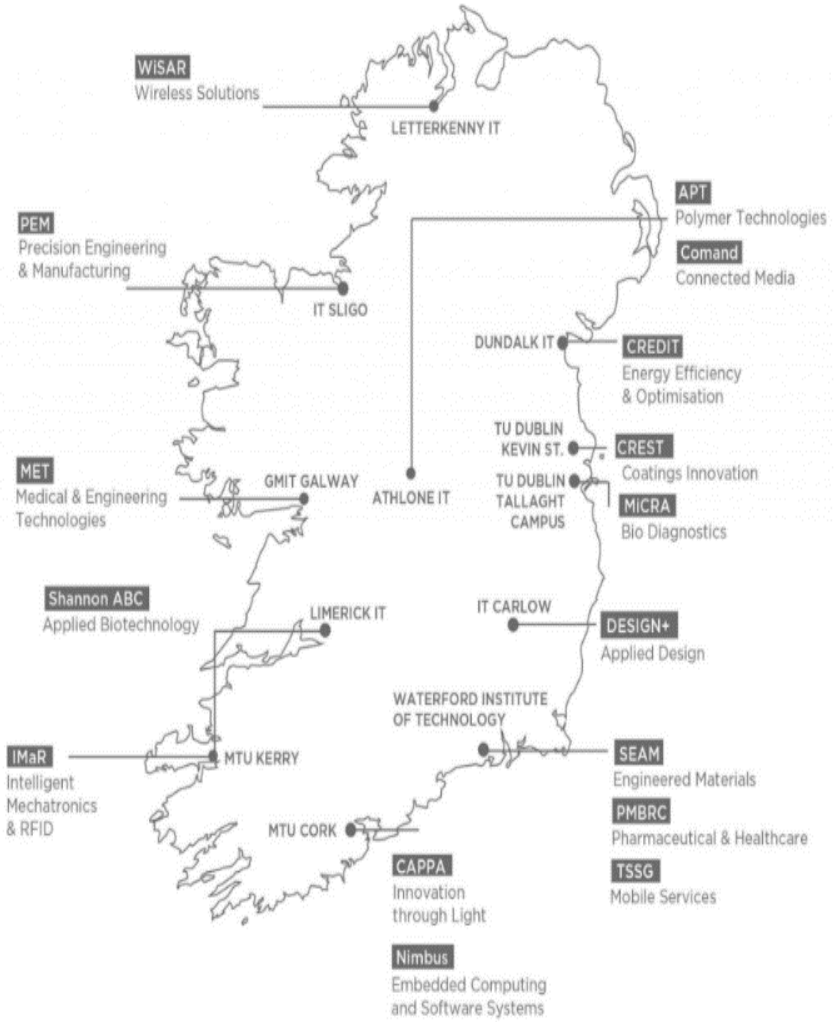
IRISH MANUFACTURING RESEARCH

- An independent manufacturing and industrial energy efficiency research centre focused on delivering solutions for the manufacturing ecosystem throughout Ireland.
- IMR offers manufacturing industry a unique environment to collaborate with peers across all manufacturing sectors, and to inform and guide manufacturing research that not only addresses industry problems but also visions for future factories.
- IMR is a cross-sectoral research centre with partner companies in semiconductors, ICT, pharmaceuticals, medical devices, food, energy services, aerospace and other areas.

8 Public research ecosystem

Enterprise Ireland Technology Gateways

Enterprise Ireland Technology Gateways: Enterprise Ireland Technology Gateways work in partnership with Institutes of Technology and Technological Universities across Ireland. Consisting of 16 specialised Gateways and 3 sectoral clusters, the Technology Gateway Network delivers innovation expertise and solutions for Irish industry. There are 11 gateways which currently have links to the construction technology sector across two clusters.[18]



Engineering, Materials and Design Cluster

APT: The APT Gateway is based on the Athlone Institute of Technology campus. APT is providing polymer technology solutions for companies in the medical, composite, recycling and pharmaceutical sectors. Expertise includes Advanced Analytical Facilities for materials research, testing and troubleshooting, Design, Rapid Prototyping, Insert Tooling and Micro-Moulding Capabilities, Unrivalled Polymer Materials Formulation and Development Expertise.[19]

CREST: The CREST Technology Gateway is the only dedicated surface coatings laboratory on the island of Ireland. CREST operates within a certified ISO 9001 Quality Management System and provides a range of consultancy services to over 100 companies per year, from Irish SMEs to multinationals. Expertise includes: Protective coatings for challenging environments, Surface treatment of metal components, Coatings for environmental application and Biomedical devices.[20]

Design: The Design+ Gateway, based in Institute of Technology Carlow, applies industrial design capabilities for companies from the engineering, ICT & software and bio life science sectors nationally. Expertise includes: Design: Product Design, Prototype design, 3D Printing, Design Strategy, Engineering: Prototype design and scale to manufacture, ICT & Software: Integration of user experience and interface design and Bio life sciences: Product design orientated around end-user needs.[21]

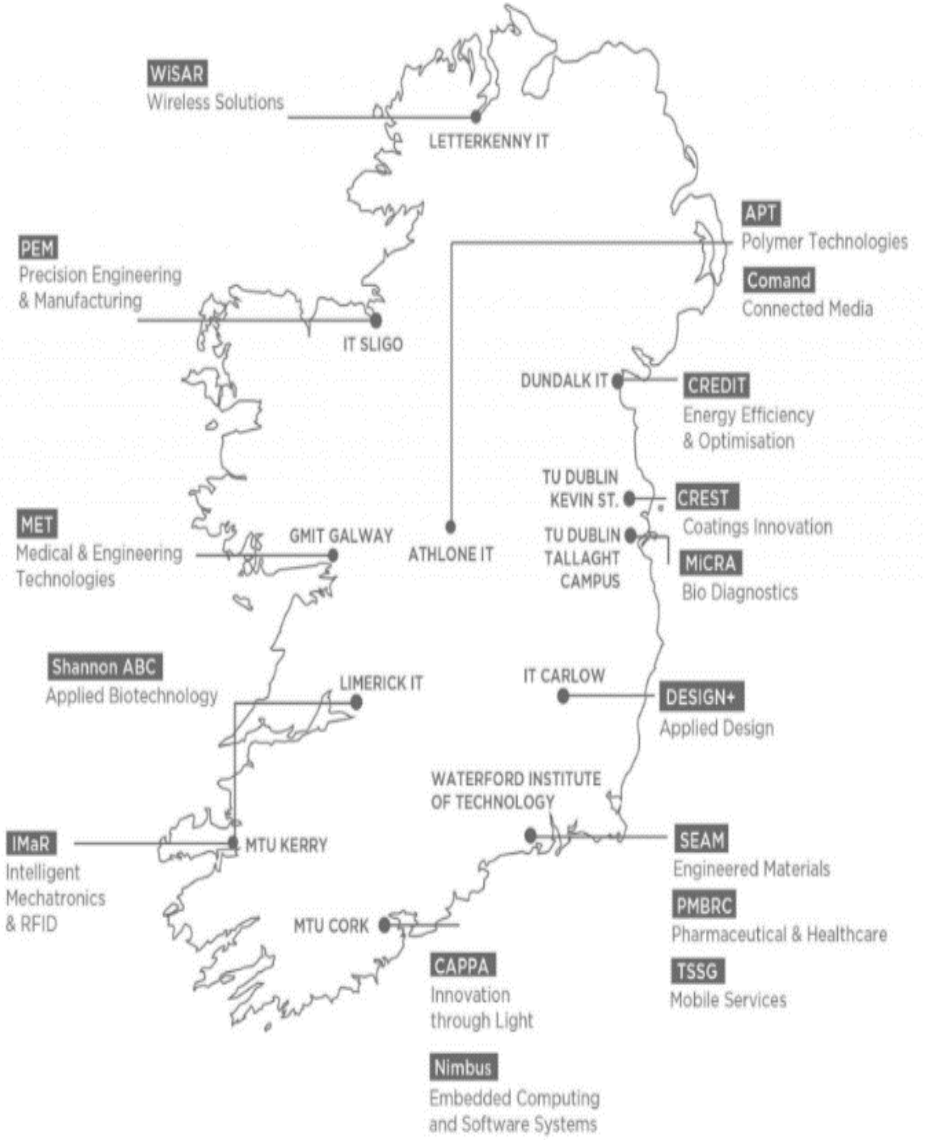
MET: The MET Gateway, based in Galway-Mayo Institute of Technology, offers cutting-edge, industry focused solutions for Start-Ups, SMEs and larger organisations across the MedTech, Engineering and Lifesciences sectors. Expertise includes: Data analytics and visualisation.[22]

PEM: The PEM Gateway, based in the Institute of Technology Sligo provides Industry-focused research and development of precision engineering, manufacturing and materials technologies and innovation. Expertise includes: Product Development & Design, Manufacturing Operations and Materials Development.[23]

SEAM: The SEAM Gateway, based in Waterford Institute of Technology, provides engineering material solutions for industry in sectors such as biomedical devices, pharmaceuticals, micro-electronics, precision engineering & construction. Expertise includes: Finite element analysis: 3D software modelling 3D metal additive manufacturing, Materials and Biomedical engineering.[24]

8 Public research ecosystem

Enterprise Ireland Technology Gateways



The Internet of Things (Sensors) Cluster

COMAND: Connected Media Application Design and Delivery Gateway. Hosted by Athlone Institute of Technology.* The COMAND Technology Gateway focuses on the research and development of prospective interactive media technologies. Expertise includes: real time data analytics, interoperability of the internet of things and multimodal interfacing.COMAND works closely with industrial collaborators in all sectors of connected media applications delivery and provides to companies from start ups and SMEs to multinationals.[25]

IMaR: The IMaR Technology Gateway, based in MTU Kerry, applies its core expertise in electronics, mechatronics, automation technologies, software, IoT, RFID and data analytics to address process and product innovation requirements of enterprises. Expertise includes: Intelligent and connected smart sensors and devices, Internet of Things (IoT) and Automation and robotics.[26]

Nimbus: Cork, is the industry interface for the Nimbus group. The Gateway develops Internet of Things (IoT) and Cyber Physical System prototypes for a broad range of companies, connecting everyday objects and systems and making them smart. Expertise includes: Virtual and augmented reality, Data analytics and User Interface.[27]

TSSG: The TSSG Gateway, based in Waterford Institute of Technology, is a one-stop-shop for industry to access cutting knowledge and solutions in advanced mobiles services and service enablers. Expertise includes: Virtual and augmented reality services.[28]

WiSAR: The WiSAR Gateway, based in Letterkenny Institute of Technology, provides solutions to Irish industry for the Internet of Things (IoT) using expertise in wireless, embedded systems and power electronics. Expertise includes: Internet of Things.[29]

* The Athlone Institute of Technology is a constituent institute of the Technological University of the Shannon, located in Athlone, Ireland. The institute merged with the Limerick Institute of Technology to form Ireland's third technological university, which started operations in October 2021.

8 Public research ecosystem

SFI Research Centres

SFI Research Centres: SFI is the national foundation for investment in scientific and engineering research. Its remit includes the investment in academic researchers and research teams who are most likely to generate new knowledge, leading-edge technologies and competitive enterprises in the fields of science, technology, engineering and maths (STEM). SFI also advances co-operative efforts between education, government and industry.

There are 12 world leading SFI Research Centres each of a scale spanning several Higher Education Institutions (HEIs), with an investment over six years of €355m from government through SFI and a further €190m from industry collaborators. The centres have over 200 industry partners and focus on strategically important areas for Ireland, including: pharmaceuticals, software, digital content, big data, telecommunications, applied geosciences and more.[30]

There are four research centres which are linked to the construction sector and technology: MaREI,[31] iFORM,[32] AMBER[33] and iCRAG.[34]

MaREI

MaREI is the SFI Research Centre for Energy, Climate and Marine research and innovation co-ordinated by the Environmental Research Institute (ERI) at University College Cork. The Centre comprises over 220 researchers focusing on defined global challenges such as the Energy Transition, Climate Action and the Blue Economy.

iFORM

I-Form brings together a nationwide pool of expertise in materials science, engineering, data analytics and cognitive computing. I-Form is applying developments in digital technologies to materials processing, to improve understanding, modelling and control, thus increasing the competitiveness of Irish manufacturing.

Research Focus areas:

- Data analytics, enabling real-time process feedback
- Augmented reality, for enhanced operator decision-making
- Additive manufacturing (3D printing).

AMBER

The SFI Research Centre for Advanced Materials and Bio-Engineering Research is a dynamic, multidisciplinary partnership between world-leading material scientists, bioengineers and industry. They work to address fundamental research questions and create solutions with impact for society in ICT, MedTech, energy and sustainable industrial technologies.

iCRAG

iCRAG is the SFI Research Centre for Applied Geosciences.

They develop innovative science and technologies to better understand the Earth's past, present, and future and how people are connected to it

Work includes enabling methodologies in the areas of geophysics, geochemistry and 3D modelling, along with our research on the public perception and understanding of geosciences.

8 Public research ecosystem

The public research ecosystem must cater for the domestic construction sector

The quality of Ireland's research ecosystem is critical in terms of the country's reputation as an innovation leader and its ability to attract overseas investment. Ireland, over several decades, has attracted global leaders in a range of sectors including Pharmaceuticals, Biotechnology, Medical Devices, ICT and Financial Services.

Recently, Ireland signed up to landmark reforms for a global minimum corporate tax rate of 15%, up from the current level of 12.5%, in the biggest shift for the country's tax system in almost 20 years. Therefore, the level of innovation and the availability of a highly skilled, highly educated workforce becomes even more important if Ireland is to stay ahead of the curve.

Whilst Ireland's highly skilled workforce and strong levels of STEM graduates are creating jobs in foreign direct investment companies as well as domestic companies, this creates a challenge in terms of providing suitable accommodation and infrastructure for those looking to work in these companies.

The demands on the construction sector have never been higher and the rationale for a joined-up approach to Research, Development and Innovation to deliver productivity in the sector has never clearer.

The National Construction Research, Development, Innovation, Education and Training ecosystem is relatively fragmented for a small country. It includes Enterprise Ireland Technology Gateways, EI/IDA Technology Centres and SFI Centres as well as research in 3rd Level institutions such as UCD, NUIG, TCD and TU Dublin and an estimated 44 construction undergraduate courses in 12 institutions plus apprenticeship and training offerings.

To deliver technological advances for the future of the Construction sector, it will be necessary to continue to invest in and develop the country's innovative capacity.

The avoidance of short term or stop-start cycles will be required to protect and develop the public research ecosystem.

Ensuring that research institutions have access to long term flexible investment and funding to develop long term strategic goals and objectives will be important.

The processes for approval of funding can sometimes take a long time, and this could potentially deter investors, researchers and enterprises from taking part in innovation initiatives.

Collaboration is key to improving the research ecosystem and it will be important to continue to build strong working relationships between business, academia and government in Ireland and also to develop international collaboration, relationships and partnerships.

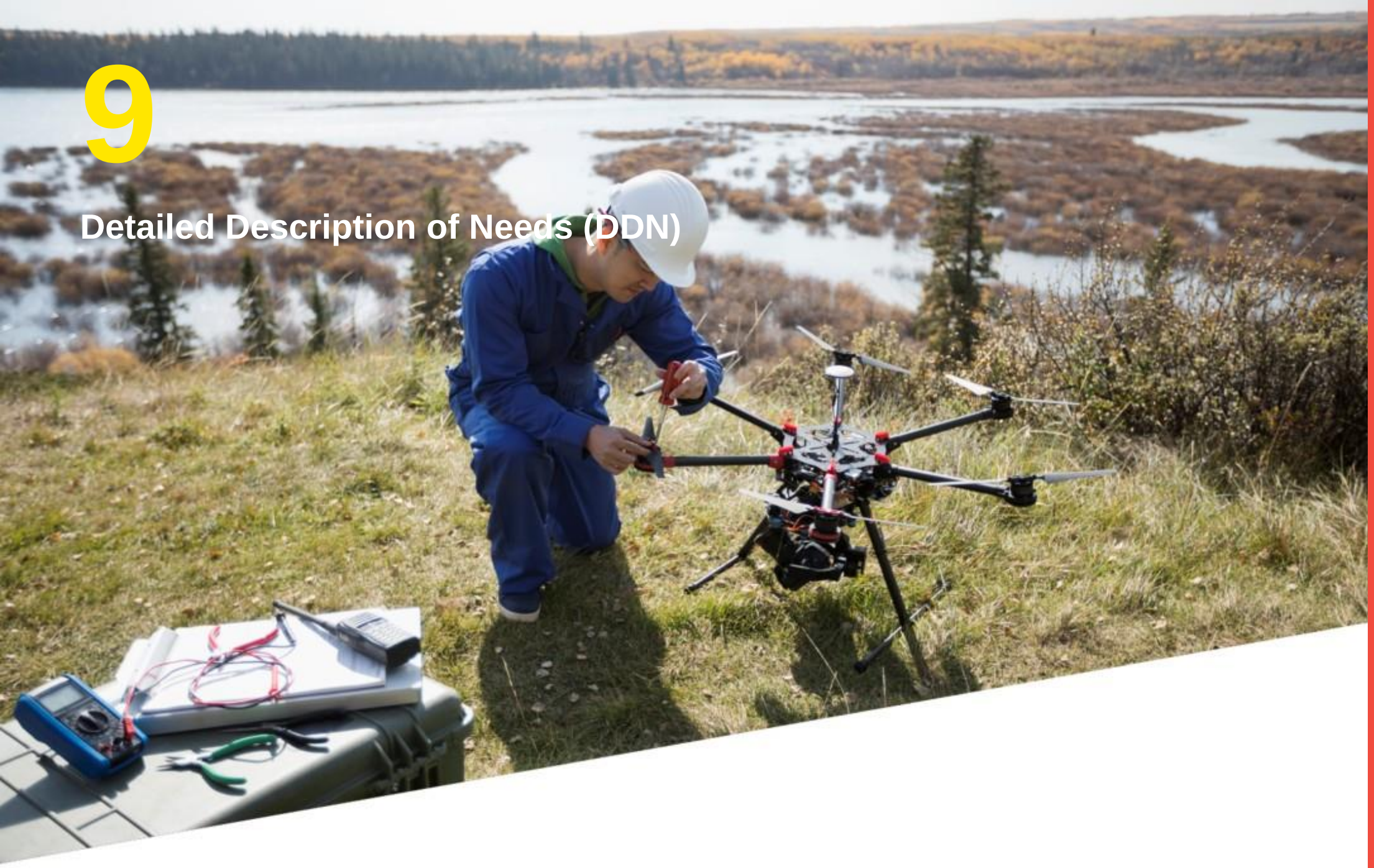
The Public Research ecosystem is also vital in supporting businesses in attracting, growing and developing their R&D workforce, matching their needs with provision and upskilling their management practices and leadership teams.

The primary and post primary education curriculums need to be monitored, and the opportunities for careers in construction related roles need to be highlighted, particularly in relation to gender balance.

There is an opportunity to support entrepreneurs and start-ups and increase capital flow into firms carrying out R&D.

9

Detailed Description of Needs (DDN)



9 Detailed Description of Needs (DDN)
Key observations

The DDN establishes the needs and current challenges amongst construction firms and stakeholders with respect to the adoption of innovation, digitalisation and digital systems and technology.

The most important role of the DDNs is to inform decisions on the interventions required to improve innovation, competitiveness, and productivity in the construction sector.

Key findings are as follows:

- There is a strong willingness to collaborate for RD&I across the representative firms by main activity; architects had the lowest response at 88% stating a 'yes' or 'maybe' willingness to collaborate.
- The capacity to allocate personnel time to undertake collaborative R&D varied between 24% (Consulting Engineers) and 80% (Tech start-ups). Excluding Tech start-ups, the activity with the highest percentage with respect to the capacity to collaborate on personnel was Main Contractors (51%).
- The capacity to allocate funding for R&D work varied between 14% (Architects) and 60% (Tech start-ups). Excluding Tech start-ups, the activity with the highest percentage with respect to the capacity to collaborate on funding was Materials Manufacturers (55%).

An interesting observation from the Heatmaps (pages 165 and 166), which show how a Centre could help stakeholders and firms, is that stakeholders strongly believe a Centre can benefit the industry whereas the firms appear to be less convinced of the benefits. This may be a reflection of the lack of understanding of the role of a Centre in helping the industry as well as the overall low adoption levels of technology, digitalisation and modern methods of construction which are evident from the firms' survey. This suggests that stakeholders have a body of work to do to engage with their members to drive the initiative.

A number of the findings in the surveys helped inform the recommendations for the Centre based on how firms and stakeholders say the Centre could benefit them. These results were (aggregating the 'moderate', great' and 'very great' extent responses):

- Both firms (89%) and stakeholders (100%) mentioned relevant training as a key area they would like to see the Centre focus on
- Both firms (79%) and stakeholders (100%) mentioned funding as a key area they would like to see the Centre focus on
- 78% of firms mentioned introductions to like-minded firms
- 75% of firms said a technology sandbox would benefit them to (i.e. a place to explore the latest technologies without having to purchase them)
- However, 52% of firms were not interested in Robotics/Automation and 50% were not interested in Materials Prototyping.
- Stakeholders were generally positive about most of the elements provided in the survey. The elements they were least positive about the Centre supporting them on were Materials Prototyping (19% said it would benefit to some extent), Network based technologies (16%) and Robotics and Automation (15%).

The following challenges to implementing new technologies were noted by small and micro firms:

- 57% of small firms and 59% of micro firms mentioned 'other priorities' with running their day-to-day businesses
- 41.5% of small firms and 51% of micro firms mentioned a 'lack of time'
- 32% of small firms and 47% of micro firms mentioned a 'lack of budget'

The Centre needs to cater for the above firms in particular, while also catering for medium (employ 50-249) and large (employ 250 and above) enterprises. Only by having all enterprises on board, can the success of the Centre be guaranteed, and the productivity of the industry be raised.

9 Detailed Description of Needs (DDN)

The Detailed Description of Needs builds a representative persona for each stakeholder group and firm by main activity

This section of the report presents a Detailed Description of Needs (DDN) for each stakeholder group and for firms categorised by their main activity. The data from a stakeholder survey and a firms' survey has been analysed and used to build profiles (personas) for the key players in the sector. The purpose of completing this exercise is to use the DDN's to inform part of the specifications to consortia of Research Providing Organisations in Ireland who will bid to supply their expertise in the formation of a Construction Technology Centre.

Enterprise Ireland is the State agency responsible for the provision of funding and supports for companies and researchers to develop new technologies and processes. This DDN exercise normally occurs as part of the scoping exercise for an Enterprise Ireland/IDA Technology Centre. In the construction sector, the establishment of a Technology Centre for Construction would be expected to lead to improved business processes and increased exports with the support of research on digital technologies and innovation.

This DDN study is being undertaken by Enterprise Ireland for a number of reasons:

- To establish the extent to which there is a culture of innovation in the broader construction sector,
- To establish the needs and current challenges amongst construction stakeholders with respect to the adoption of innovation, digitalisation and digital systems and technology,
- To ascertain if significant numbers of stakeholders have the capacity and appetite for co-funding research on a collaborative basis with all to invest in innovation and personnel, subject to their being a solid business case for doing so and
- To recommend and inform decisions on the interventions required to improve innovation, competitiveness and productivity in the construction sector.

Figure 26 provides a breakdown of the 30 DDNs that have been prepared for this study, comprising 11 by main activity for the firms surveyed and 21 for the stakeholders.

Figure 26: Detailed Description of Needs for Personas

Firms with main activities	
Architecture	Structural and Civil Engineering
Consulting Engineering	Sub-Contractor
Developer	Tech Start-up
Main Contractor	Trades (carpentry, bricklaying, plumbing, electrics)
Materials Manufacturers	Others (see footnote page 121)
Off- Site/ Modern Methods of Construction	

Stakeholder groups	
Alliance of Specialist Contractors Association	Irish Hardware Association
Association of Consulting Engineers of Ireland	Irish Homebuilders Association
BRE Global Ireland	Irish Timber Frame Manufactures Association
Centre for Excellence in Universal Design	Lean Construction Ireland
Civil Engineering Contractors Association	Master Builders' and Contractors' Association
Construction Industry Federation	Mechanical and Electrical Contractors Association
Construction IT Alliance	National Standards Authority of Ireland
Engineers Ireland	Property Industry Ireland
Enterprise Ireland	Royal Institute of Architects Ireland
IDA Ireland	Society of Chartered Surveyors Ireland
Irish Green Building Council	

9 Detailed Description of Needs (DDN)

Small and micro enterprises in the domestic construction sector state that they don't have the time or the budget to implement new technologies; the Centre needs to prioritise this group

The purpose of the DDN is to establish the needs and current challenges amongst construction firms with respect to the adoption of innovation, digitalisation and digital systems and technology. It also seeks to ascertain if significant numbers of firms have the capacity and appetite to commit co-funding and personnel to collaborative projects, subject to their being a solid business case for doing so.

The following pages set out:

- The DDN for a total of 21 stakeholders, comprising the 26 unique responses to the survey; with a page for each stakeholder *
- The DDN for 11 main activities, based on 250 of the 260 firms that were surveyed; with two pages for each activity**
- The 30 DDN (comprising 41 pages) are followed by three heatmaps which summarise the following:
  - The elements of a Centre that could assist the clients of stakeholders
  - The elements of a Centre that firms stated a Centre could assist them with
  - The issues on which stakeholders engages with their members firms

The most important role of the DDNs is to inform decisions on the interventions required to improve innovation, competitiveness, and productivity in the construction sector. There is now an opportunity to establish the right technical infrastructure to support and drive growth in the construction and built environment sectors. In this regard a number of questions arise in relation to the planning and design of a Construction Technology Centre, namely

- Who are the target clients for the Construction Technology Centre?
- What are the competencies that these clients need as they seek to digitally transform their businesses and start their innovation journey?
- Related to the above, what are the key areas that a Centre could assist these enterprises with?
- What interventions are required from the State to ensure all enterprises in the domestic construction sector (DCS), regardless of scale, are on board the innovation journey?
- Who takes responsible for enabling the Centre and under what policy does it lie?
- Finally and critically, what funding is put in place to ensure that it is well funded and can sustain the DCS on its innovation journey over the next decade and beyond?

Specifically, the focus needs to be on the domestic construction sector (DCS) and on those enterprises which don't have the time to implement new technologies. There needs to be a strategy for these micro (employ <10) and small (employ 10-49) firms which between them make up the vast bulk of construction enterprises (99.7%). The following challenges to implementing new technologies were noted by these firms:

- 57% of small firms and 59% of micro firms mentioned 'other priorities' with running their day-to-day businesses
- 41.5% of small firms and 51% of micro firms mentioned a 'lack of time'
- 32% of small firms and 47% of micro firms mentioned a 'lack of budget'

The Centre needs to cater for the above groups in particular, while also catering for medium (employ 50-249) and large (employ 250 and above) enterprises. Only by having all enterprises on board, can the success of the Centre be guaranteed, and the productivity of the industry be raised.

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* A total of 21 stakeholders were surveyed. Allowing for those for which more than 1 person responded, there were 26 unique responses in total. A DDN is provided for all of the 21 stakeholders. There was one case (SCSI) where one person responded on behalf of 3 stakeholders, which generated two additional responses.

** Of the remaining 10 firms, none reached the minimum response number of 5 to be classified as an activity. The following activities represent the 10 firms which were not included in the DDNs:

- Fire Safety, Life Safety Systems
- Facilities Management
- Finance/Investment
- Planning
- Assigned Certifier
- Government Contracting Authority

9 Detailed Description of Needs (DDN)

There is a strong willingness amongst firms to collaborate for RD&I

From the analysis of the DDN presented, it is evident from the 11 main activities analysed that:

- There is a strong willingness to collaborate for RD&I across the representative firms by main activity; architects had the lowest response at 88% stating a 'yes' or 'maybe' willingness to collaborate.
- The capacity to allocate personnel time to undertake collaborative R&D varied between 24% (Consulting Engineers) and 80% (Tech start-ups), while the capacity to allocate funding for R&D work varied between 14% (Architects) and 60% (Tech start-ups). Excluding Tech start-ups, the activity with the highest percentage with respect to the capacity to collaborate on personnel was Main Contractors (51%) and on funding was Materials Manufacturers (55%).
- There was a notable gap for the main activity groupings between firms using automated technologies today – Tech start- ups, Main Contractors, Trades, Developers all responded with at least one technology which was used by 80% of the respondents, while usage rates of less than 50% for at least one automated technology were reported by Architects and 'Others'
- The activities reporting the highest use of some form of MMC methods were Off-Site manufacturers (85% panelised systems and 70% sub-assemblies) and Structural and Civil Engineers (63% volumetric or modular systems).

From the analysis of the DDNs presented for the 19 stakeholders:

- There were mostly 'yes' responses to the willingness to collaborate, apart from five who responded with 'maybe'.
- Most responded on the capacity to allocate funding to undertake collaborative R&D with 'moderate extent' or higher apart from the RIAI (not sure), NSAI and IHBA (some extent), Master Builders' and Contractors' Association and Civil Engineering Contractors Association (Not at all).
- Most responded on the capacity to allocate personnel time to undertake collaborative R&D with 'moderate extent' or higher apart from the RIAI (not sure) and the Master Builders' and Contractors' Association and the Civil Engineering Contractors Association (some extent).

9 Detailed Description of Needs (DDN)

Firms: Architecture

Survey profile

50
member firm responses to survey (19% of total responses)

92%
of firms had less than 50 employees

Turnover

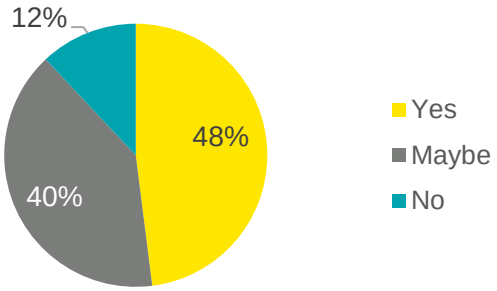
81%
of turnover of firms generated by:

1. New residential buildings
2. Renovation, Maintenance, and refurbishment (all buildings)
3. Commercial Buildings

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Lack of time

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

26%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

14%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Funding
3. Creation of a mentor network

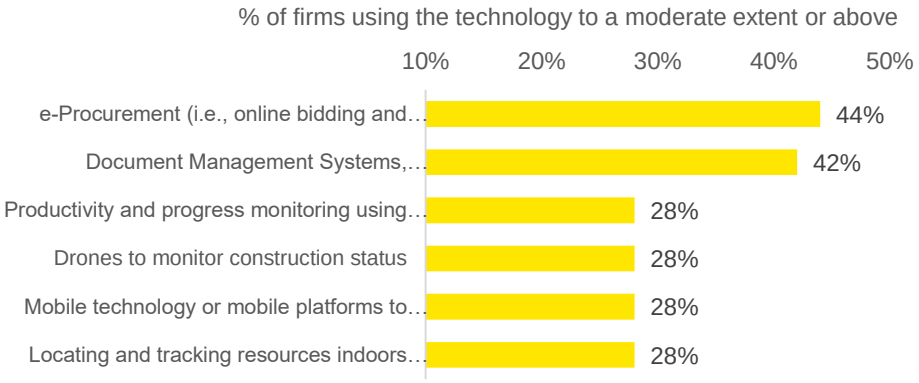
Least important elements

1. Robotics / Automation
2. Network-based technologies (e.g. blockchain)
3. Material Prototyping

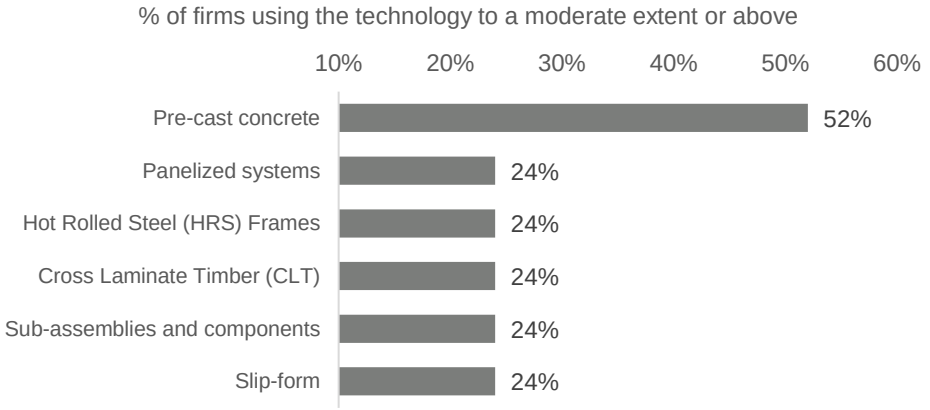
9 Detailed Description of Needs (DDN)
Firms: Architecture

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption

1. Digitisation of the Planning Process
2. Digital Education and Training
3. Business Information Modelling (BIM)

Technology and Innovation

1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction

1. Design Aesthetic and Functionality
2. Innovative Materials/Sustainable Materials

Commentary

- The survey suggested that the majority (48%) of firms within Architecture are willing to collaborate with others in regard to RD&I
- The top challenges when implementing new technologies cited by Architecture firms were Other priorities (e.g. day-to-day running of the business) and lack of time.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, funding and the creation of a mentor network.
- Only 14% of Architects surveyed stated that they could allocate funding to undertake collaborative R&D, whilst 26% stated that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)
Firms: Consulting Engineering

Survey profile

33
member firm responses to survey (13% of total responses)

48%
of firms had less than 50 employees

Turnover

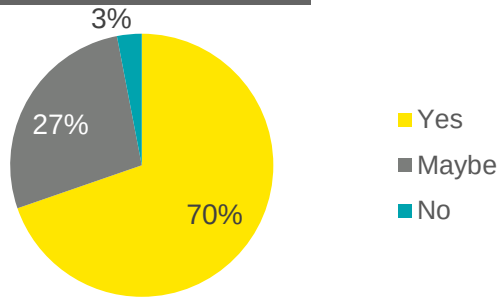
61%
of turnover of firms generated by:

1. Infrastructural Projects (e.g. civil and structural engineering)
2. New residential buildings
3. Industrial Projects (e.g. pharma plant, data centre, etc.)

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Lack of time

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

24%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

15%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Funding
3. Technology sandbox*

Least important elements

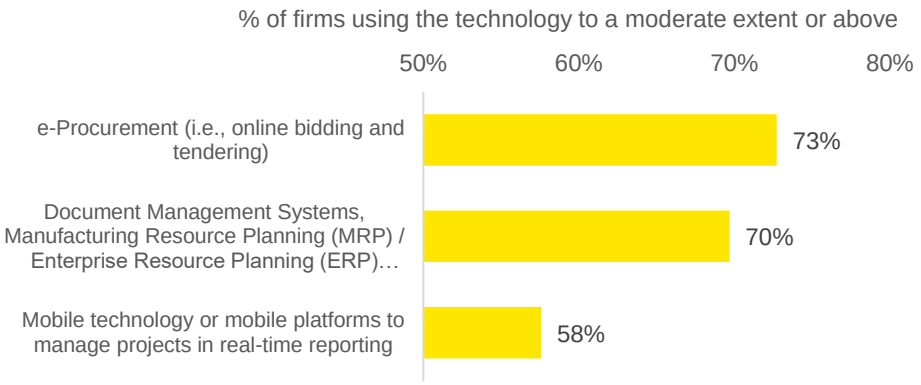
1. Material Prototyping
2. Modular Assemblies
3. Robotics / Automation

*a place to explore the latest technologies without having to purchase them

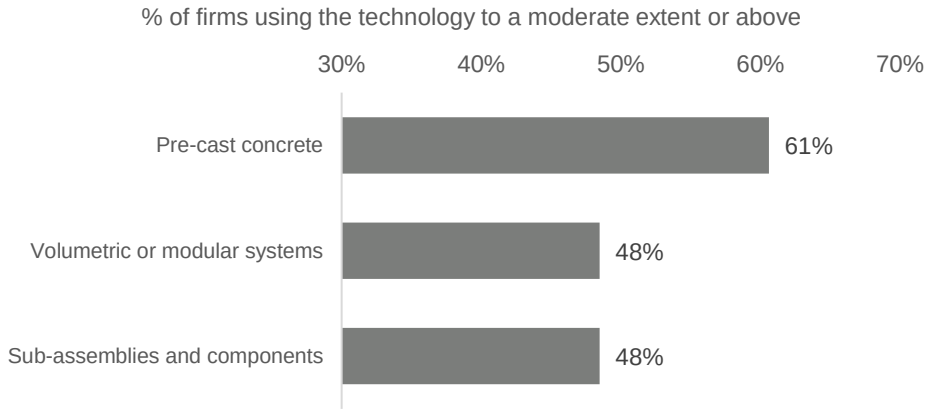
9 Detailed Description of Needs (DDN)
Firms: Consulting Engineering

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Digital Standards
2. Business Information Modelling (BIM)

Technology and Innovation
1. Sustainability and Energy
2. Data Analytics and Artificial Intelligence

Modern Methods of Construction
1. Whole Life Performance of Buildings
2. Modular Construction / Modular Components

Commentary

- The survey suggested that the vast majority (70%) firms within Consulting Engineering are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by those firms within Consulting Engineering were Other priorities (e.g. day-to-day running of the business) and lack of time.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, funding and the creation of a technology sandbox.
- Only 15% of Consulting Engineers surveyed stated that they could allocate funding for collaborative R&D, whilst 24% stated that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)
Firms: Developer

Survey profile

9
member firm responses to survey (3% of total responses)

67%
of firms had less than 50 employees

Turnover

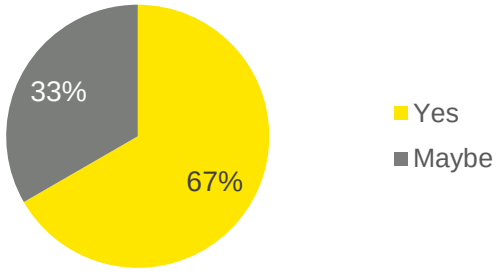
100%
of turnover of firms generated by:

1. New Residential Buildings
2. Renovation, Maintenance, and refurbishment (all buildings)
3. Commercial Buildings (e.g. offices, retail, etc.)

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Lack of time

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

33%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

22%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Technology sandbox*
3. Hub for prioritised processes

Least important elements

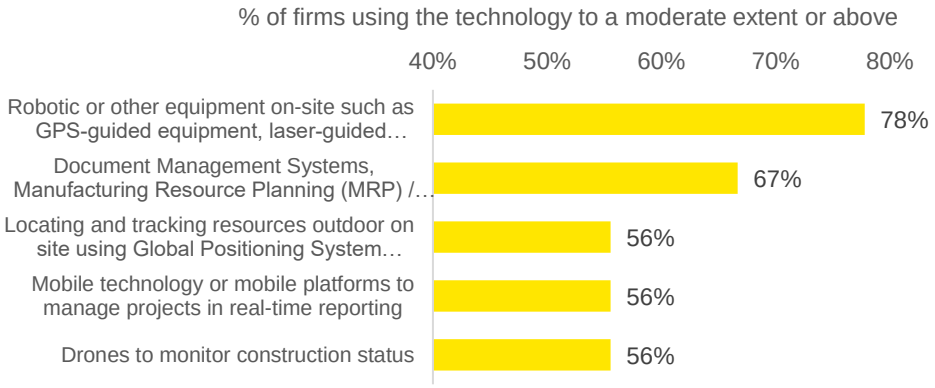
1. Robotics / Automation
2. Network-based technologies (e.g. blockchain)
3. Funding

*a place to explore the latest technologies without having to purchase them

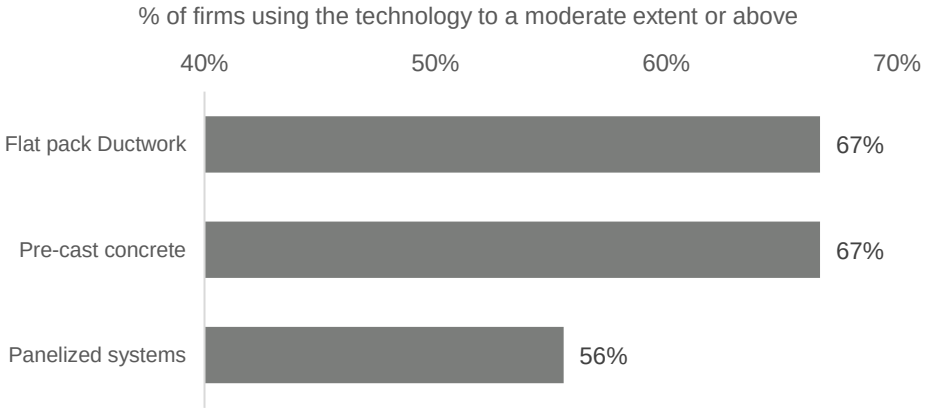
9 Detailed Description of Needs (DDN)
Firms: Developer

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Digitisation of the Planning Process
2. Digital Education and Training

Technology and Innovation
1. Cloud Cybersecurity and Blockchain
2. Materials Performance

Modern Methods of Construction
1. Whole Life Performance of Buildings
2. Design Aesthetic and Functionality

Commentary

- The survey suggested that the vast majority (67%) of Developers are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by developers were other priorities (e.g. day-to-day running of the business) and lack of time.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, the creation of a technology sandbox and the creation of a Hub for prioritised processes.
- Around 1 in 5 (22%) of Developers reported that they could allocate funding for collaborative R&D, whilst 1 in 3 stated that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Main Contractor

Survey profile

41
member firm responses to survey (16% of total responses)

24%
of firms had less than 50 employees

Turnover

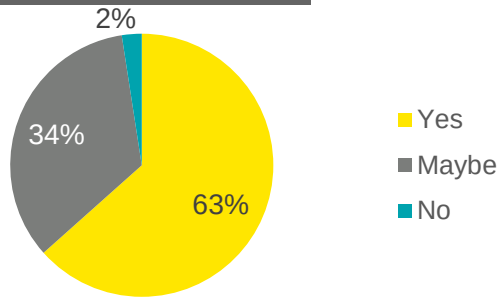
51%
of turnover of firms generated by:

1. Commercial Buildings
2. Infrastructural Projects (e.g. civil and structural engineering)
3. New residential buildings

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Lack of financial incentives to embrace technology

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

51%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

51%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Technology sandbox*
3. Funding

Least important elements

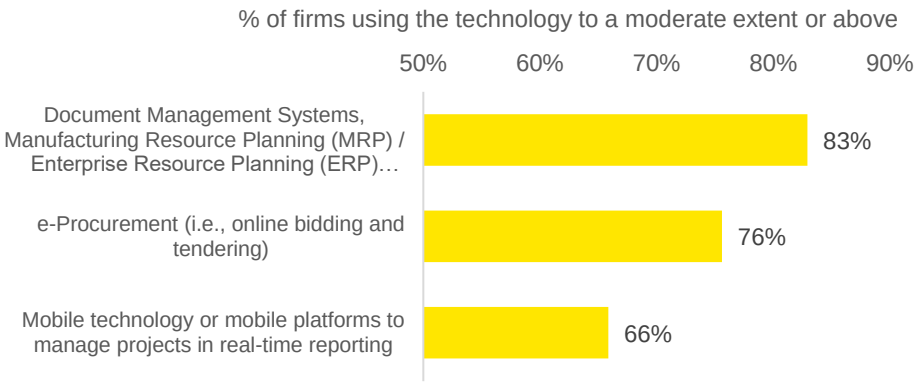
1. Material Prototyping
2. Creation of a mentor network
3. Community of practice (e.g. quarterly meet-ups for special interest groups)

*a place to explore the latest technologies without having to purchase them

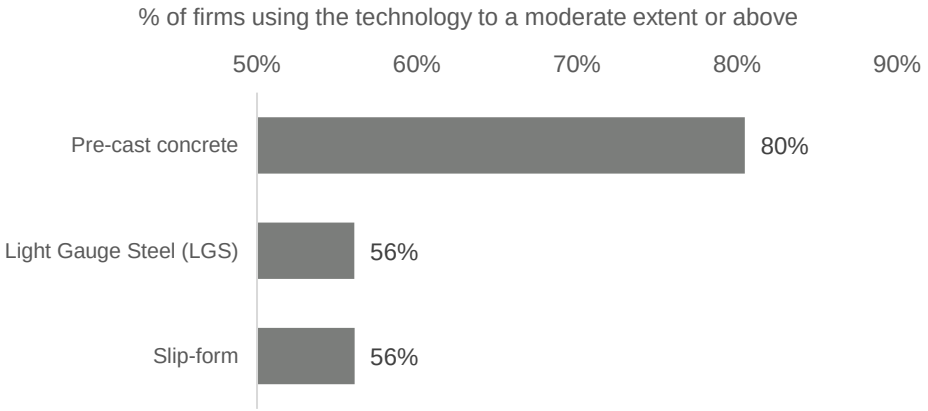
9 Detailed Description of Needs (DDN)
Firms: Main Contractor

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Digital Education and Training
2. Digital Standards

Technology and Innovation
1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction
1. Innovative Materials / Sustainable Materials
2. Integrated Supply Chain

Commentary

- The survey suggested that the majority (63%) of those whose main activity is acting as the main contractor are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by main contractors those were other priorities (e.g. day-to-day running of the business) and a lack of financial incentives to embrace technology.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, the creation of a technology sandbox and funding.
- Over half (51%) of main contractors reported that they could allocate funding for collaborative R&D and that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Materials Manufacturers

Survey profile

29
member firm responses to survey (11% of total responses)

69%
of firms had less than 50 employees

Turnover

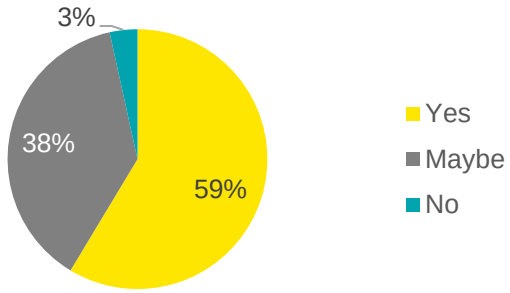
50%
of turnover of firms generated by:

1. Commercial Buildings
2. New residential buildings
3. Industrial Projects (e.g. pharma plants, data centres, manufacturing etc.)

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Limited availability of suitable in-house personnel to deliver new technology successfully

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

45%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

55%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Introductions to like-minded firms
3. Hub for prioritised processes

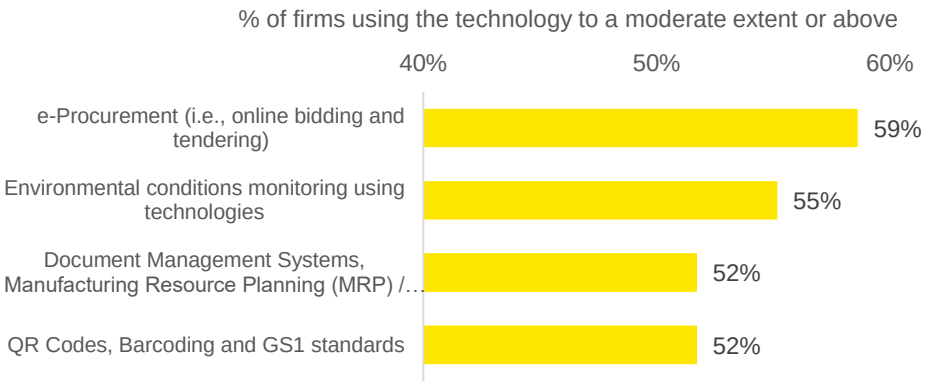
Least important elements

1. Robotics / Automation
2. Network-based technologies (e.g. blockchain)
3. Creation of a mentor network

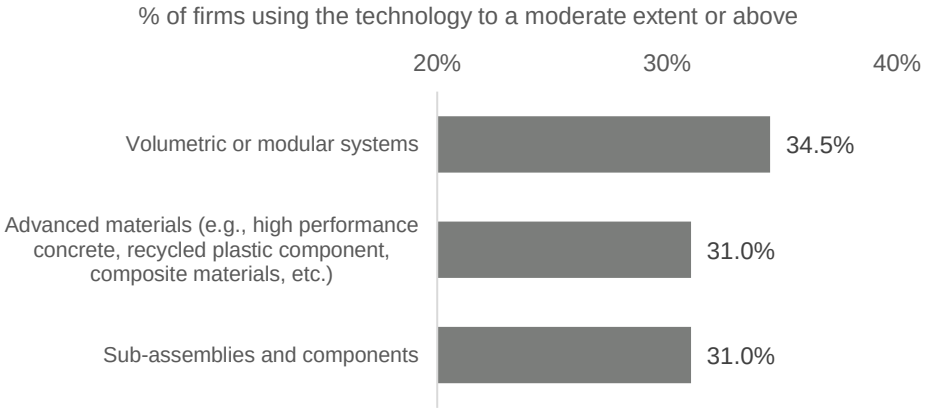
9 Detailed Description of Needs (DDN)
Firms: Materials Manufacturers

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption

1. Digital Education and Training
2. Digitisation of the Planning Process

Technology and Innovation

1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction

1. Innovative Materials / Sustainable Materials
2. Whole Life Performance of Buildings
3. Integrated Supply Chain

Commentary

- The survey suggested that over half (59%) of those firms whose main activity is material manufacturing are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by material manufactures were other priorities (e.g. day-to-day running of the business) and limited availability of suitable in-house personnel to deliver new technology successfully.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, introductions to like-minded firms and the creation of a hub for prioritised processes.
- Over half (55%) of firms reported that they could allocate funding for collaborative R&D and 45% reported that they had the capacity to allocate personnel time to undertake collaborative R&D

9 Detailed Description of Needs (DDN)

Firms: Off-Site/Modern Methods of Construction (MMC)

Survey profile

20
member firm responses to survey (8% of total responses)

50%
of firms had less than 50 employees

Turnover

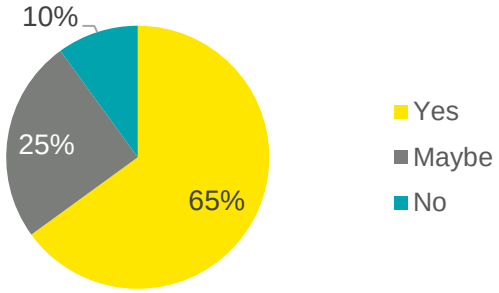
83%
of turnover of firms generated by:

1. New residential buildings
2. Commercial Buildings (e.g. offices, retail, tourism, etc)
3. Infrastructural Projects (e.g. civil and structural engineering)

Top challenges when implementing new technologies

1. Lack of financial incentives to embrace technology
2. Other priorities (e.g. Day-to-day running of the business)

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

45%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

45%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Funding
2. Technology sandbox*
3. Relevant Training/Continuing Professional Development

Least important elements

1. Network-based technologies (e.g. blockchain)
2. Research hub for collaboration at the pre-competitive stage
3. Modular Assemblies

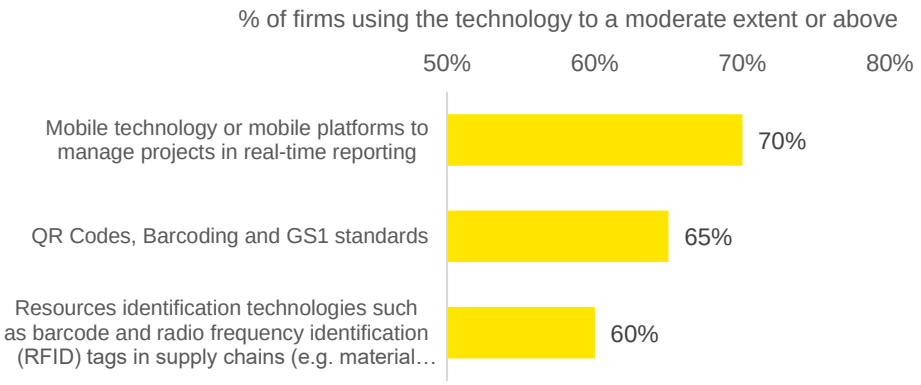
*a place to explore the latest technologies without having to purchase them

9 Detailed Description of Needs (DDN)

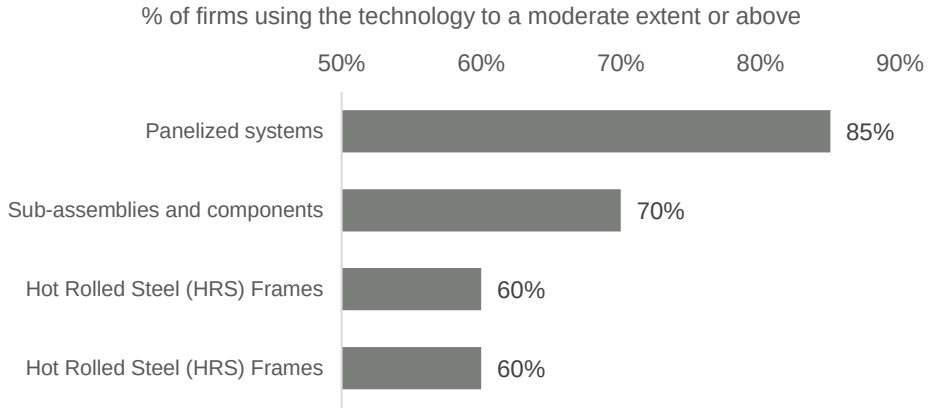
Firms: Off-Site/Modern Methods of Construction (MMC)

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption

1. Business Information Modelling (BIM)
2. Digital Education and Training

Technology and Innovation

1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction

1. Innovative Materials / Sustainable Materials
2. Modular Construction / Modular Components

Commentary

- The survey suggested that a majority (65%) of those firms whose main activity is completing off-site/MMC are willing to collaborate with others in regard to Research, Development, and Innovation.
- The top challenges when implementing new technologies cited by those firms participating in off-site/ modern methods of construction were lack of financial incentives to embrace technology and other priorities (e.g. Day-to-day running of the business).
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were funding, the creation of a technology sandbox and relevant training/ continuing professional development.
- Close to half (45%) of firms reported that they could allocate funding for collaborative R&D and that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Others

Survey profile

30
member firm responses to survey (12% of total responses)

80%
of firms had less than 50 employees

Turnover

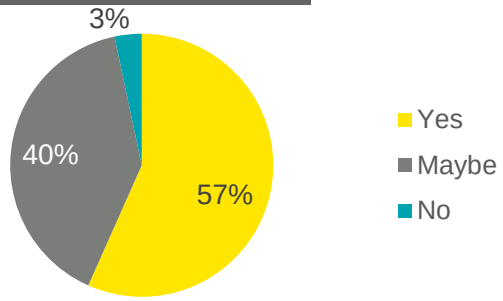
46%
of turnover of firms generated by:

1. Others
2. New residential buildings
3. Renovation, Maintenance, and refurbishment (all buildings)

Top challenges when implementing new technologies

1. Other priorities (e.g. Day-to-day running of the business)
2. Lack of time

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

27%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

23%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Funding
3. Technology sandbox*

Least important elements

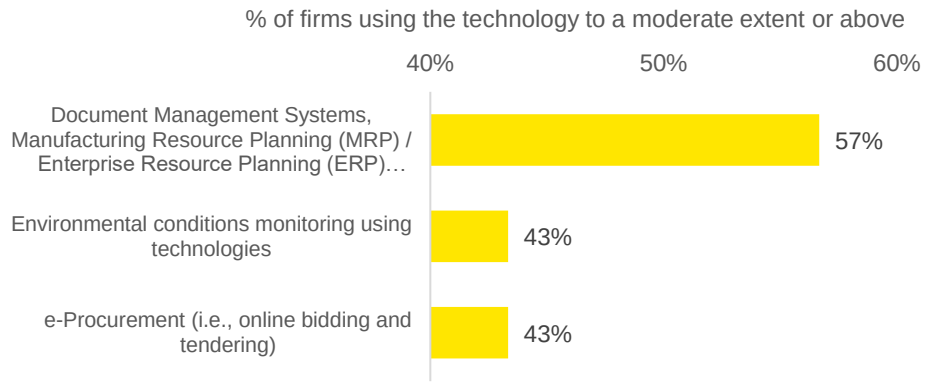
1. Community of practice (e.g. quarterly meet-ups for special interest groups)
2. Creation of a mentor network
3. Robotics / Automation

*a place to explore the latest technologies without having to purchase them

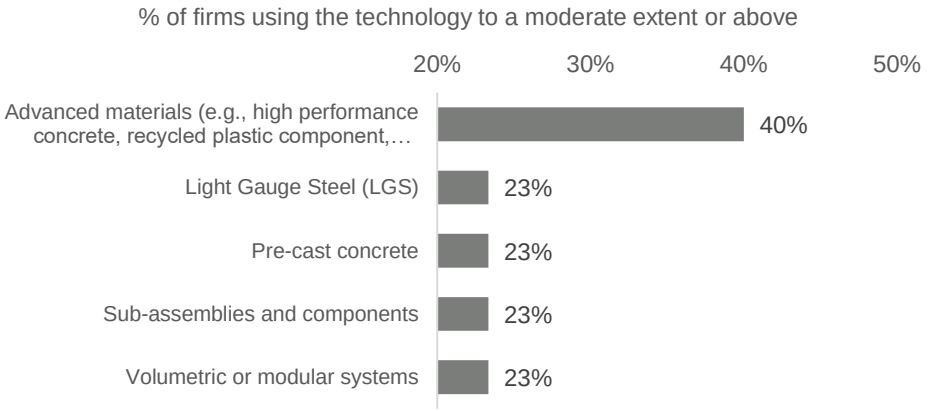
9 Detailed Description of Needs (DDN)
Firms: Others

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Digital Education and Training
2. Digital Leadership and Culture Change

Technology and Innovation
1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction
1. Innovative Materials / Sustainable Materials
2. Whole Life Performance of Buildings

Commentary

- The survey suggested that over half (57%) of those firms who fell under the 'other' within the construction sector are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by those other firms were other priorities (e.g. day-to-day running of the business) and a lack of time.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, funding and the creation of a technology sandbox.
- Less than 1 in 4 (23%) of firms reported that they could allocate funding for collaborative R&D and around 27% reported that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Structural and Civil Engineering

Survey profile

8
member firm responses to survey (3% of total responses)

63%
of firms had less than 50 employees

Turnover

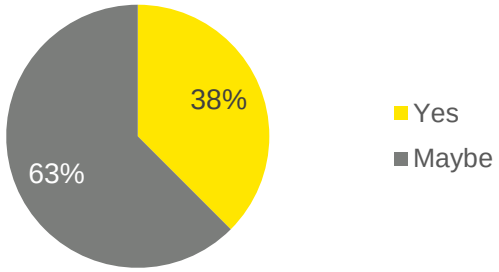
61%
of turnover of firms generated by:

1. Infrastructural Projects (e.g. civil and structural engineering)
2. Commercial Buildings (e.g. offices, retail, etc.)
3. New Residential Buildings

Top challenges when implementing new technologies

1. Lack of time
2. Lack of budget
3. Other priorities (e.g. Day-to-day running of the business)

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

25%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

38%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Funding
3. Introductions to like-minded firms

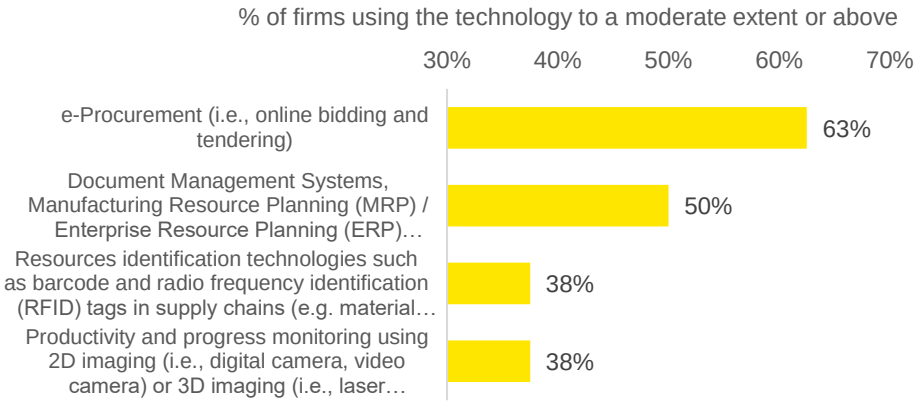
Least important elements

1. Creation of a mentor network
2. Community of practice (e.g. quarterly meet-ups for special interest groups)
3. Robotics / Automation

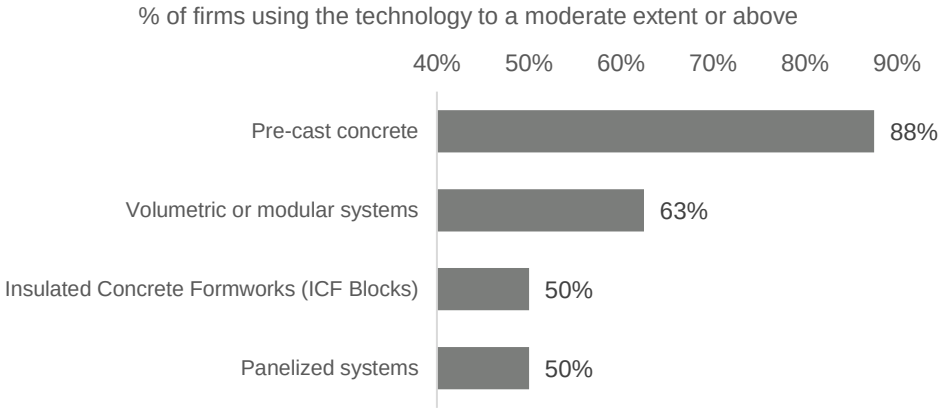
9 Detailed Description of Needs (DDN)
Firms: Structural and Civil Engineering

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Business Information Modelling (BIM)
2. Digital Education and Training

Technology and Innovation
1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction
1. Design Aesthetic and Functionality
2. Modular Construction / Modular Components

Commentary

- The survey suggested that the minority (38%) of those structural and civil engineering firms surveyed are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by structural and civil engineers were lack of time and budget and other priorities (e.g. the day-to-day running of the business).
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, funding and introductions to like-minded firms.
- The survey suggested that 38% of firms reported that they could allocate funding for collaborative R&D and around 1 in 4 (25%) would have the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Sub-Contractor

Survey profile

15
member firm responses to survey (6% of total responses)

27%
of firms had less than 50 employees

Turnover

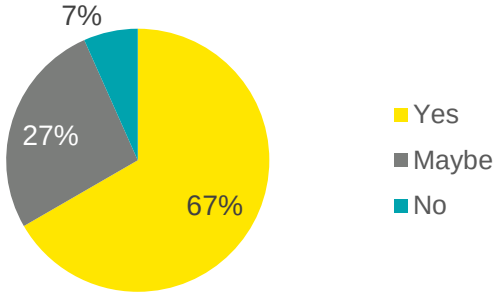
62%
of turnover of firms generated by:

1. Commercial Buildings (e.g. offices, retail, tourism, etc)
2. Industrial Projects (e.g. pharma plant, data centre, manufacturing etc.)
3. Data Centres

Top challenges when implementing new technologies

1. Lack of time
2. Limited availability of suitable in-house personnel to deliver new technology successfully

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

47%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

33%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Funding
2. Relevant Training/Continuing Professional Development
3. Modular Assemblies

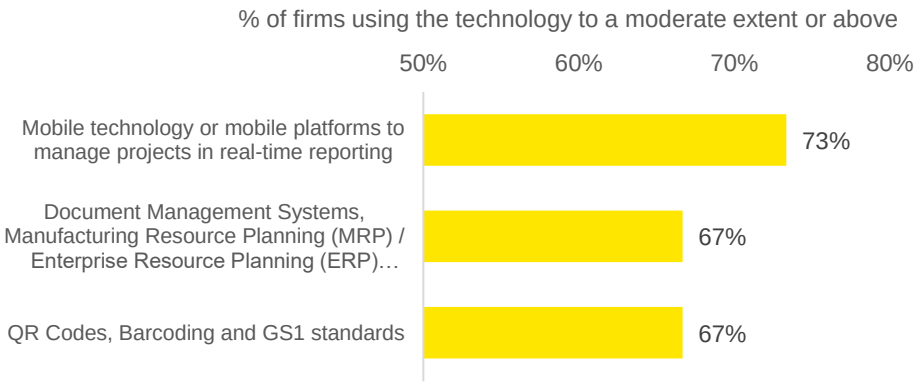
Least important elements

1. Community of practice (e.g. quarterly meet-ups for special interest groups)
2. Network-based technologies (e.g. blockchain)
3. Material Prototyping

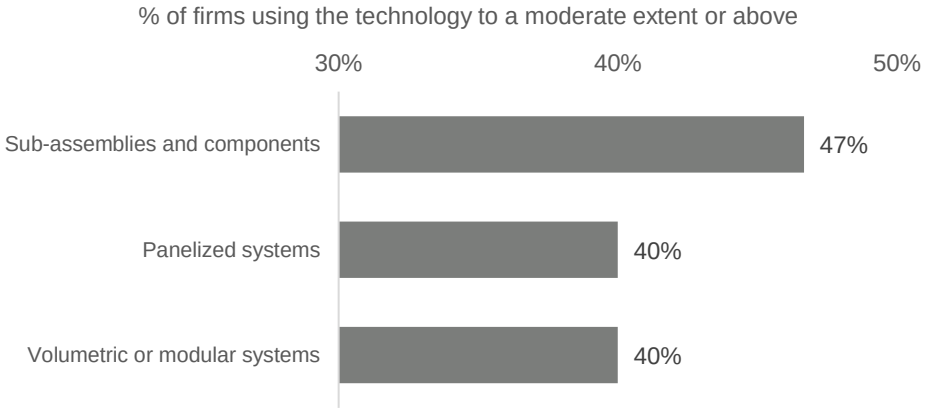
9 Detailed Description of Needs (DDN)
Firms: Sub-Contractor

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption
1. Business Information Modelling (BIM)
2. Digital Education and Training

Technology and Innovation
1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction
1. Integrated Supply Chain
2. Modular Construction / Modular Components

Commentary

- The survey suggested that the vast majority (67%) of sub-contractors are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by sub-contractors were lack of time and the limited availability of suitable in-house personnel to deliver new technology successfully.
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were funding, relevant training/ continuing professional development and modular assemblies.
- Around 1 in 3 (33%) of firms reported that they could allocate funding for collaborative R&D with 47% of firms reporting that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Tech Start-Up

Survey profile

5
member firm responses to survey (2% of total responses)

100%
of firms had less than 50 employees

Turnover

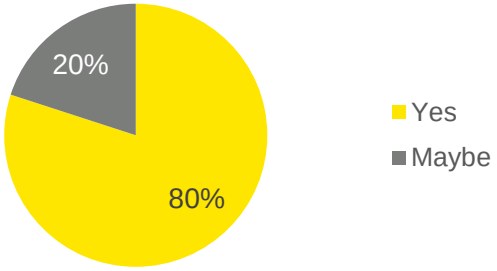
56%
of turnover of firms generated by:

1. Commercial Buildings (e.g. offices, retail, tourism, hospitality, culture, sport)
2. Renovation, Maintenance, and refurbishment (all buildings)
3. Life Sciences

Top challenges when implementing new technologies

1. Lack of time
2. Lack of budget
3. Other priorities (e.g. Day-to-day running of the business)

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

80%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

60%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Creation of a mentor network
2. Introductions to like-minded firms
3. Technology sandbox*

Least important elements

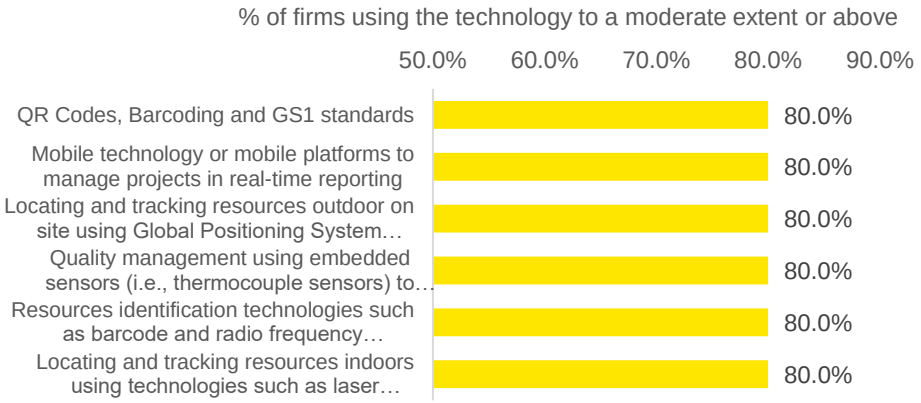
1. Material Prototyping
2. Modular Assemblies
3. Robotics / Automation

*a place to explore the latest technologies without having to purchase them

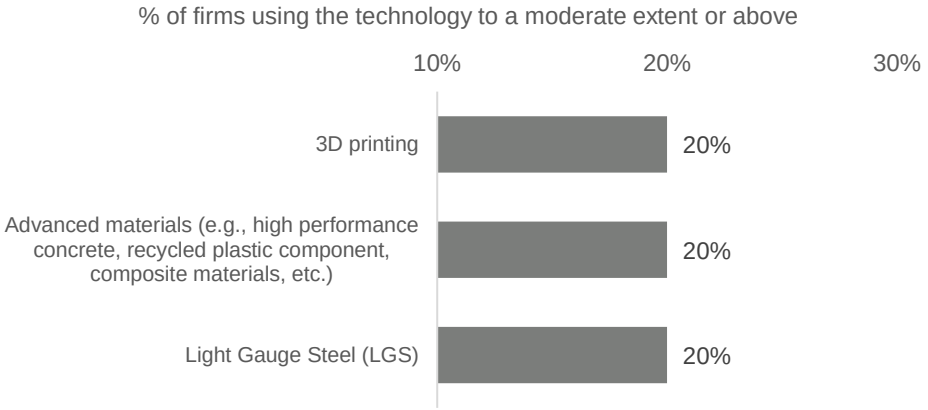
9 Detailed Description of Needs (DDN)
Firms: Tech Start-Up

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption

1. Digital Education and Training
2. Business Information Modelling (BIM)

Technology and Innovation

1. Data Analytics and Artificial Intelligence
2. Sustainability and Energy
3. Digital Twins

Modern Methods of Construction

1. Whole Life Performance of Buildings
2. Innovative Materials / Sustainable Materials

Commentary

- The survey suggested that the majority (80%) of tech start-ups surveyed are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by tech start-ups were lack of time and budget and other priorities (e.g. the day-to-day running of the business).
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were the creation of a mentor network, introductions to like-minded firms and the creation of a technology sandbox.
- The survey suggested the majority of firms, 60%,could allocate funding for collaborative R&D and 80% would have the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Firms: Trades (carpentry, bricklaying, plumbing, electrics etc.)

Survey profile

10
member firm responses to survey (4% of total responses)

30%
of firms had less than 50 employees

Turnover

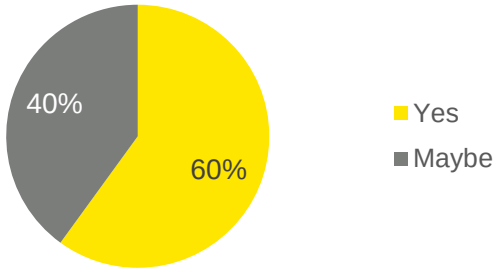
53%
of turnover of firms generated by:

1. Renovation, Maintenance, and refurbishment (all buildings)
2. Industrial Projects (e.g. pharma plant, data centre, etc.)
3. Commercial Buildings (e.g. offices, retail, etc.)

Top challenges when implementing new technologies

1. Lack of time
2. Other priorities (e.g. Day-to-day running of the business)

Willingness of firms to collaborate for R, D & I



Capacity to allocate personnel time

30%
of firms described the extent to which they could allocate personnel time to undertake collaborative R&D **as moderate or above**

Capacity to allocate funding

30%
of firms described the extent to which they could allocate funding to undertake collaborative R&D **as moderate or above**

Technology Centre

Most important elements

1. Relevant Training/Continuing Professional Development
2. Funding
3. Hub for prioritised processes

Least important elements

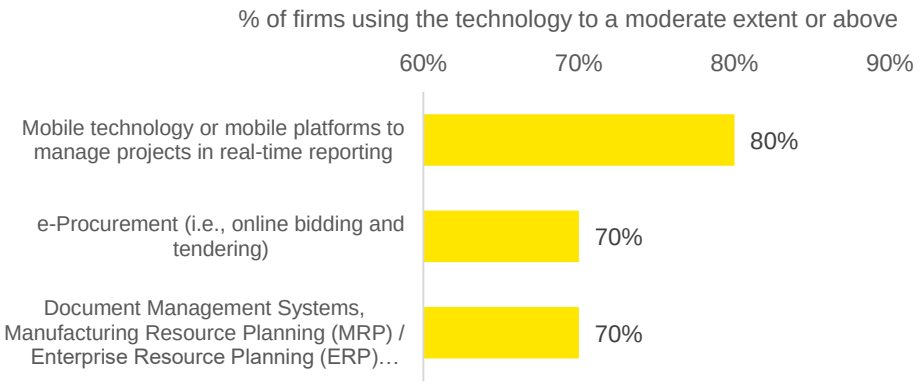
1. Research hub for collaboration at the pre-competitive stage
2. Network-based technologies (e.g. blockchain)
3. Material Prototyping

9 Detailed Description of Needs (DDN)

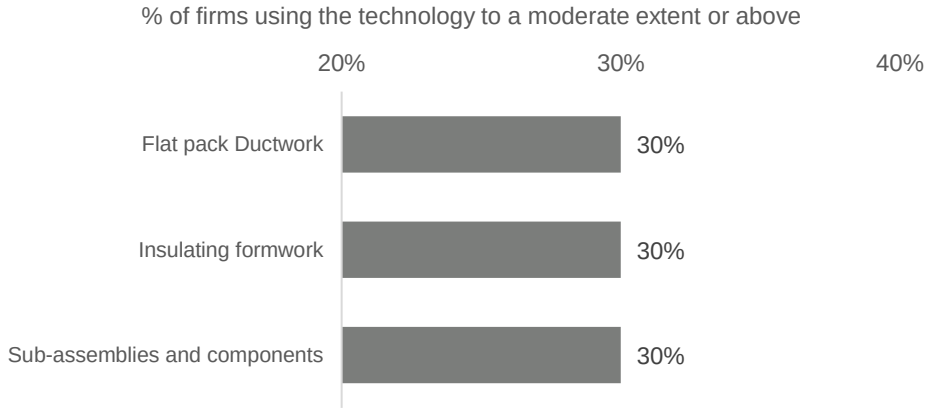
Firms: Trades (carpentry, bricklaying, plumbing, electrics etc.)

TODAY: What do firms use most?

Most commonly used automated technologies today



Most commonly used MMC methods today



10 YEARS' TIME: What will be most important?

Digital Adoption

1. Procurement Rules/Digital Procurement
2. Digital Standards

Technology and Innovation

1. Sustainability and Energy
2. Materials Performance

Modern Methods of Construction

1. Mechanical, Electrical and Piping (MEP) Systems assemblies, modules, or skids
2. Whole Life Performance of Buildings

Commentary

- The survey suggested that the vast majority (60%) of those from the trades profession (carpentry, bricklaying, plumbing and electrics etc.) are willing to collaborate with others in regard to RD&I.
- The top challenges when implementing new technologies cited by traders were lack of time and other priorities (e.g. the day-to-day running of the business).
- In regard to what a Construction Technology Centre should focus on, the top three cited areas were relevant training/ continuing professional development, funding and the creation of a Hub for prioritised processes.
- The survey suggested that 30% of firms reported that they could allocate funding for collaborative R&D and that they had the capacity to allocate personnel time to undertake collaborative R&D.

9 Detailed Description of Needs (DDN)

Stakeholder Group: Irish Green Building Council

Survey profile

1
Response from the stakeholder group

201-500
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Sustainability and Climate Change
- Careers/Skills/Education/Training
- Technology Trends and Opportunities
- Lean for Production and Services

Least frequent topics

- Digital Practices including Building Information Modelling
- Research and Innovation Funding Sources
- Supply Chain Management

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

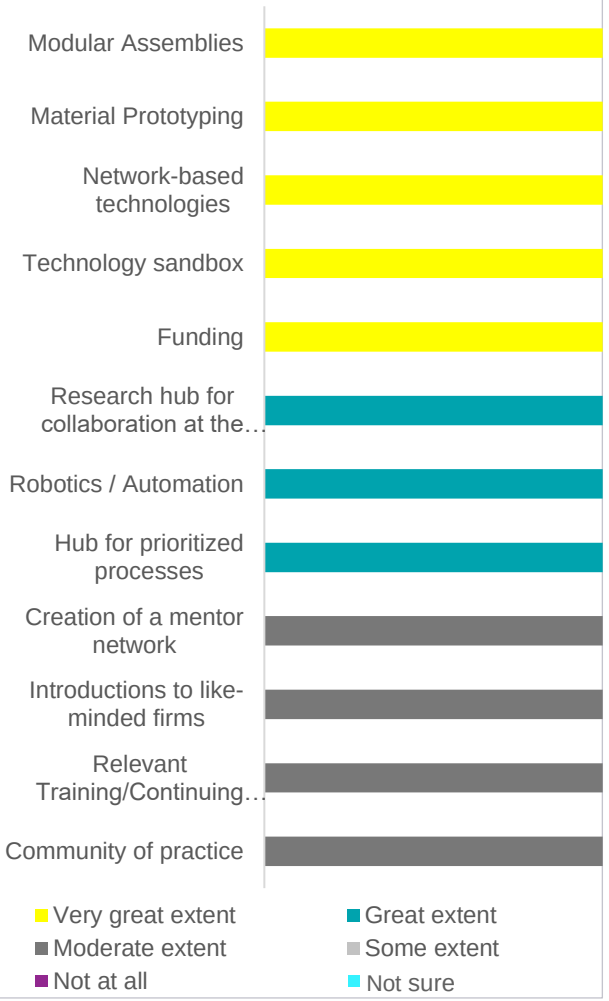
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Royal Institute of the Architects of Ireland

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Capacity to allocate funding

Not sure

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Sustainability and Climate Change
- Careers/Skills/Education/Training

Least frequent topics

- Research and Innovation Expertise Internationally
- Economics and Pricing
- Business Models

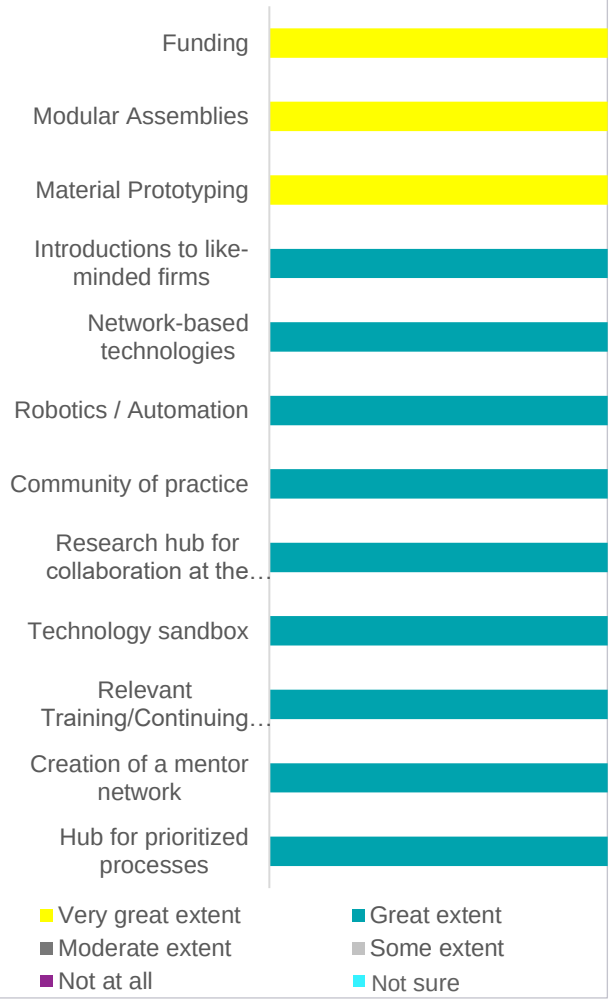
Capacity to allocate personnel time

Not sure

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

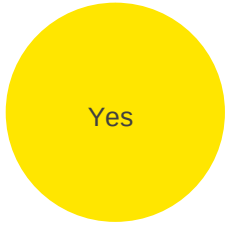
Stakeholder Group: Construction Industry Federation

Survey profile

3
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate



Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Digital Practices including Building Information Modelling
- Modern Methods of Construction
- Research, Development & Innovation
- Careers/Skills/Education/Training
- Supply Chain Management

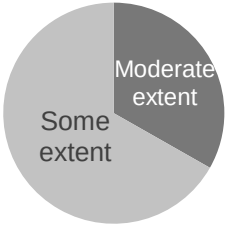
Least frequent topics

- Smart Buildings/ Smart Cities
- Research and Innovation Expertise Internationally

Capacity to allocate funding

The extent to which their members could allocate funding to undertake collaborative R&D

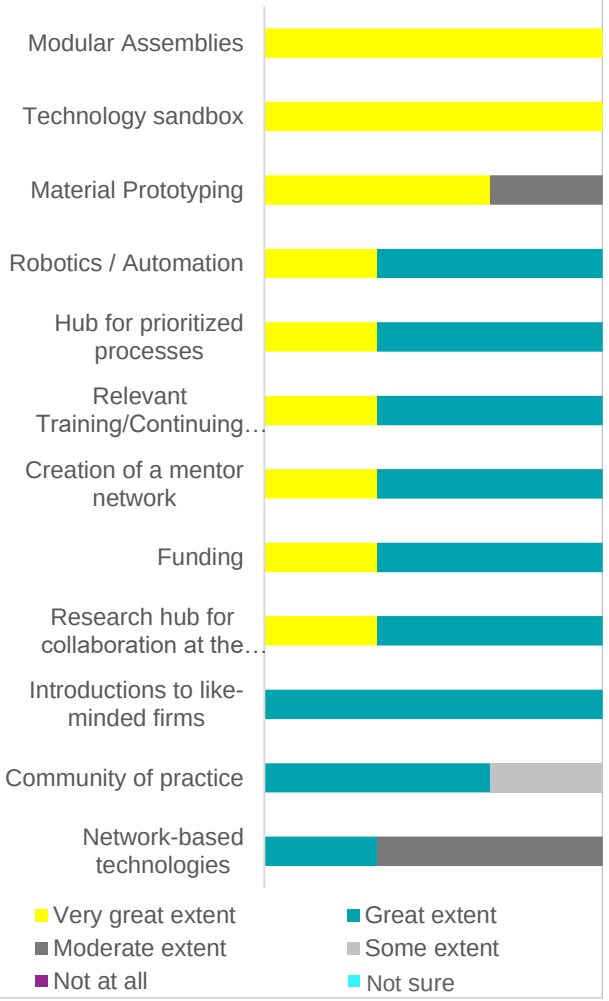
Capacity to allocate personnel time



The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Engineers Ireland

Survey profile

2
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Sustainability and Climate Change
- Careers/Skills/Education/Training
- Technology Trends and Opportunities
- Legislation, Regulations and Guidelines

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

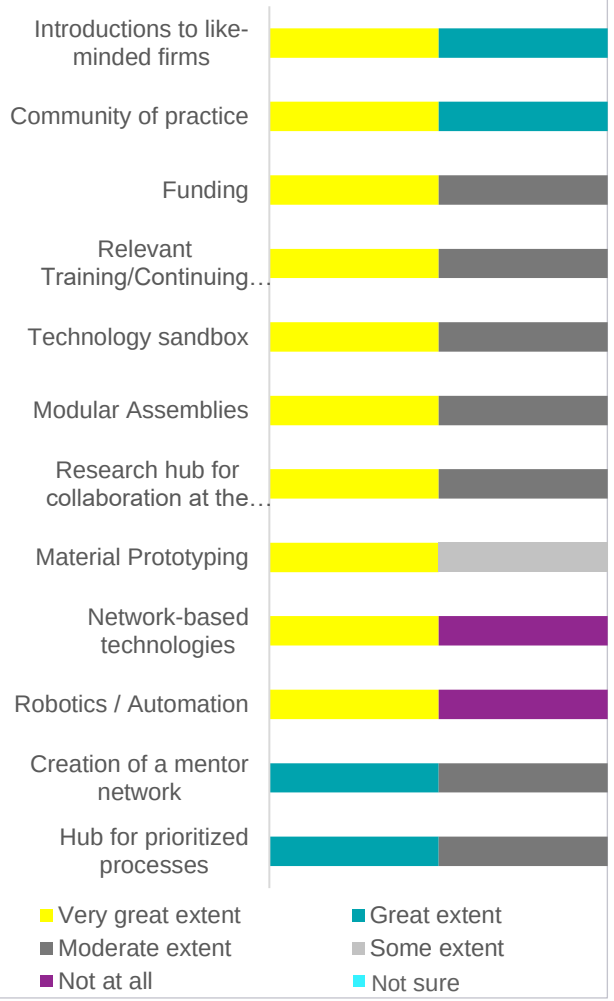
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

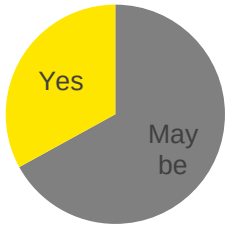
Stakeholder Group: Enterprise Ireland

Survey profile

3
Response from the stakeholder group

501-1000
Member firms

Willingness of member firms to collaborate



Members/clients would be willing to collaborate

Engagement with member firms

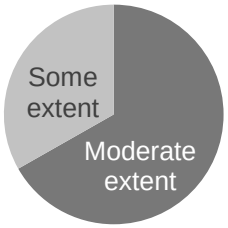
Most frequent topics

- Market Trends and Opportunities
- Technology Trends and Opportunities
- Research and Innovation Funding Sources
- Modern Methods of Construction
- Digital Practices including Building Information Modelling

Least frequent topics

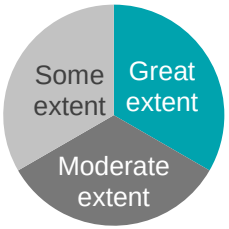
- Sustainability and Climate Change
- Design and Build for Disability and/or Ageing

Capacity to allocate funding



The extent to which their members could allocate funding to undertake collaborative R&D

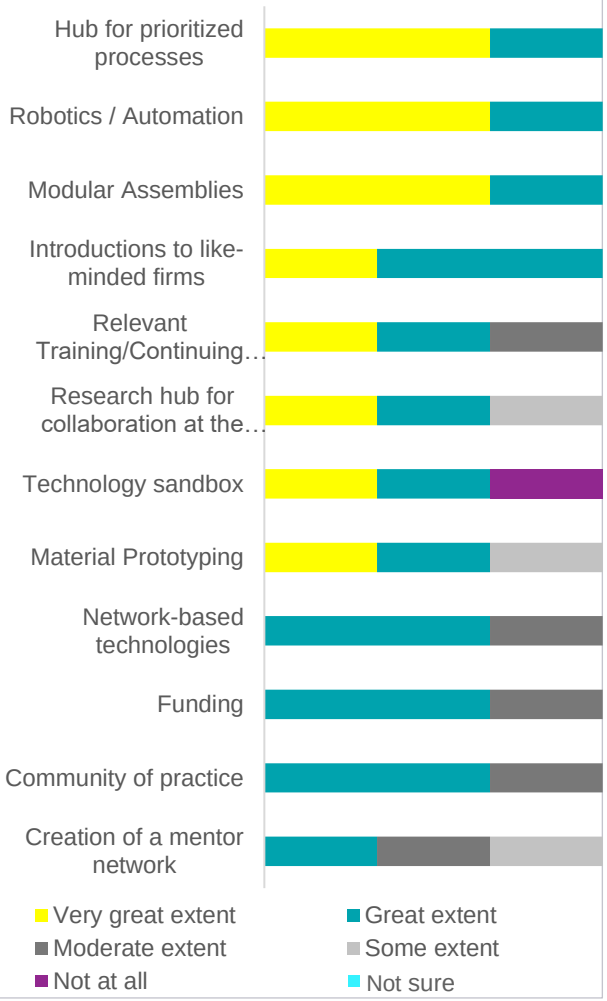
Capacity to allocate personnel time



The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: National Standards Authority of Ireland

Survey profile

1
Response from the stakeholder group

501-1000
Member firms

Willingness of member firms to collaborate

Maybe

Members/clients would be willing to collaborate

Capacity to allocate funding

Some extent

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Legislation, Regulations and Guidelines

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Research and Innovation Expertise Internationally
- Technology Trends and Opportunities
- Economics and Pricing

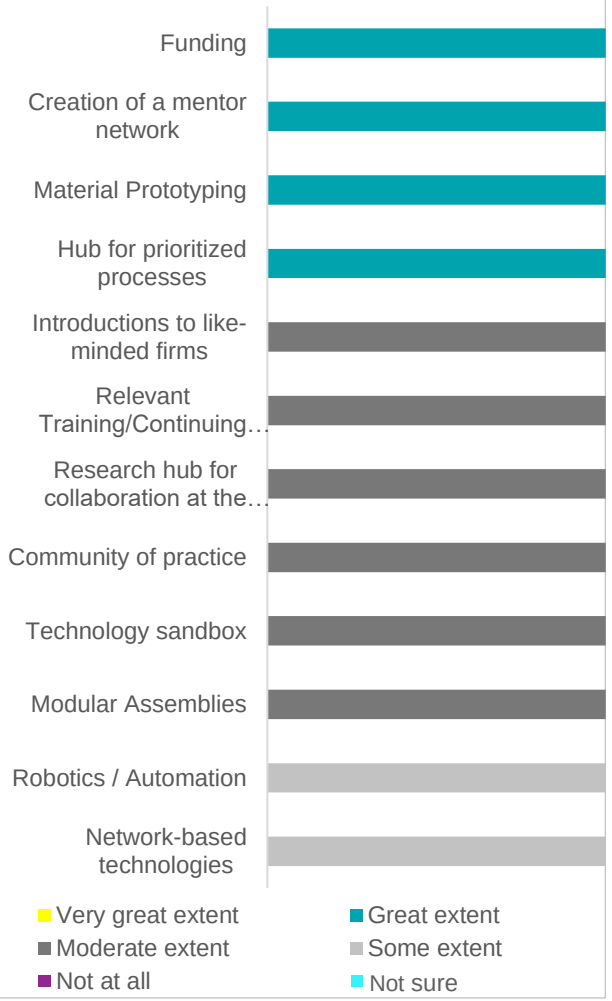
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Association of Consulting Engineers of Ireland

Survey profile

1
Response from the stakeholder group

201-500
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Careers/Skills/Education/Training
- Sustainability and Climate Change

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research, Development & Innovation
- Research and Innovation Expertise Internationally
- Lean for Production and Services
- Legislation, Regulations and Guidelines
- Economics and Pricing
- Business Models
- Supply Chain Management

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

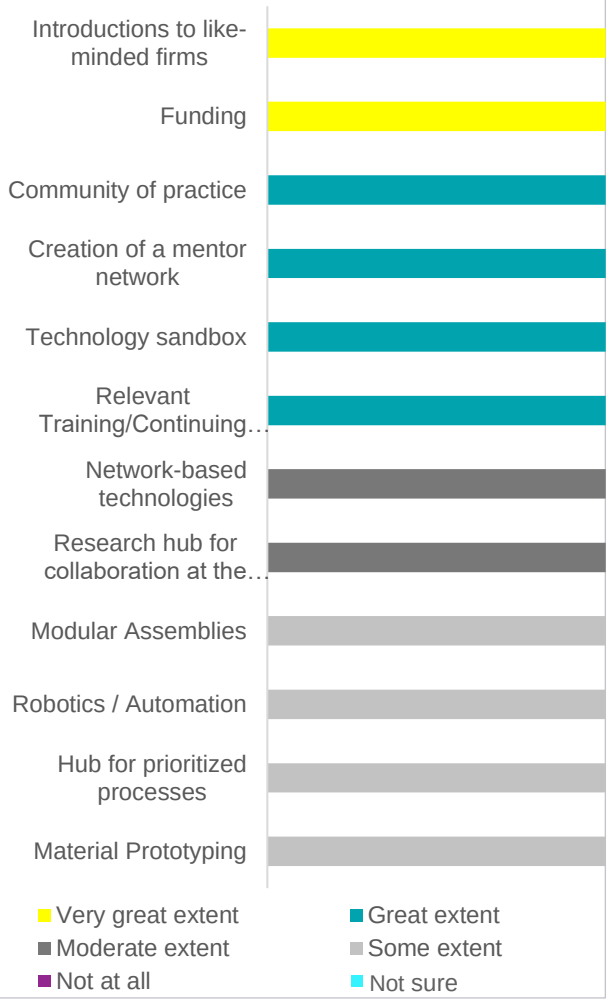
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Lean Construction Ireland

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Technology Trends and Opportunities
- Market Trends and Opportunities

Least frequent topics

- Design and Build for Disability and/or Ageing

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

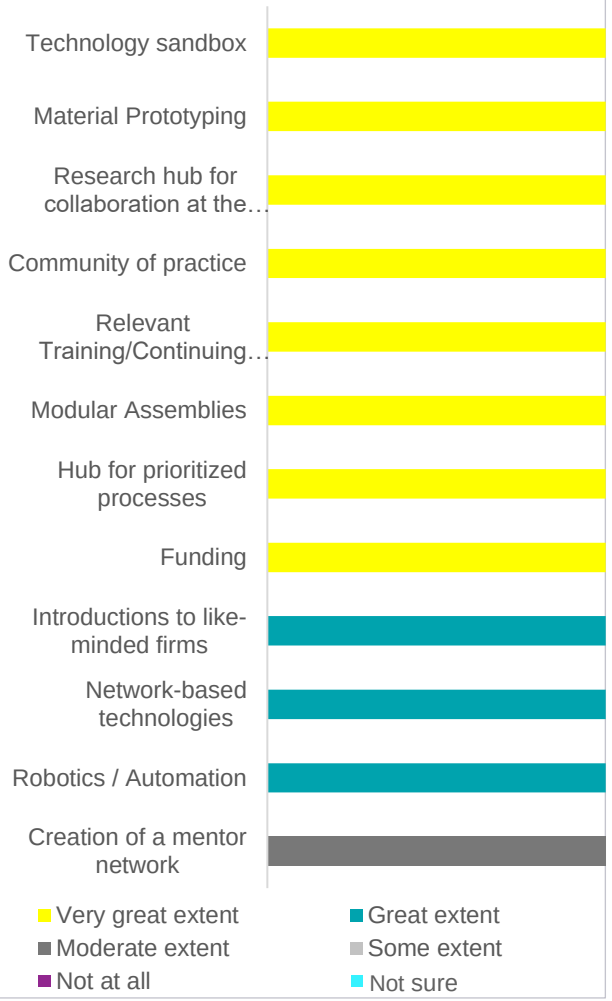
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

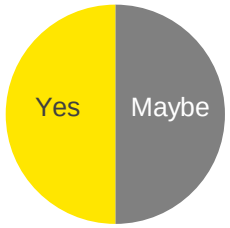
Stakeholder Group: Society of Chartered Surveyors Ireland

Survey profile

2
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate



Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Sustainability and Climate Change
- Careers/Skills/Education/Training
- Technology Trends and Opportunities
- Market Trends and Opportunities
- Legislation, Regulations and Guidelines
- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland

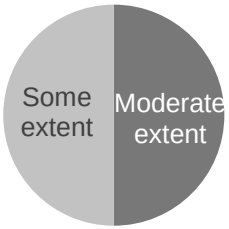
Least frequent topics

- Design and Build for Disability and/or Ageing
- Research and Innovation Funding Sources/ Research and Innovation Collaboration Opportunities /Research and Innovation Expertise in Ireland/ Research and Innovation Expertise Internationally

Capacity to allocate funding

The extent to which their members could allocate funding to undertake collaborative R&D

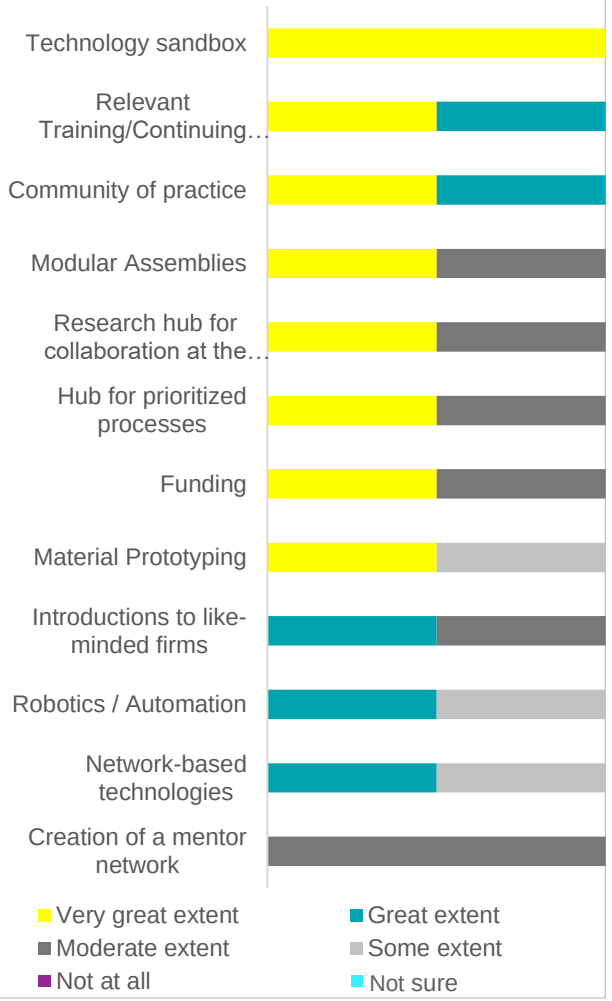
Capacity to allocate personnel time



The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Irish Homebuilders Association

Survey profile

1
Response from the stakeholder group

201-500
Member firms

Willingness of member firms to collaborate

Maybe

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Market Trends and Opportunities
- Legislation, Regulations and Guidelines
- Economics and Pricing
- Business Models
- Supply Chain Management

Least frequent topics

- Research and Innovation Expertise Internationally

Capacity to allocate funding

Some extent

The extent to which their members could allocate funding to undertake collaborative R&D

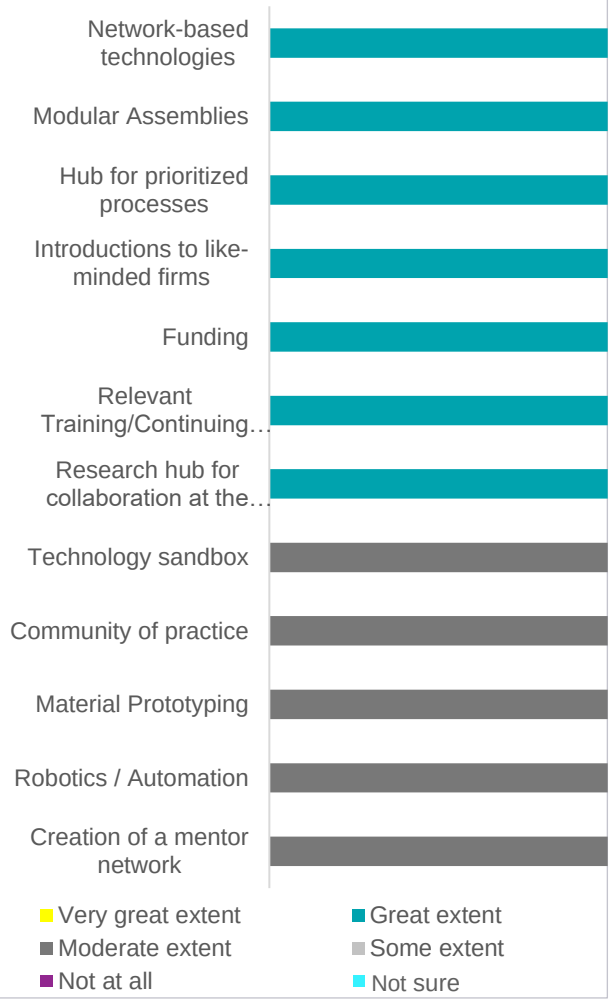
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

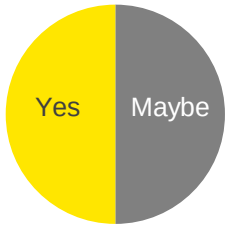
Stakeholder Group: Mechanical and Electrical Contractors Association

Survey profile

2
Response from the stakeholder group

51-100
Member firms

Willingness of member firms to collaborate



Members/clients would be willing to collaborate

Engagement with member firms

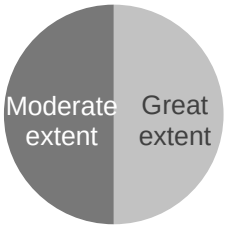
Most frequent topics

- Digital Practices including Building Information Modelling
- Legislation, Regulations and Guidelines

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Research and Innovation Expertise Internationally
- Research and Innovation Funding Sources

Capacity to allocate funding



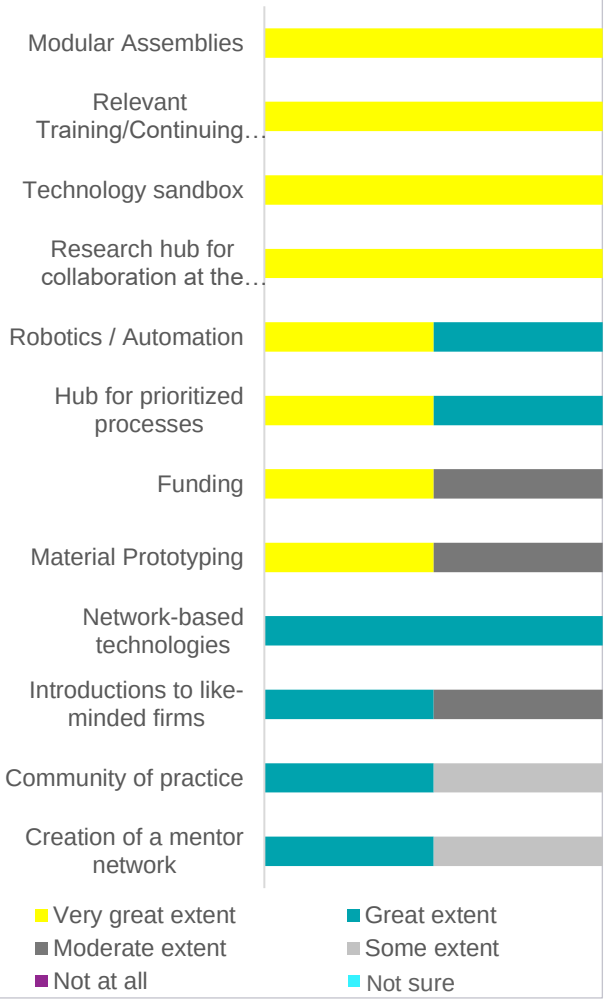
The extent to which their members could allocate funding to undertake collaborative R&D

Capacity to allocate personnel time

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Master Builders' and Contractors' Association

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Capacity to allocate funding

Not at all

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Careers/Skills/Education/Training

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Research and Innovation Expertise Internationally
- Business Models
- Supply Chain Management

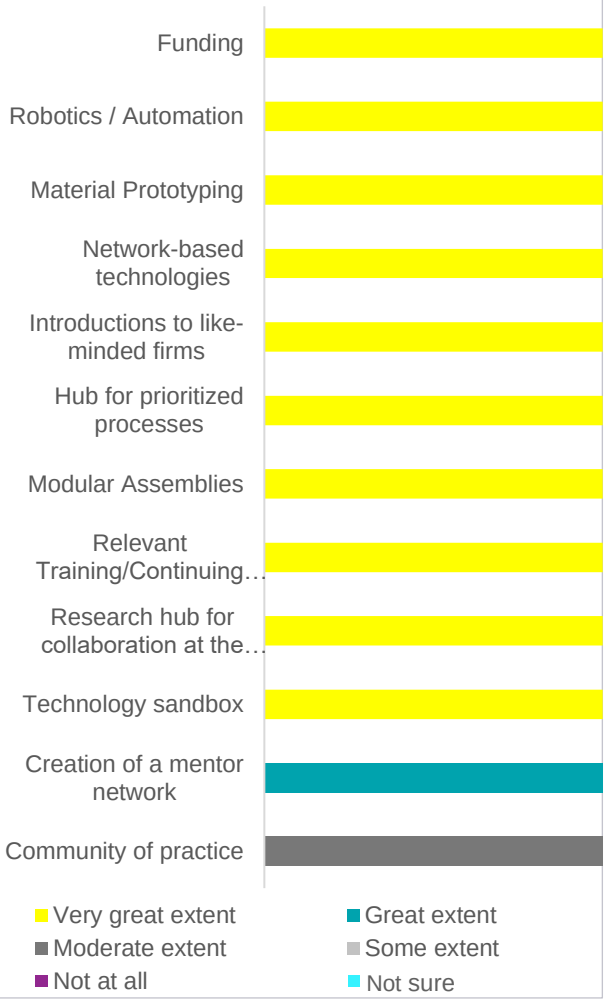
Capacity to allocate personnel time

Some extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Construction IT Alliance

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Technology Trends and Opportunities
- Market Trends and Opportunities

Least frequent topics

- Design and Build for Disability and/or Ageing

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

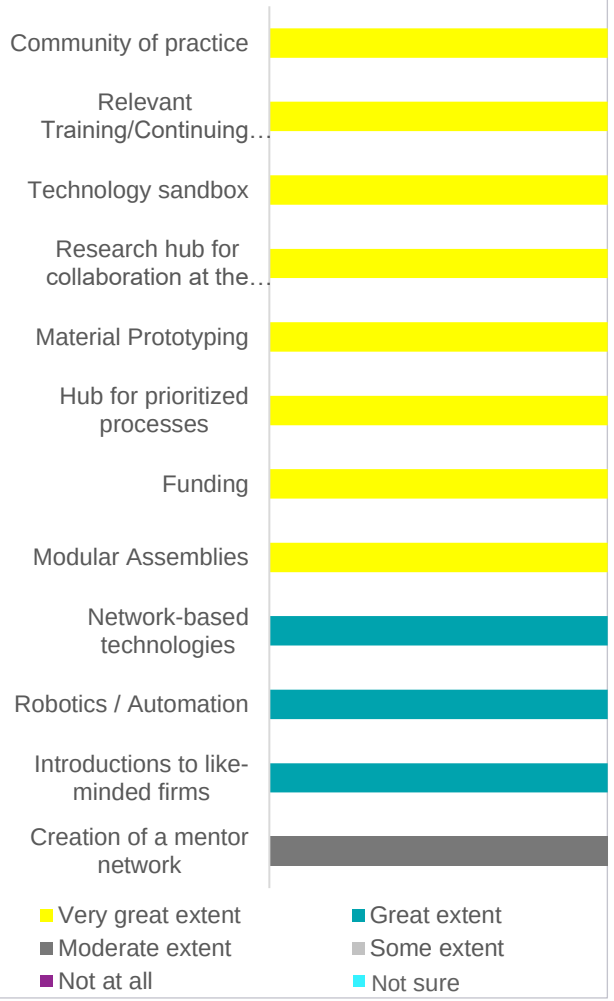
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Civil Engineering Contractors Association

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Capacity to allocate funding

Not at all

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Careers/Skills/Education/Training

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise in Ireland
- Research and Innovation Expertise Internationally
- Business Models
- Supply Chain Management

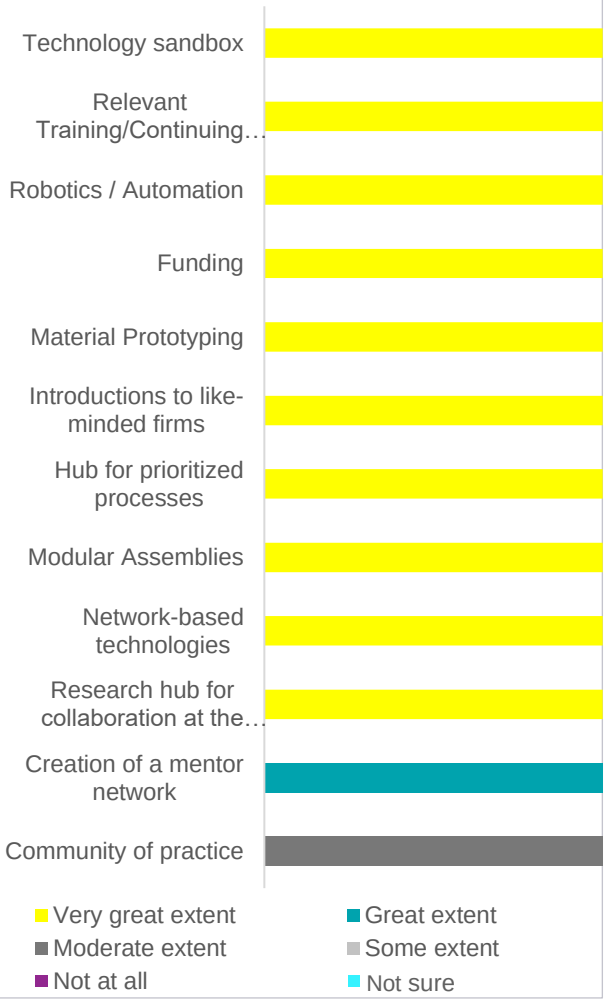
Capacity to allocate personnel time

Some extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: BRE Global Ireland

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Sustainability and Climate Change
- Digital Practices including Building Information Modelling
- Modern Methods of Construction
- Research, Development & Innovation
- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities
- Research and Innovation Expertise Internationally
- Technology Trends and Opportunities
- Lean for Production and Services
- Market Trends and Opportunities
- Legislation, Regulations and Guidelines
- Supply Chain Management

Capacity to allocate funding

Very great extent

The extent to which their members could allocate funding to undertake collaborative R&D

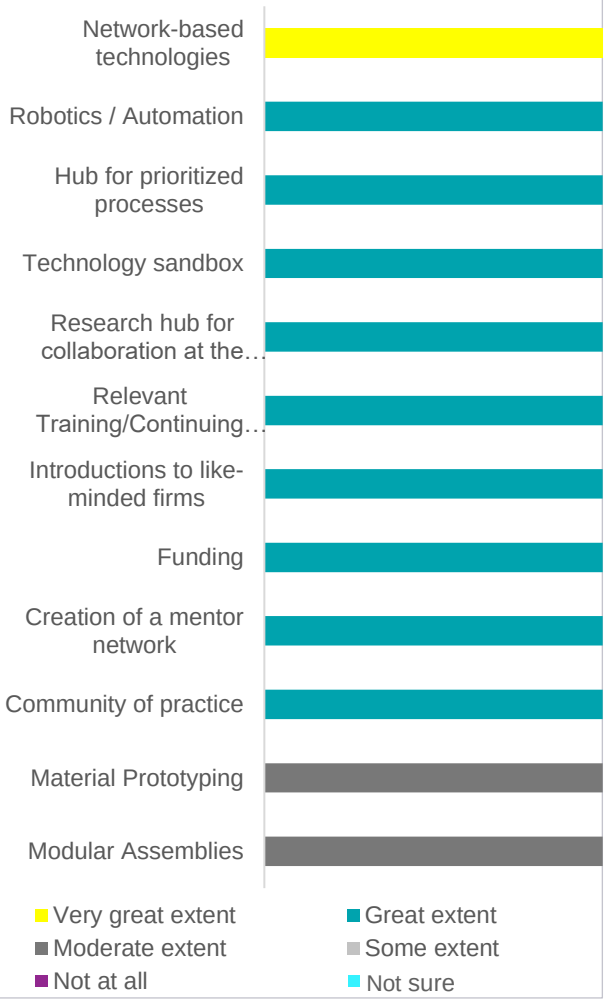
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)
Stakeholder Group: IDA Ireland

Survey profile

1
Response from the stakeholder group

> 1,001
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Careers/Skills/Education/Training
- Market Trends and Opportunities
- Economics and Pricing
- Supply Chain Management

Least frequent topics

- Design and Build for Disability and/or Ageing

Capacity to allocate funding

Very great extent

The extent to which their members could allocate funding to undertake collaborative R&D

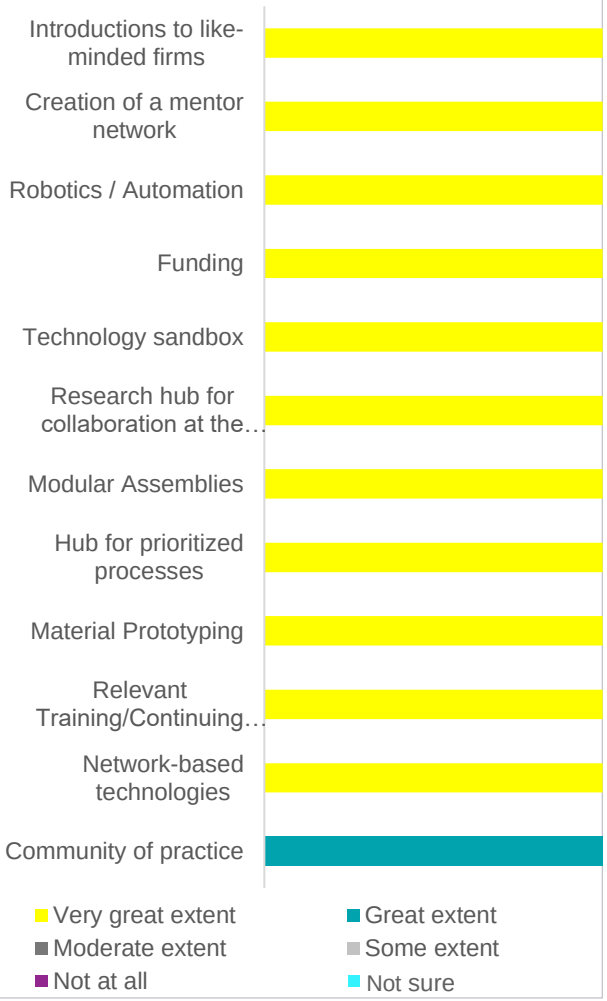
Capacity to allocate personnel time

Very great extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Irish Hardware Association

Survey profile

1
Response from the stakeholder group

201-500
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Legislation, Regulations and Guidelines
- Sustainability and Climate Change
- Market Trends and Opportunities
- Economics and Pricing
- Business Models
- Supply Chain Management

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Research and Innovation Funding Sources
- Research and Innovation Collaboration Opportunities

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

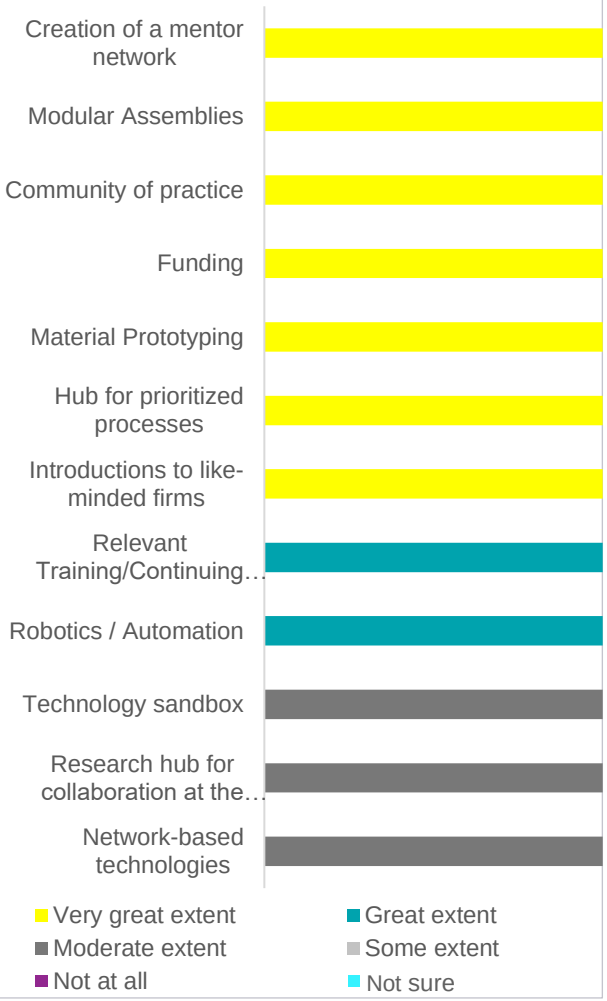
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Alliance of Specialist Contractors Association

Survey profile

1
Response from the stakeholder group

101-200
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Most frequent topics

- Careers/Skills/Education/Training
- Market Trends and Opportunities
- Legislation, Regulations and Guidelines
- Economics and Pricing
- Business Models
- Supply Chain Management

Least frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Research and Innovation Expertise Internationally

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

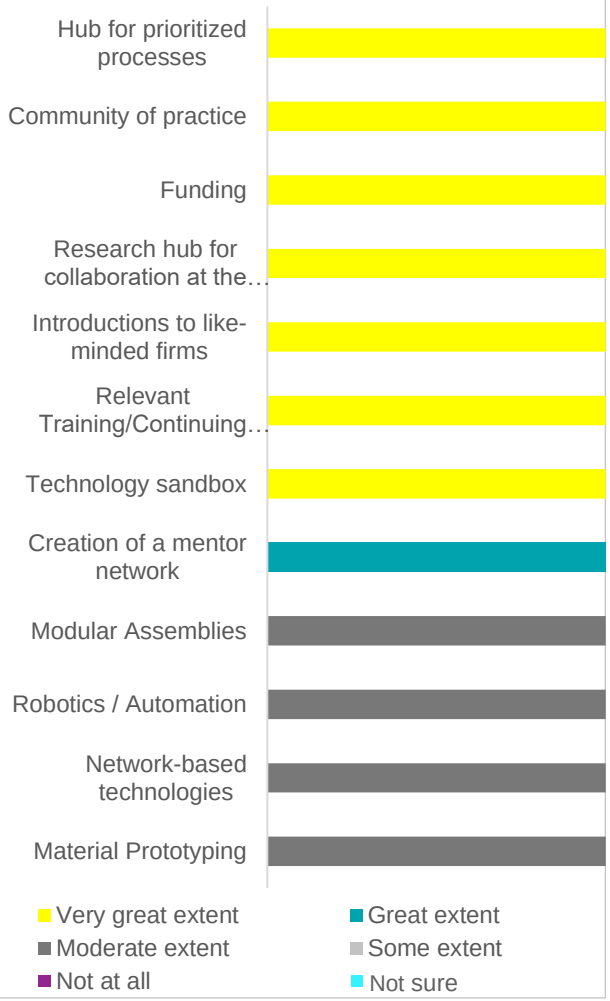
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

Stakeholder Group: Irish Timber Frame Manufacturers Association

Survey profile

1
Response from the stakeholder group

1-20
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Engagement with member firms

Least frequent topics

- Digital Practices including Building Information Modelling
- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Research and Innovation Funding Sources
- Research and Innovation Expertise in Ireland
- Lean for Production and Services
- Economics and Pricing
- Business Models
- Supply Chain Management

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

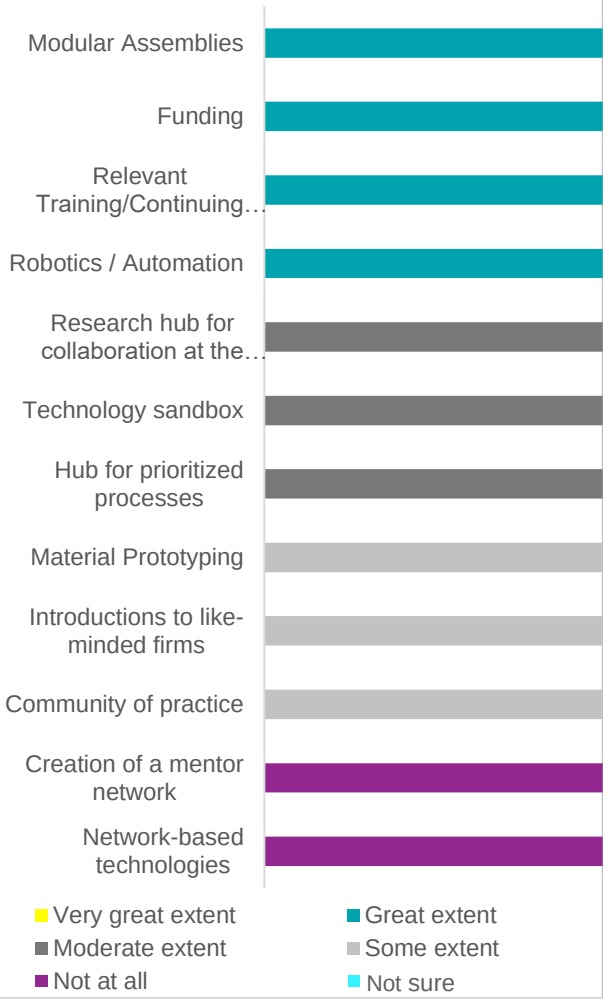
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



Dashboard

Stakeholder Group: Centre for Excellence in Universal Design

Survey profile

1
Response from the stakeholder group

21-50
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Capacity to allocate funding

Very great extent

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Design and Build for Disability and/or Ageing
- Design and Build for Quality of Life
- Technology Trends and Opportunities
- Legislation, Regulations and Guidelines

Least frequent topics

- Lean for Production and Services
- Supply Chain Management
- Modern Methods of Construction
- Research and Innovation Funding Sources

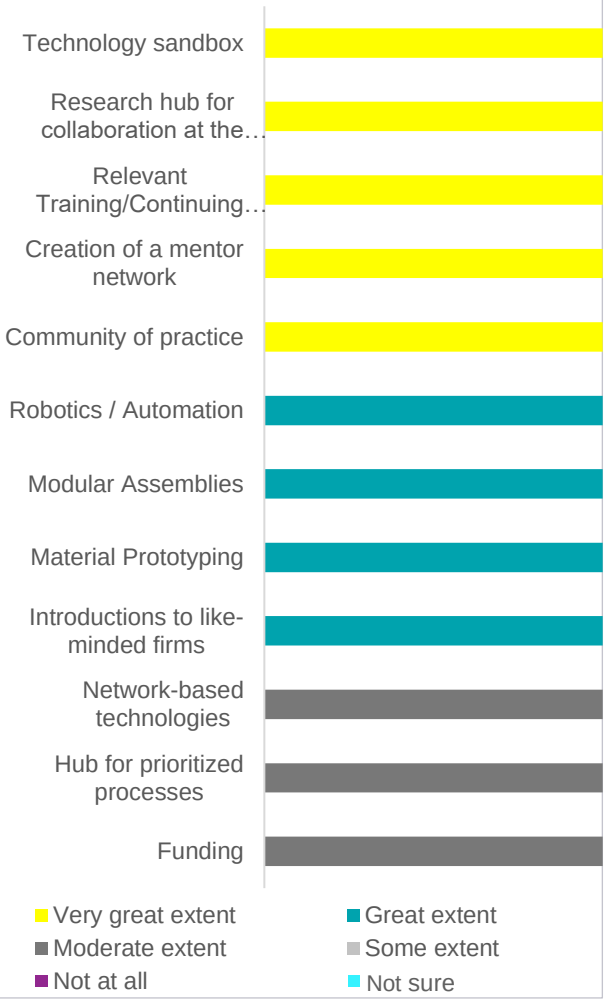
Capacity to allocate personnel time

Very great extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



Dashboard

Stakeholder Group: Property Industry Ireland

Survey profile

1
Response from the stakeholder group

51-100
Member firms

Willingness of member firms to collaborate

Yes

Members/clients would be willing to collaborate

Capacity to allocate funding

Moderate extent

The extent to which their members could allocate funding to undertake collaborative R&D

Engagement with member firms

Most frequent topics

- Design and Build for Quality of Life
- Smart Buildings/ Smart Cities
- Careers/Skills/Education/Training
- Market Trends and Opportunities
- Legislation, Regulations and Guidelines
- Economics and Pricing
- Business Models
- Supply Chain Management

Least frequent topics

- Research and Innovation Expertise in Ireland
- Research and Innovation Expertise Internationally
- Lean for Production and Services

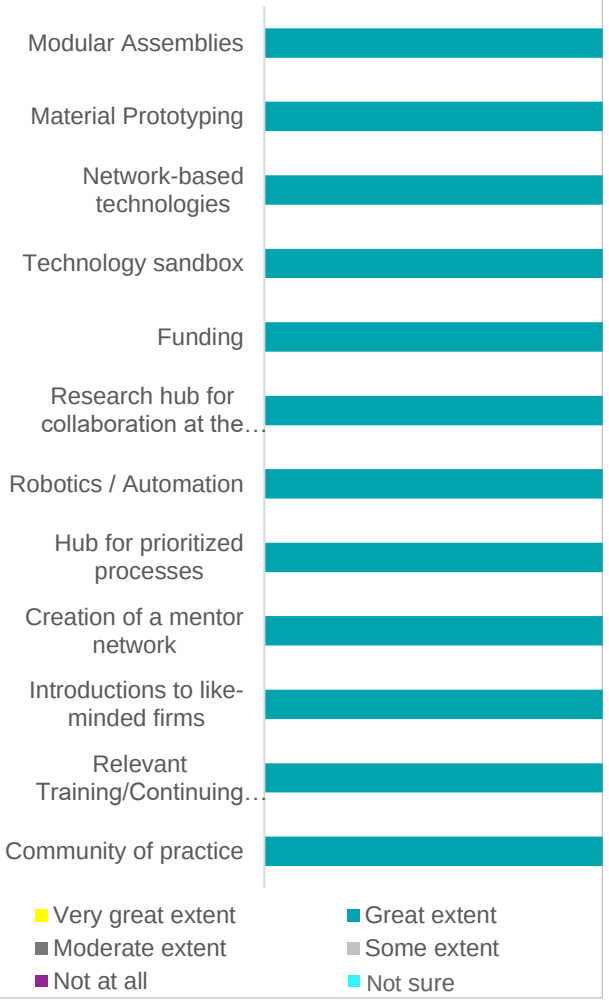
Capacity to allocate personnel time

Moderate extent

The extent to which their members could allocate personnel time to undertake collaborative R&D

Technology Centre

Extent of elements of Centre that could assist organisation's clients



9 Detailed Description of Needs (DDN)

The key elements that a Construction Technology Centre could help stakeholders and firms with

From the surveys of stakeholders and firms, the most important elements noted that a Centre could help them with are ranked below (based on number of responses stating 'very great extent' and 'great extent'):

For stakeholders	For firms
Funding	Funding
Relevant training/CPD	Relevant training/CPD
Hub for prioritised processes	Technology Sandbox
Modular assemblies and research for collaboration at the pre-competitive stage	Introduction to like-minded people
Introduction to like-minded people and technology sandbox	Modular assemblies
Robotics and Automation	Hub for prioritised processes
Community of Practice, Materials prototyping, and Materials based technologies	Creation of a mentor network

The heatmaps on the next two pages summarise the key elements that a Construction Technology Centre could help stakeholders and firms with separately.

An interesting observation from the Heatmaps is that stakeholders strongly believe a Centre can benefit the industry; the firms appear to be less convinced of the benefits based on the shades in their heatmap. This may be a reflection of the lack of understanding of the role of a Centre and how it would help the industry as well as the overall low adoption levels of MMC, digitalisation and technology which are evident from the firms' survey. This suggests that stakeholders have a body of work to do to engage with their members to drive the initiative.

9 Detailed Description of Needs (DDN)

Firms: Extent of elements of Centre that could assist your firm

Not at all ← → Very Great Extent

	Community of practice	Creation of a mentor network	Funding	Hub for prioritised processes	Introductions to like-minded firms	Material Prototyping	Modular Assemblies	Network-based technologies	Relevant Training /Continuing Professional Develop-ment	Research hub for collaboration at the pre-competitive stage	Robotics / Automation	Technology sandbox
Architecture												
Main Contractor												
Consulting Engineering												
Other firms *												
Materials Manufacturer												
Off-Site/Modern Methods of Construction (MMC)												
Sub-Contractor												
Trades (carpentry, bricklaying, plumbing, electrics etc.)												
Developer												
Engineering - Structural and Civil												
Tech Start-Up												

The ‘other firms’ category include firms which were not allocated an activity as none reached the minimum response number of 5 to be classified as an activity. The following activities (representing 10 firms) were not included in the DDN: Fire Safety, Life Safety Systems; Facilities Management; Finance/Investment; Planning; Assigned Certifier; and Government Contracting Authority.

9 Detailed Description of Needs (DDN)

Stakeholder Group: Extent of elements of a Centre that could assist your organisations' clients/members

Not at all ◄ ► Very Great Extent

	Community of practice	Creation of a mentor network	Funding	Hub for prioritized processes	Introductions to like-minded firms	Material Proto-typing	Modular Assemblies	Network-based technologies	Relevant Training/ CPD	Research hub for collaboration at the pre-competitive stage	Robotics / Automation	Technology sandbox
Irish Timber Frame Manufacturers Association												
National Standards Authority of Ireland												
Association of Consulting Engineers of Ireland												
Irish Homebuilders Association												
Engineers Ireland												
Society of Chartered Surveyors Ireland												
BRE Global Ireland												
Enterprise Ireland												
Property Industry Ireland												
Irish Green Building Council												
Centre for Excellence in Universal Design												
Mechanical and Electrical Contractors Association												
Royal Institute of the Architects of Ireland												
Alliance of Specialist Contractors Association												
Construction Industry Federation												
Irish Hardware Association												
Lean Construction Ireland												
Construction IT Alliance												
Master Builders' and Contractors' Association												
Civil Engineering Contractors Association												
IDA Ireland												

9 Detailed Description of Needs (DDN)

Stakeholder Group: Organisation engages with the members/clients in the built environment and construction sectors

Not at all ◀ ▶ Weekly

	Sustain-ability & Climate Change	Digital Practices incl. BIM	Modern Methods of Constr.	RD&I	Design & Build for Disability and/or Ageing	Design & Build for Quality of Life	Smart Buildings/ Smart Cities	Careers/ Skills/ Education & Training	Research & Innovation Funding Sources	Research & Innovation Collaboration Opportunities	Research & Innovation Expertise in Ireland	Research & Innovation Expertise Inter-nationally	Technology Trends & Opps.	Lean for Production & Services	Market Trends & Opportunities	Legislation, Regulations & Guidelines	Economics & Pricing	Business Models	Supply Chain Manage-ment
National Standards Authority of Ireland																			
Irish Timber Frame Manufacturers Association																			
Master Builders' and Contractors' Association																			
Civil Engineering Contractors Association																			
Association of Consulting Engineers of Ireland																			
Alliance of Specialist Contractors Association																			
Engineers Ireland																			
Mechanical and Electrical Contractors Association																			
Irish Hardware Association																			
Property Industry Ireland																			
Centre for Excellence in Universal Design																			
Construction Industry Federation																			
Royal Institute of the Architects of Ireland																			
Irish Homebuilders Association																			
Irish Green Building Council																			
Society of Chartered Surveyors Ireland																			
Enterprise Ireland																			
IDA Ireland																			
Lean Construction Ireland																			
Construction IT Alliance																			
BRE Global Ireland																			

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Appendices

Appendix 1
Glossary of Terms

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Appendix 1: Glossary of terms

Acronym	Term
AEC	Architecture , Engineering and Contracting
AHSS	Arts, Humanities and Social Sciences
AI	Artificial Intelligence
AIM	Asset Information Modelling
AMBER	SFI Research Centre for Advanced Materials for Impact
APT	Applied Polymer Technologies Gateway
BERD	Business Expenditure on Research and Development
BIM	Building Information Modelling
BRE	Building Research Institute
BRI	Danish Building Research Institute
C&D	Construction and Demolition
CAD	Computer Aided Design
CCC	Construction City Cluster
CDBB	Centre for Digital Built Britain
CICEM	Centre for Innovation in Construction and Infrastructure Engineering and Management
CIH	The Construction Innovation Hub
CitA	Construction IT Alliance
COMAND	Connected Media Application Design and Delivery Gateway
Cork IT	Cork Institute of Technology
CPD	Continuing Professional Development
CREST	Centre for Research in Engineering Surface Technology Gateway
CSG	Construction Sector Group
CSIC	Construction Scotland Innovation Centre
CSO	Central Statistics Office
CTIL	Construction Technology Innovation Laboratory

Acronym	Term
DAFM	Department of Agriculture, Food and Marine
DDN	Detailed Description of Needs
DE	Department of Education
DETE	Department for Enterprise Trade and Employment
DPER	Department of Public Expenditure and Reform
DTIF	Disruptive Technologies Innovation Fund
Dundalk IT	Dundalk Institute of Technology
EEB	Energy Efficient Buildings
EI	Enterprise Ireland
EPA	Environmental Protection Agency
ERI	Environmental Research Institute
EU	European Union
GERD	Gross Expenditure on Research and Development
GMIT	Galway-Mayo Institute of Technology
GOVERD	Government Expenditure on Research and Development
H2020	Horizon 2020
HEA	Higher Education Authority
HERD	Higher Education Expenditure on Research and Development
HRB	Health Research Board
HSE	Health Service Executive
iCRAG	SFI Research Centre for Applied Geosciences
iForm	SFI Research Centre for Advanced Manufacturing
IIoT	Industrial Internet of Things
IIRS	Institute for Industrial Research and Standards
IMaR	Intelligent Mechatronics and RFID Gateway
IMR	Irish Manufacturing Research

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Appendix 1: Glossary of terms

Acronym	Term
IoT	Internet of Things
IP	Intellectual Property
IT Carlow	Institute of Technology Carlow
IT Sligo	Institute of Technology Sligo
KTI	Knowledge Transfer Ireland
Letterkenny IT	Letterkenny Institute of Technology
Limerick IT	Limerick Institute of Technology
M&E	Monitoring and Evaluation
MaREI	SFI Research Centre for Energy, Climate and Marine Research &Innovation
MCCI	Microelectronic Circuits Centre Ireland
MET	Medical and Engineering Technology Gateway
MMC	Modern Methods of Construction
MTC	Manufacturing Technology Centre
NBS	National Building Specification
NDP	National Development Plan
NFQ	National Framework of Qualifications
Nimbus	Embedded Computing and Software Systems Gateway
NUIG	National University of Ireland Galway
OGP	Office of Government Procurement
OPW	Office of Public Works
OSM	Off-site Manufacturing

Acronym	Term
PEM	Precision Engineering and Manufacturing Gateway
R&D	Research and Development
RD&I	Research, Development, and Innovation
SCSI	Society of Chartered Surveyors Ireland
SEAM	South Eastern Applied Materials Gateway
SFI	Science Foundation Ireland
SIT	Singapore Institute of Technology
SMEs	Small and Medium Enterprises
STEM	Science, Technology, Engineering and Maths
TCD	Trinity College Dublin
T-Shaped Worker	A reference to qualities that make an employee valuable; they possess excellent knowledge of and skills in specific areas and are good at working with others in a collaborative way.
TSSG	Telecommunications Software and Systems Group Gateway
TU Dublin	Technological University Dublin
UCD	University College Dublin
UKG	United Kingdom Government
UL	University of Limerick
VR	Virtual Reality
WRAP	Waste and Resource Action Programme
Waterford IT	Waterford Institute of Technology
WiSAR	Wireless Sensor Applied Research Laboratory Gateway

Appendix 2
Definition of the Construction Sector

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Appendix 2: Definition of the construction sector

The definition of the construction sector is defined according to the Eurostat statistical classification of economic activities in the European Community. This is otherwise known as NACE, the Eurostat framework for collecting and presenting a large range of statistical data relating to productive economic activities. The NACE classification is the subject of legislation at the European Union level, which imposes the use of the classification uniformly within all Member States. The definitions have been revised over time and the current classification is known as NACE Rev. 2 which has been developed to reflect the technological developments and structural changes in the economy between 2002 and 2007.

The construction industry incorporates three broad divisions of work:

- The **construction of buildings** (Division 41), which includes general construction of buildings of all kinds. This includes new work, repair, additions and alterations, the erection of pre-fabricated buildings or structures on the site and also construction of a temporary nature.
- The **construction of civil engineering structures** (Division 42). This includes new work, repair, additions and alterations, the erection of pre-fabricated structures on the site and also construction of a temporary nature. Included in this class is the construction of motorways, streets, bridges, tunnels, railways, airfields, harbours and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, outdoor sports facilities, etc. This work can be carried out on own account or on a fee or contract basis. Portions of the work and sometimes even the whole practical work can be subcontracted out.
- **Specialised construction activities**, i.e. special trades (Division 43) or the construction of parts of buildings and civil engineering works or preparation for that purpose. These activities are usually specialised in one aspect common to different structures, requiring specialised skills or equipment, such as pile-driving, foundation work, carcass work, concrete work, brick laying, stone setting, scaffolding, roof covering, etc. The erection of steel structures is included, provided that the parts are not produced by the same unit. Specialised construction activities are mostly carried out under subcontract, but especially in repair construction it is done directly for the owner of the property. Also included are building finishing and building completion activities.

The CSO measures the value of construction activity as part of the Gross Fixed Capital Formation ("GFCF") in the economy. The breakdown provided is between Dwellings, Roads, Other Building and Construction and Transfer Costs, which are the costs associated with the transfer of land and buildings.

The three divisions are summarised below and show the detailed composition of the type of work classified under each division:

n.e.c. : not elsewhere classified			
Division	Group	Class	
			SECTION F — CONSTRUCTION
41			Construction of buildings
	41.1		Development of building projects
		41.10	Development of building projects
	41.2		Construction of residential and non-residential buildings
		41.20	Construction of residential and non-residential buildings
42			Civil engineering
	42.1		Construction of roads and railways
		42.11	Construction of roads and motorways
		42.12	Construction of railways and underground railways
		42.13	Construction of bridges and tunnels
	42.2		Construction of utility projects
		42.21	Construction of utility projects for fluids
		42.22	Construction of utility projects for electricity and telecommunications
	42.9		Construction of other civil engineering projects
		42.91	Construction of water projects
		42.99	Construction of other civil engineering projects n.e.c.
43			Specialised construction activities
	43.1		Demolition and site preparation
		43.11	Demolition
		43.12	Site preparation
		43.13	Test drilling and boring
	43.2		Electrical, plumbing and other construction installation activities
		43.21	Electrical installation
		43.22	Plumbing, heat and air conditioning installation
		43.29	Other construction installation
	43.3		Building completion and finishing
		43.31	Plastering
		43.32	Joinery installation
		43.33	Floor and wall covering
		43.34	Painting and glazing
		43.39	Other building completion and finishing
	43.9		Other specialised construction activities
		43.91	Roofing activities
		43.99	Other specialised construction activities n.e.c.

Source: NACE Rev. 2 Statistical classification of economic activities in the European Community, Eurostat, European Commission, available at:
https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Appendix 3

Focus Group Participants

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Appendix 3: Focus Groups

A total of three focus groups were completed as part of the consultation and information gathering exercise. The EY team along with Enterprise Ireland hosted three Focus Group Meetings to hear first hand from key representatives from the industry.

- Government Representatives; 28th July 2021
- Stakeholder Representatives; 23rd August 2021
- Firms Representatives; 24th August 2021

The agenda was as follows;

- **Welcome & Introduction:**
  Chair of the Innovation and Digital Adoption for Construction Sector Group (CSG)
- **Update of Progress:**
  EY provided an update on the project in relation to the initial findings from the surveys, the international benchmarking and the examination of global trends and introduced key themes for the round table discussions in this focus group.
- **Round Table Stakeholder Focus Group Discussion**
  Facilitated by EY
- **Next steps, Follow up and Close**

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List of attendees at Focus Groups

Government Department/Organisation Focus Group 1	Industry Stakeholder Focus Group 2	Firms operating in the construction and built environment sector Focus Group 3
Chair of the CSG Innovation and Digital Adoption Subgroup	Chair of the CSG Innovation and Digital Adoption Subgroup	Chair of the CSG Innovation and Digital Adoption Subgroup
Department of Enterprise, Trade and Employment - 2 representatives	Association of Consulting Engineers of Ireland	Architectural firm
Department of Health - 3 representatives	BRE Global Ireland	Architectural firm
Department of Public Expenditure and Reform (DPER) - 3 representatives	Centre For Excellence in Universal Design	Architectural firm
Department of Housing, Local Government and Heritage – 2 representatives	Cogent Associates (Fellow of the Society of Chartered Surveyors Ireland)	Building contractor
Department of Transport	Construction Industry Federation	Construction firm
Department of Further & Higher Education, Research, Innovation and Science	Construction Industry Federation	Construction firm
Land Development Agency	Construction Industry Federation	Construction firm
Office of Public Works	Engineers Ireland	Construction firm
Transport Infrastructure Ireland	Engineers' Ireland	Construction specialist in Quality and Lean Management#
Grangegorman Development Agency (GDA)	Irish Green Building Council	Construction specialist in Quality and Lean Management#
Enterprise Ireland - 2 representatives	Kingspan Century Ltd (Irish Timber Frame Manufacturers' Association)	Construction Technology Consultancy
	National Standards Authority of Ireland	Construction Technology firm
	National Standards Authority of Ireland	Consulting Engineering firm
	Public Expenditure and Reform (DPER)	Consulting Engineering firm
	Quality Positive (Chair of CIF Working Group on MMC)	Design, manufacture and supply of precast cladding
	RKD Architects (The Royal Institute of the Architects of Ireland)	Digital Technology firm
	RKD Architects (The Royal Institute of the Architects of Ireland)	National Training Agency
	Technological University Dublin	Supply chain partner providing R&D services
	The Royal Institute of the Architects of Ireland	

Appendix 4

International Benchmarking Case Studies

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Case Study: Main Activities of the Construction Scotland Innovation Centre

Construction Scotland Innovation Centre

The majority of support from the CSIC is delivered on a project basis. Projects supported by CSIC are required to be innovative in nature or lead to innovation solutions for the construction industry.

The Construction Scotland Innovation Centre have supported over 350 innovation projects by working with industry, academia and the public sector to research new products, processes, businesses models and services across the sector.

The Centre's innovation projects fall under five categories:

- Advanced industrialisation: Modern Methods to industrialise the sector
- Building sustainably: Working towards a more sustainable future
- Digital transformation: new technology to modernise and digitalise construction
- Culture change: moving towards collaboration, opportunity and innovation, and
- Future skills and workforce: funded Masters' projects and investing in industry skill gaps.

Sources: kenoteq-k-briq-case-study.pdf (cs-ic.org)
skills-and-training-case-studies-2.pdf (cs-ic.org)
Construction Scotland | Industry Leadership Group | Case studies (cs-ic.org)

BIM Level 2: Affordable Housing

Over 200 Housing Associations in Scotland and the Scottish Government's had pledged to build 50,000 houses by 2021. The Scottish Federation of Housing Association (SFHA) identified a need for additional training and introduced the concept of BIM for Affordable Housing at their Conference in February 2017.

CSIC in collaboration with SFHA and a consultancy firm, developed an intensive 2 day CPD training course aimed to equip those responsible for the design and delivery of affordable housing projects across Scotland attain BIM Level 2 standards. This CPD workshop was aimed at development teams, maintenance teams and design teams including architects, engineer's construction partners and their supply chain.

Outputs:

- The main principles of BIM level 2
- Understanding how to implement BIM across an organisation
- How BIM applies to asset management and refurbishment projects
- Making sense of the BIM roles
- An understanding of the need for true collaboration
- The benefits of applying BIM Level 2 to a construction project.

The programme highlighted that there are a limited number of case studies available for BIM Level 2 housing projects in Scotland. Many companies seek evidence of the benefits of adopting BIM Level 2 in a project before entering contracts.

The K-Briq: The Sustainable Brick

The K-briq is a new sustainable brick that has been in development for over 10 years by academics from Heriot-Watt University. This product is made from 90% recycled material. The Sustainable Brick has no equivalent product on the market; the K-briq has the highest recycled content and the lowest energy required for production, it is not fired like traditional clay bricks and no cement is used in its production.

It uses building waste, such as bricks, stone and plasterboard cut off. This is crushed to make a powder, mixed with a binding agent and then molded using a press. This production technique and brick content dramatically reduce the K-briq's emissions.

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Governance Case Study: The Construction Innovation Hub UK

Governance Case Study: Construction Innovation Hub UK

The Construction Innovation Hub is governed by a Board. The Board is responsible for the overall strategy and performance of the Hub. Board members include senior representatives from the three partner organisations which formed the Hub (MTC, CDBB and BRE), along with the Hub's Programme Director, Operations Director, Security Manager and the UK Research and Innovations Transforming Construction Challenge Director.

The Hub also has a Project Management Office which supports programme level activities, operational leadership, management, delivery and reporting.

The Hub has also created an Industry Advisory Board which aims to bring the voice of the construction industry to the programme. The Industry Advisory Board provides external challenge and direction, shares vital information and encourages collaboration. The Industry Advisory Board also makes sure the outputs of the programme reach businesses with the potential to drive the transformation of the sector.

The Industry Advisory Board currently consist of the following members:

- Chief Executive of Royal Town Planning Institute
- Chief Executive of Civil Engineering Contractors Association
- Chief Executive of Construction Products Association
- Head of Performance, Commercial Advisor Team Infrastructure and Projects Authority
- Chief Executive of Cast Consultancy
- Chief Executive of Association for Consultancy and Engineering

Government, Industry and Academic Partners

Sources: Governance - Construction Innovation Hub
Industry Advisory Board - Construction Innovation Hub

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Commercialisation Case Study: Construction Scotland Innovation Centre

Case Study : Construction Scotland Innovation Centre

The Construction Scotland Innovation Centre (CSCI) is an industry led, Innovation Centre connecting businesses, public sector and academia with the aim of delivering transformational change in the construction sector. The Innovation Centre offers a number of; product development, manufacturing, robotics and visualisation equipment. The equipment is available to be hired on a Pay-As-You-Go basis or as part of an annual membership.

Equipment available for hire:

Digital Router: The Digital Router is capable of processing timber, composites, laminates, non-ferrous metals (among other materials). This creates flexible solutions for processing applications such as sheet material cutting, cladding panels, 3D profiling, general woodworking, exhibition stands, interiors, plastic fabrication, metal fabrication, foam modelling and more.

Benefits:

Automation: The automated CNC router can successfully and accurately repeat tasks fed from a digital design or CAD model without the need for manual input.

Accuracy: This state of the art technology allows for intricate processes to be performed with ease. If the design is drawn to the correct scale measurements then the router can efficiently execute the task.

Safety: Fitted with all relevant safety features and through remote operation (minimal reliance on manual input) this machine offers a higher quality product with reduced risk to the operator.

Reduced labour costs: The automated nature of this machine allows constant and reliable production from a single operator.

Flexibility: In built memory provides the ability for this machine to access numerous programmed operations at the click of a button meaning your organisation can focus on a range of projects simultaneously**.**

Multi-material 3D printer: The large-format Multi-material 3D printer offers an industrial scale build volume, meaning you can create 3D models faster and larger. The material quality allows working structural prototypes to be created and developed and for use in finished application. The extended build volume means scale models can be larger and printed in one batch.

The multi-material prints allow mixing and blending of material properties. Printing fuses together flexible and rigid material optimising the finished product's attributes. 3D printing is ideal for staged prototyping and product development. Working prototype models allow direct comparison and testing with the physical environment. The Multi-material 3D printer can complete a wide range of applications for both large and small prototypes for a variety of applications including over-moulded parts, multi-material assemblies, rubber-like components, dies, jigs, fixtures, brackets among many others.

Benefits:

Versatile: Capable of printing a range of material finishes.

Volume: The large build plate is ideal for industrial sized components or larger batch production of smaller items.

Speed: Faster than traditional prototyping processes.

Definition: The high accuracy of the print allows fine and detailed features or models.

Reduced costs: 3D printing requires low initial capital investment. Tooling and moulds are not required to create new products.

Sources: Construction Scotland | Industry Leadership Group | Digital Router (cs-ic.org)
membership packages 1217 (cs-ic.org)

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Commercialisation Case Study: Construction Scotland Innovation Centre

Membership Available The centre has a membership option available for organisations, businesses and individuals to sign up to. The annual membership fee includes an allocation of credits which members can redeem against a number of products and services at CSCI. This includes discounted equipment hire, training workshops, information events an access to hot desking facilities. Additional credits can also be purchased.

Annual Membership Costs	Membership (from 2017) exc. VAT	Credits
Large Business (>250 employees)	£2,000	10
Medium Business (50-249 employees)	£1.125	6
Small Business (6-49 employees)	£700	4
Micro Business (<5 employees)	£450	3
Students	£200	3
Universities, Colleges and Public Sector	£2,800	20

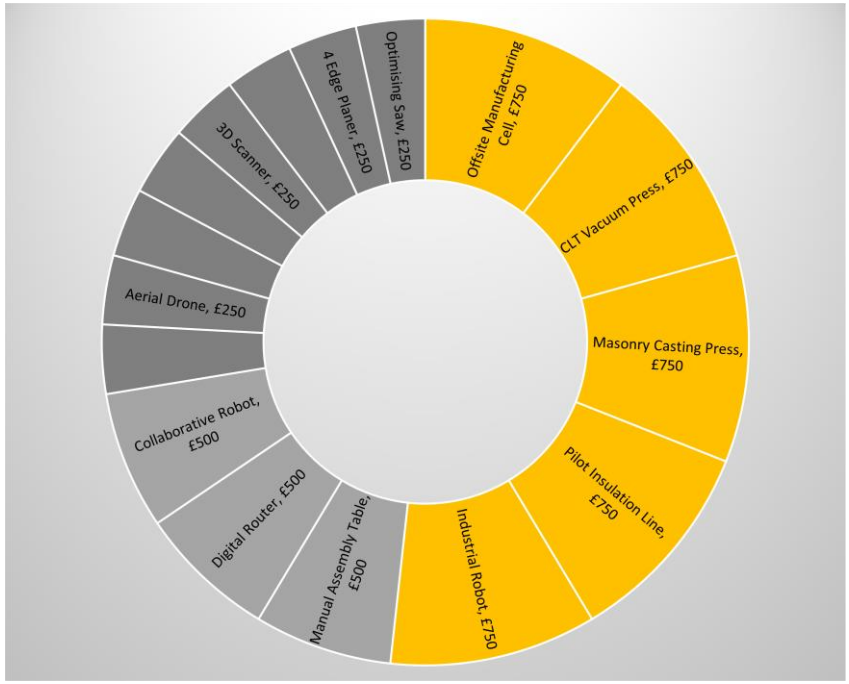
Equipment for hire	Number of credits for 1 day hire
Industrial Robot	3
Pilot Insulation Line	3
Masonry Casting Press	3
CLT Vacuum Press	3
Offsite Manufacturing Cell	3
Collaborative Robot	2
Digital Router	2
Manual Assembly Table	2
Optimising Saw	1
4 Edge Planer	1
Multi Material 3D Printer	1
3D Scanner	1
Augmented Reality Headset	1
Virtual Reality Headset	1
Aerial Drone	1
Mobile Training Suite for BIM and IT-based learning	1

Pay-As-You-Go: The Centre also gives organisations, businesses and individuals a more flexible option in the form of Pay-As-You-Go renting and use of equipment.

Table: Pay-As-You-Go Costs

Price Level	Half Day	Full Day
3	£375	£750
2	£250	£500
1	£125	£250

The chart below provides a breakdown in the cost of hiring each piece of equipment for one day.



Source: membership packages 1217 (cs-ic.org)

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Case Study: Existing EU Funding

Horizon 2020: BIM based fast toolkit for Efficient Renovation in Buildings

Project Name: Smart BIM based toolkit for building renovations

Date: January 2019 – June 2022

Budget: € 6,993,942

EU Horizon Contribution to Budget: 100%

Coordinated by: POLITECNICO DI MILANO (Italy)

While information management is crucial in the architecture, engineering and construction sectors, it faces complications in the renovation sector due to complex exchanges of information and data collection. Adapting some of the technologies and methods of team collaboration currently existing in the building sector may serve to effectively increase output in the renovation industry. The EU-funded project aims to develop an advanced toolkit based on Building Information Modelling (BIM) for renovation processes. The goal is to increase interoperability between software and participants involved in the whole chain of renovation processes. It will use smart, attractive solutions like digital logbooks and augmented reality for building retrofitting to match highest market expectations.

The project aims to foster the renovation industry by developing an attractive and powerful BIM-based toolset able to support designers in the design and planning phase, construction companies to efficiently carry out the work and service companies to provide attractive solutions for building retrofitting. Additionally, public and private owners will be able to use a tool that eases decision making and asset management, thanks to the exploitation of augmented reality and the use of updated digital logbooks. The project will deliver an innovative common BIM management system with linked data and a set of tools. This toolkit is the basic instrument for increasing semantic interoperability between software and stakeholders involved along the overall renovation process (design, planning, construction, performance assessment and management).

Progress to Date

- In the first 18 months, the project activities have focused on the specification of the efficient renovation process based on BIM usage, the definition of the ontologies relevant in the buildings' renovation domain, the specification and the development of first release of the toolkit.
- The activities started analysing the main stakeholders' requirements and needs in order to provide the necessary input data for defining the architecture of the BIM management system and for individualising the most proper existing ontologies.
- Ontologies for renovation work of existing buildings have been defined including information to be stored in BIM model for renovation process optimisation, renovation workflows representing the connection between activities and entities, and the aspects related to indoor quality and comfort of inhabitants.

The University College Cork is included within the participation team. The university to date has received €553,612 in funding from the Horizon 2020 project fund.

Source: BIM based fast toolkit for Efficient renovation in Buildings | BIM4EEB Project | Fact Sheet | H2020 | CORDIS | European Commission (europa.eu)

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The Case Study below provides just one example of a construction project in Spain which was funded by the EU Horizon 2020 programme.

Horizon 2020: Hybrid INDustrial CONstruction through 3D printing "all- in-one" machine for large scale advanced manufacturing and building processes.

Project Name: HINDCON Date: September 2016-2019

Budget: €4,798,205 EU Horizon Contribution to Budget: 100%

Coordinated by: VIAS Y CONSTRUCCIONES SA (Spain)

The main aim of the HINDCON project was to develop and demonstrate a hybrid machine for 3D printing with concrete materials focused on the industrialisation of the Construction Industry, delivering to this sector an innovative technology that reduces environmental impact at the same time it reduces dramatically economic costs.

The collaborative aimed to:

- Integrate different technologies that converge in a hybrid solution. HINDCON "all-in-one"" machine will integrate Additive Manufacturing concrete extruder and Subtractive Manufacturing tool kit with the use of cementitious materials including mass materials with alternatives in concrete and additives, and reinforced with composites.
- Cover the different aspects concerned (technology, economic, social and environment) and demonstrate the hybrid machine from different perspectives. On the one hand, it includes testing basic capabilities of the integrated prototype in laboratory. On the other hand, it involves the demonstration of the manufacturing system in a relevant environment."

The HINDCON project finished as planned on September 14th, 2019 and the main objectives presented on the initial proposal were successfully achieved.

The European Union have a number of targets to tackle climate change and to increase the use of clean innovative technologies in the future. The EU Innovation Fund is one of the largest international funding programmes for the demonstration of innovative low carbon technologies. Further, the European Commission is working on a potential governance structure for technology infrastructures and on prioritising access through the new European Research Area policies.

Sources: Hybrid INDustrial CONstruction through a 3D printing "all-in-one" machine for large-scale advanced manufacturing and building processes | HINDCON Project | Fact Sheet | H2020 | CORDIS | European Commission (europa.eu)

Hybrid INDustrial CONstruction through a 3D printing "all-in-one" machine for large-scale advanced manufacturing and building processes | HINDCON Project | Fact Sheet | H2020 | CORDIS | European Commission (europa.eu)

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Technology Case Study: The Construction Innovation Hub UK

The Construction Innovation Hub in the UK has chosen to focus on the development and promotion of technologies linked to their four key themes: Value, Manufacturing, Assurance, and Digital.

- **Value:** The Hub is working directly with Government, clients and the industry to develop the Value Toolkit, a suite to support faster, value based decision making across the investment lifecycle.
- **Manufacturing:** Includes the development of a Platform Design Programme, a platform construction system. This consists of a standardised 'kit of parts' that can be deployed across multiple building types and sectors and offer significant benefits in terms of quality, cost, delivery time and whole life value. By working in collaboration with industry and Government, the Platform Design Programme aims to: identify, develop and prove solutions that can be deployed at scale; Design integrated, manufactured components and sub-assemblies that will adhere to new interface standards; Create a 'rulebook' that will support wider adoption and provide guidance on how the system can support delivery of multiple building types as well as guide the development of further platforms; and, Make available the new standards and rulebook to all businesses in the UK, removing barriers for SMEs and new entrants.
- **Assurance:** This includes the development and roll out of the Construction Quality Planning Process and delivery of an online compliance tool. Development and roll-out of tools to help the construction sector drive a zero defects culture, such as the Construction Quality Planning (CQP) process;
  - Creation of a robust product compliance process for Platform approach to Design for Manufacture and Assembly (P-DfMA);
  - Validation processes through physical testing and digital simulations of components and systems for offsite construction;
  - Delivery of an online compliance tool for manufacturers, offsite builders, testing facilities and government bodies;
  - Development of occupational health and safety guidelines for offsite construction industry (P-DfMA approach); and,
  - Production of guidance and best practice for the transportation, lifting, assembly and logistics processes in the offsite construction industry.
- **Digital:** The Construction Innovation Hub's Digital Framework is helping to quicken the pace towards greater digitalisation in the construction industry. The Hub is working to promote and demonstrate the potential and benefits of innovative processes, tools and technologies, including Building Information Modelling (BIM) Interoperability. It is currently creating practical guidance, tools (such as benefits realisation) – and case studies to show why and how organisations should be adopting information management using BIM, Government Soft Landings (GSL) and security-mindedness processes in procurement frameworks, construction projects and in operation.

CONSTRUCTION INNOVATION HUB

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Technology Research Case Study : Centre for Innovation in Construction and Infrastructure Engineering and Management Canada

The CICIEM focus on five areas of applied research that encourages large-scale interdisciplinary research, training of highly qualified personnel, technology transfer and interaction with industry and municipalities.

1) Automation and Robotics in construction

Addressing *Industry 4.0* trends toward automation and related data exchange and processing.

Example projects

- deep learning computer vision for detecting and classifying construction activities
- robotic earthmoving operations using multi-agent systems.

2) Sensing technologies and IoT applications in construction/infrastructure engineering and management

New algorithms will be developed by extending the recent advancements in sensing and telemetries while considering the challenging requirements of construction projects

Example projects

- Automated site data acquisition and utilisation in productivity modelling and in tracking progress reporting
- intelligent identification of construction performance variances; autonomous systems for improving worker safety

3) Big data analytics and data science applications in the context of smart cities

While digitalisation is the main driver towards smart cities, the drive is not limited to the digital aspect. Analysis of the city big data can create a new discourse for planning, construction, and operation of the physical urban infrastructure

Example projects

- developing deterioration models for urban infrastructure assets via machine learning and deep learning.
- evaluating user-driven levels of service for urban infrastructure through text mining, computational linguistics, and social network analysis
- urban information modelling and urban computation for demand detection and decision making to support emerging technologies

4) Industrialisation of construction

The knowledge from industrial engineering and supply chain management will be used to advance the research and practice in off-site and modular construction and construction 3D printing considering productivity, quality, logistics, and ergonomic issues

Example projects

- Optimisation of planning and manufacturing of modular and off-site construction
- developing manufacturing-centric, Building Information Modelling (BIM) based solutions to improve the level of automation of design, drafting, and quantity take-off
- framework for the implementation of smart factory concepts for logistics and on-site assembly in construction manufacturing

5) Reliability analysis, condition assessment and rating of infrastructure for optimised maintenance and intervention plans and value-driven budget allocation

Innovative methods will be developed to support efficient condition assessment and rating, tracking performance and optimised measures/interventions for maintenance and rehabilitation of civil infrastructure for long-term sustainability and networks resilience plans

Example projects

- computer vision for rapid screening of deteriorating infrastructure
- statistical pattern recognition method for assessing infrastructure condition
- data fusion and artificial intelligence technologies for structural health monitoring; optimisation of maintenance planning for sustainable infrastructure systems
- risk analysis for capacity enhancement of resilient transportation infrastructure networks

Source: Research activities (concordia.ca)

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Case Study: Membership Construction City Cluster

Membership: Construction City Cluster Norway

The Construction City Cluster Norway, like a number of other institutions, provides businesses and organisations based within Norway who offer or plan to offer products to the construction and real estate sector, the opportunity to become members.

The cluster encourages meetings between people and businesses, sharing insights. Members enjoy access to a set of benefits that help to transform the Norwegian construction and real estate industry:

- A vibrant innovation ecosystem that drives insight sharing, specific projects and conversations about industry challenges and strategies.
- A meeting place for events, courses and study trips that brings together a unique network of people and businesses from a variety of industry sectors.
- A co-location of the entire value chain, from promising start-ups to heavy contractors, for a common boost to the industry's overall international competitiveness.
- A laboratory for testing and developing the technology and business models that affect the industry.

The CCC does not offer individual memberships. The cluster has three membership levels:

Partner (c15 partners)
This membership level is reserved for organisations that are particularly central to the cluster's development. Educational institutions and public actors can also be offered partnerships. Membership fee: NOK 250,000 excl. VAT (€24,062).

Member (c67 members)

Any business or organisation based in Norway that offers or plans to provide products and services to in the construction and real estate industries may apply for this membership level. Membership fee: NOK 20,000 excl. VAT (= €1,925).

Entrepreneurship (c20 entrepreneurships)

Start-ups with a desire to further develop the industry within the cluster's strategic priority areas can be offered membership at this level, for a limited number of years. Membership fee: NOK 5,000 excl. VAT (€481).

Construction City Cluster

Source: Construction City | The Future of Construction

Appendix 5

Sources

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Appendix 6a

Survey Results: Firms

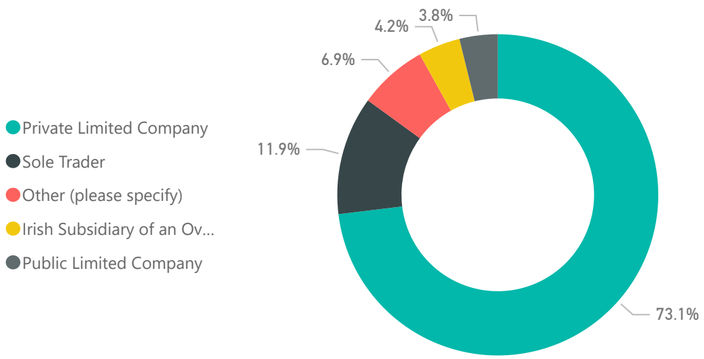
EY / Enterprise Ireland Survey

Building a better working world

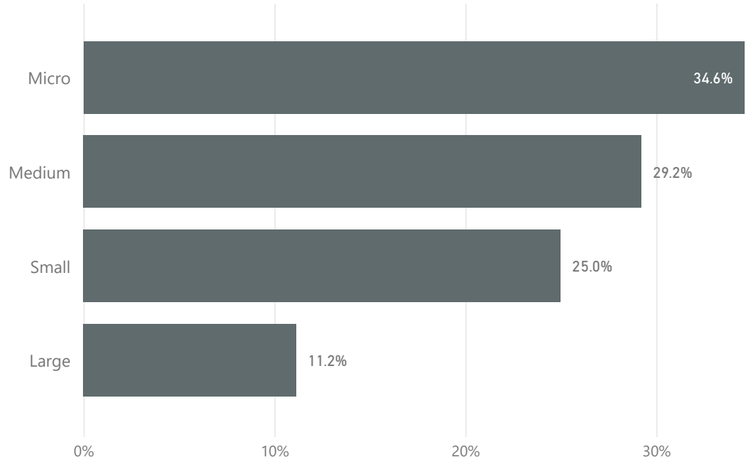
260

No of Respondents

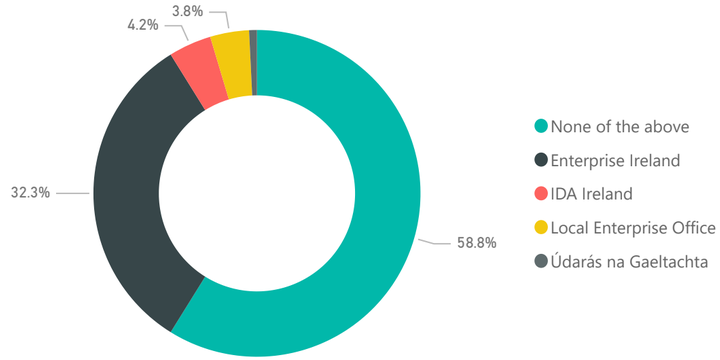
Q.1 Distribution by Firm Type



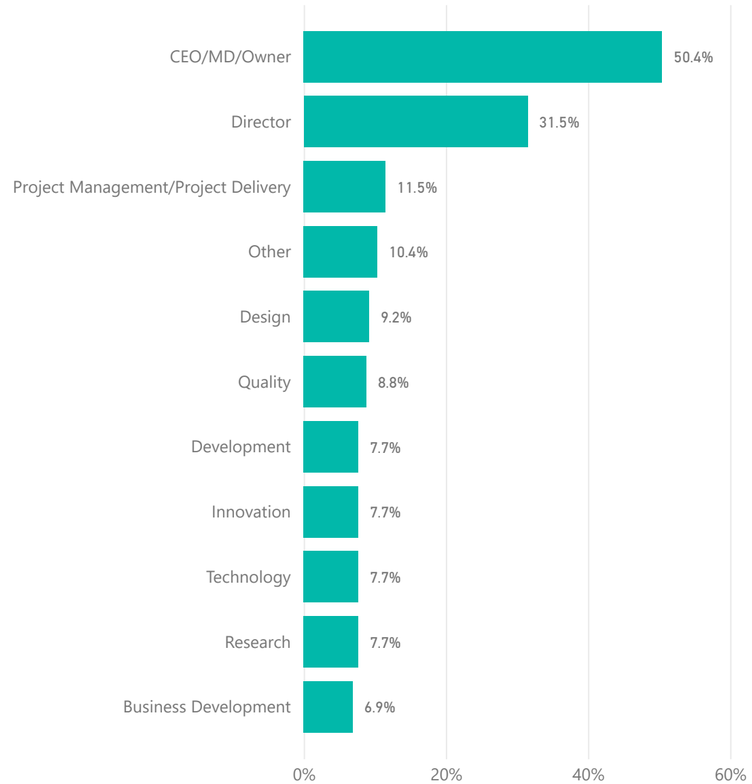
Q.3 Distribution by Number of Employees



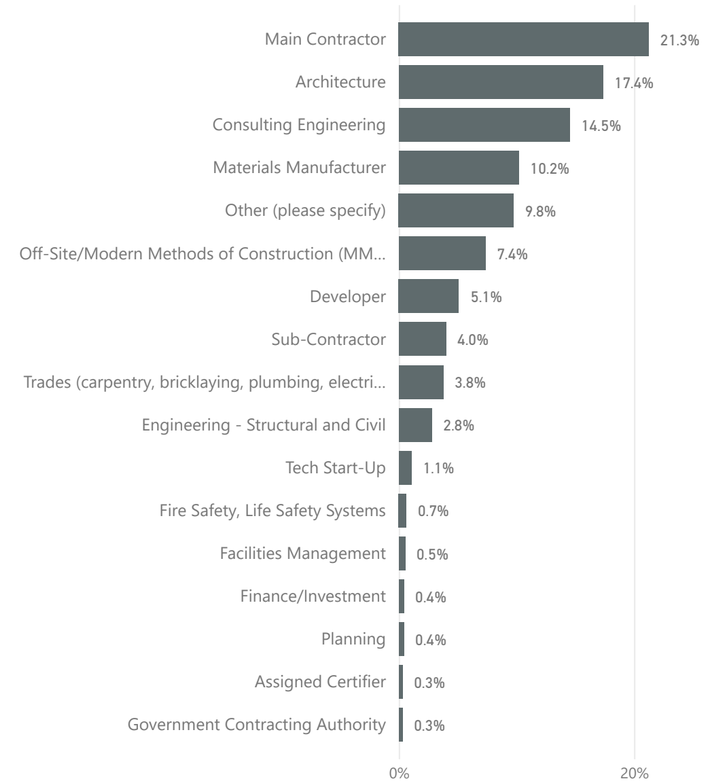
Q.4 Distribution by Development Organisation



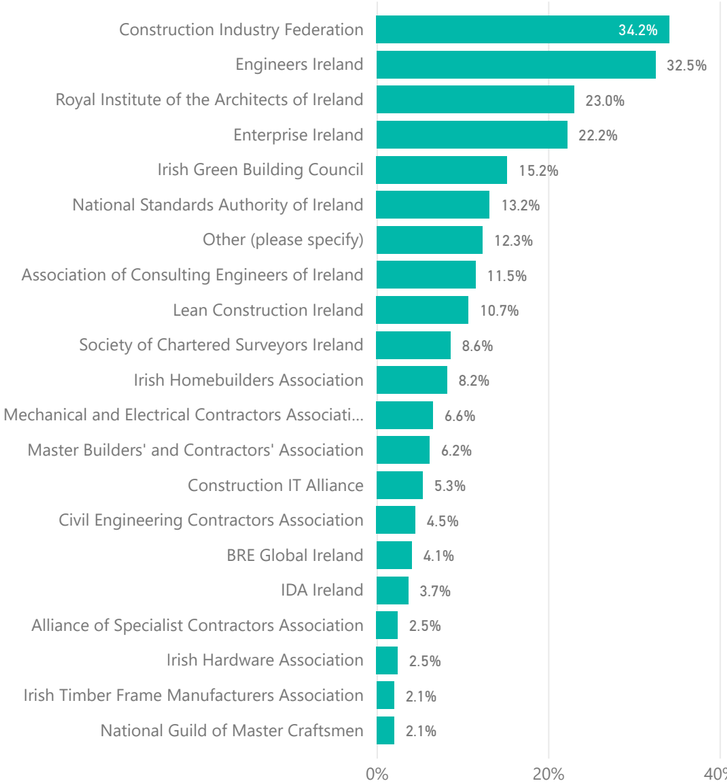
Q.2 Distribution by Role



Q.5 Predominant Activities



Q.6 Distribution by Membership Groups



Demographics Information

260

No of respondents

Firm Type: All

Type of Role: All

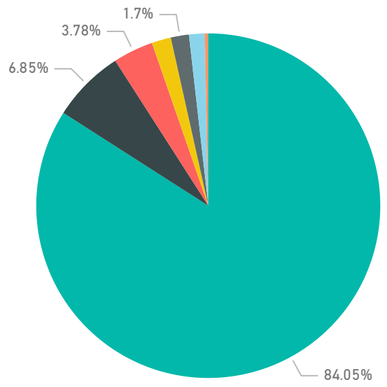
Size of Firm: All

Development Organization: All

Predominant Activities: All

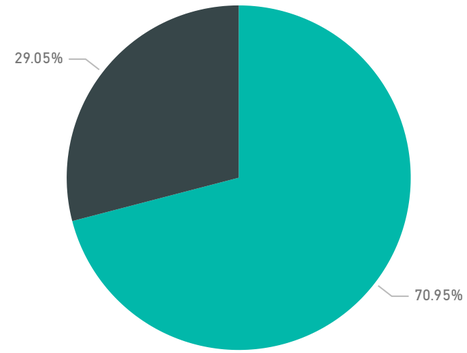
Membership Groups: All

Q7. Turnover generated from different territories



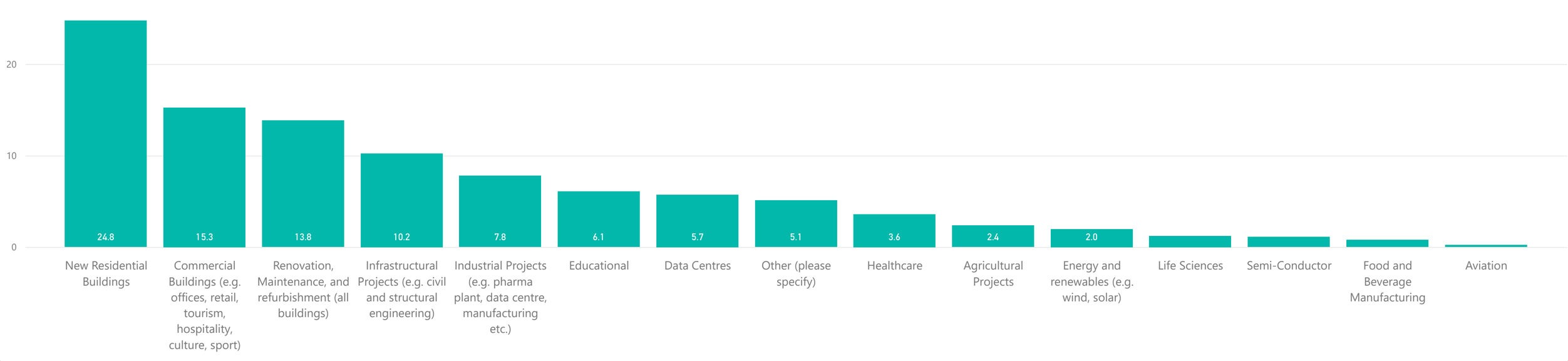
Republic of Ireland · Great Britain (excluding Northern Ireland) · European Union · Northern Ireland · Rest of World · USA and Canada · Asia

Q9. Turnover generated from different sectors



Private · Public

Q8. Turnover generated from different areas



Current Awareness- Technology and Innovation

260
No of respondents

Firm Type: All

Type of Role: All

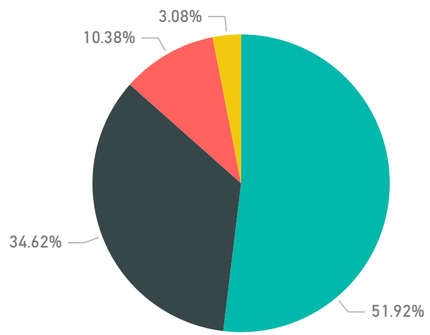
Size of Firm: All

Development Organization: All

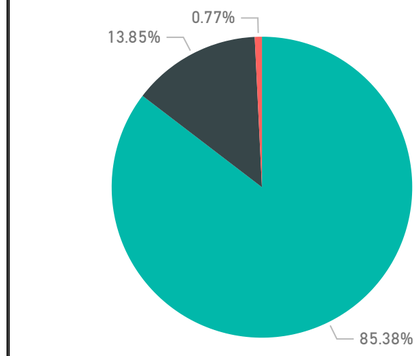
Predominant Activities: All

Membership Groups: All

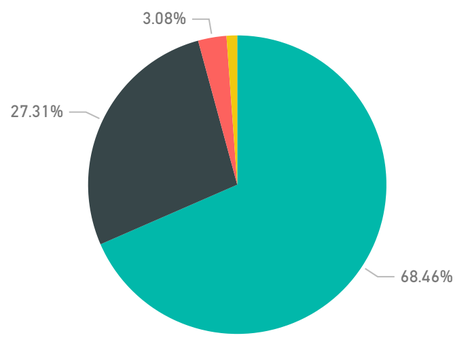
Q10 1.1 Enterprise Ireland Innovation Voucher



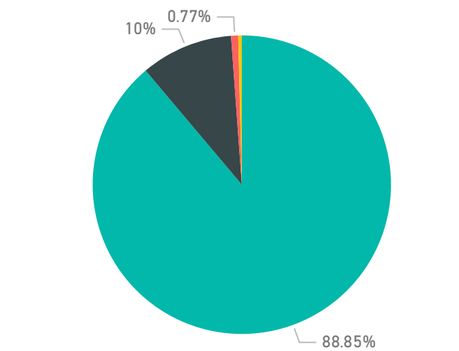
Q10 1.2 IDA Innovation Voucher



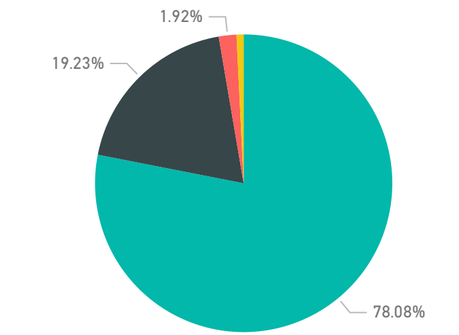
Q10 1.3 Enterprise Ireland Innovation Partnership



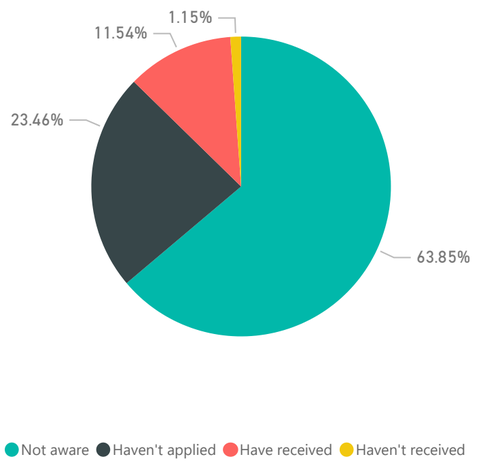
Q10 1.4 Disruptive Technologies Innovation Fund



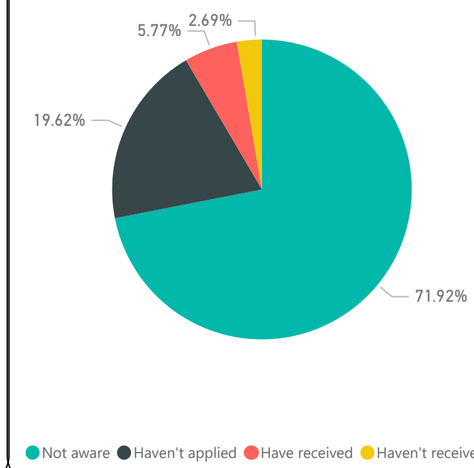
Q10 1.5 Horizon 2020 / Horizon Europe Funding



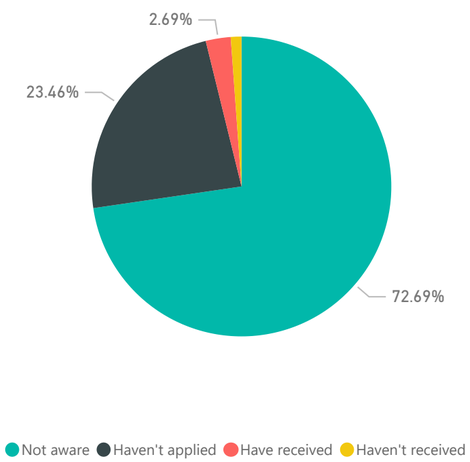
Q10 1.6 Enterprise Ireland Lean Start



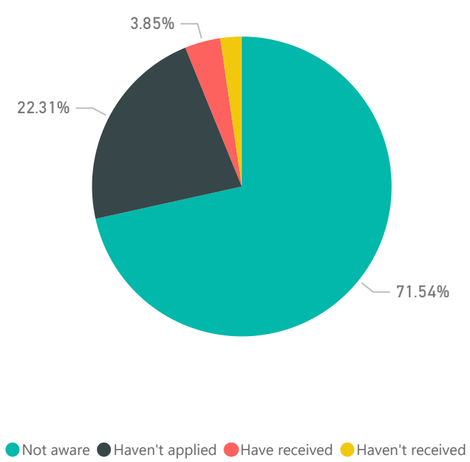
Q10 1.7 Enterprise Ireland Lean Plus



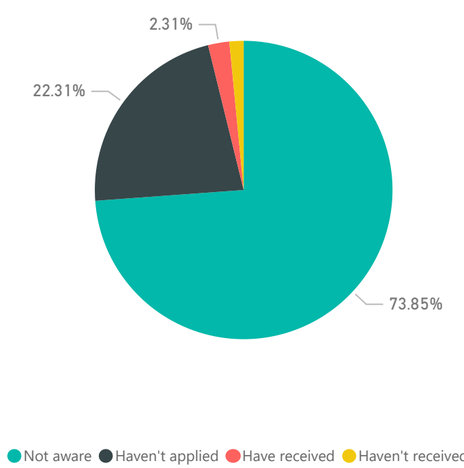
Q10 1.8 Enterprise Ireland Lean Transform



Q10 1.9 Enterprise Ireland BIM Enable



Q10 1.10 Enterprise Ireland BIM Implement



Current Awareness- Technology and Innovation

260
No of respondents

Firm Type: All

Type of Role: All

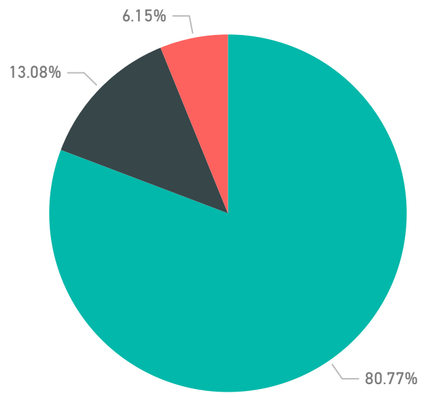
Size of Firm: All

Development Organization: All

Predominant Activities: All

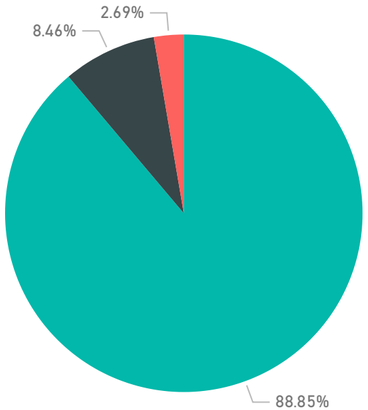
Membership Groups: All

Q11 1.1 Technology Centre in Ireland



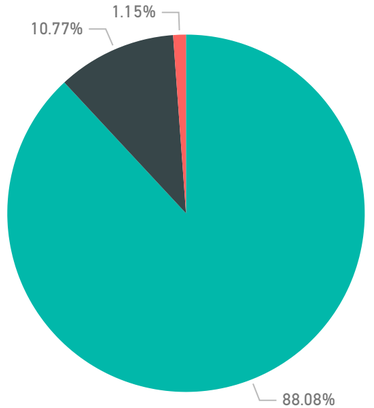
Not aware Haven't collaborated Have collaborated

Q11 1.2 Technology Gateway in Ireland



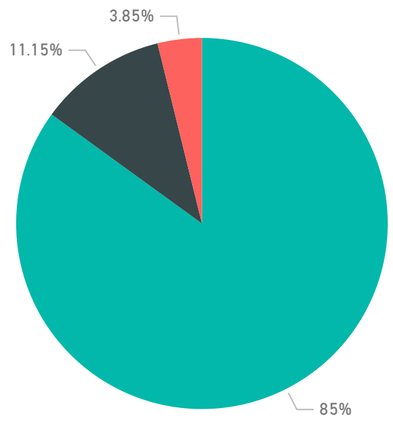
Not aware Haven't collaborated Have collaborated

Q11 1.3 Science Foundation Ireland Centre



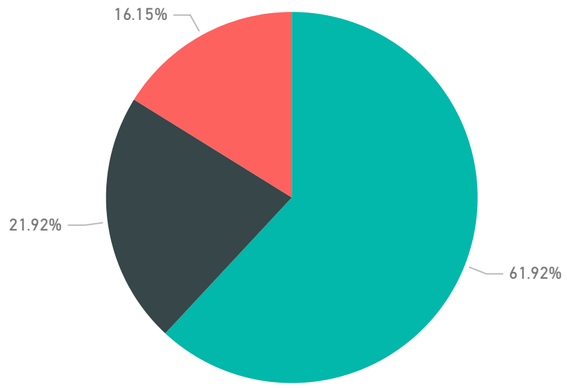
Not aware Haven't collaborated Have collaborated

Q11 1.4 International Research/Development/Innovation Centre



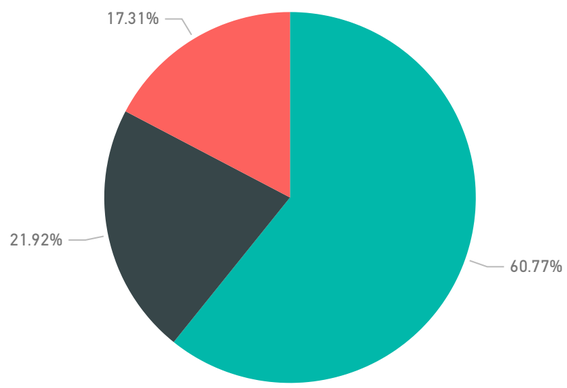
Not aware Haven't collaborated Have collaborated

Q11 1.5 University in Ireland



Not aware Haven't collaborated Have collaborated

Q11 1.6 Institute of Technology or Technological University in Ireland



Not aware Haven't collaborated Have collaborated

Current Awareness- Technology and Innovation

260
No of respondents

Firm Type: All

Type of Role: All

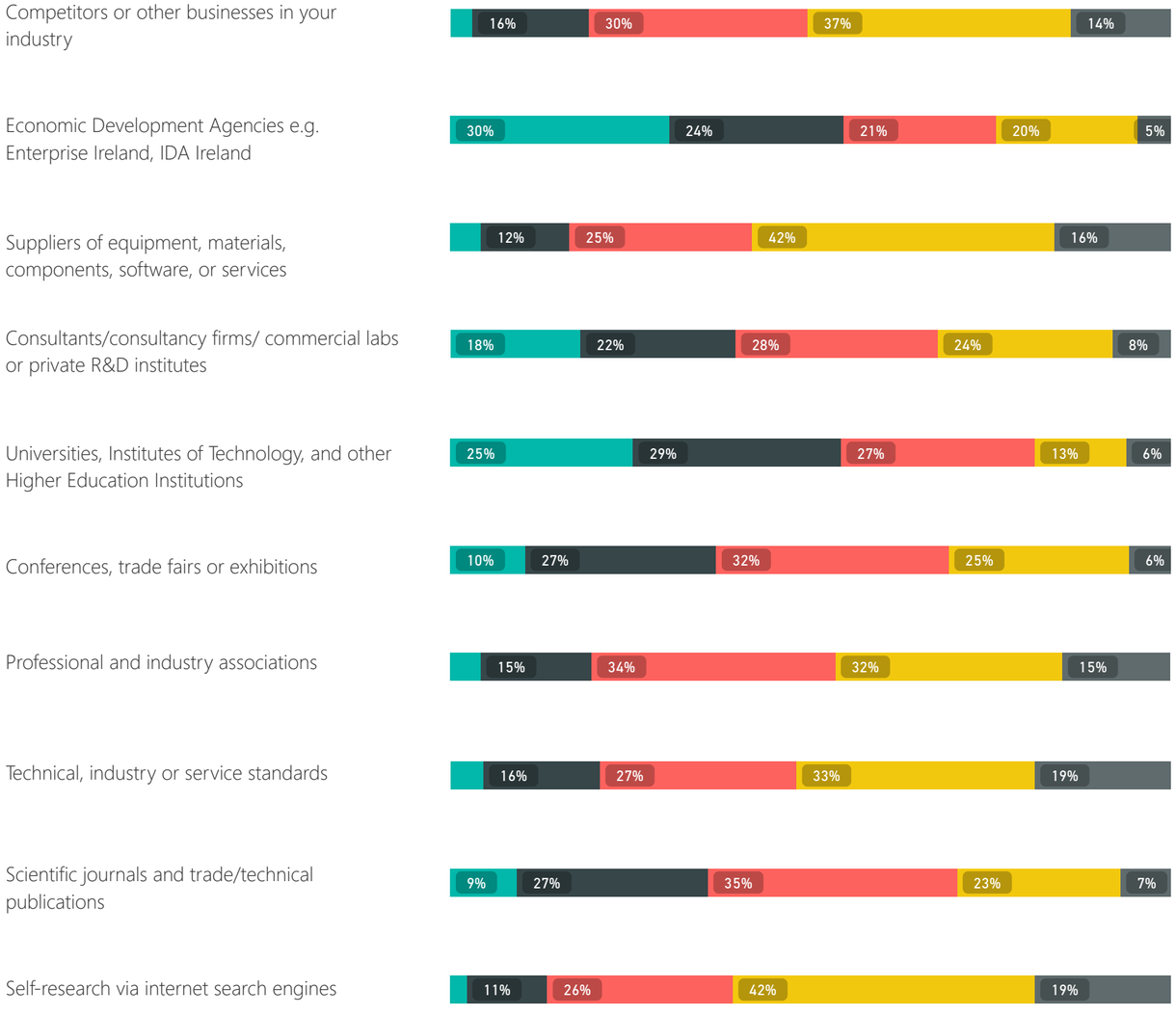
Size of Firm: All

Development Organization: All

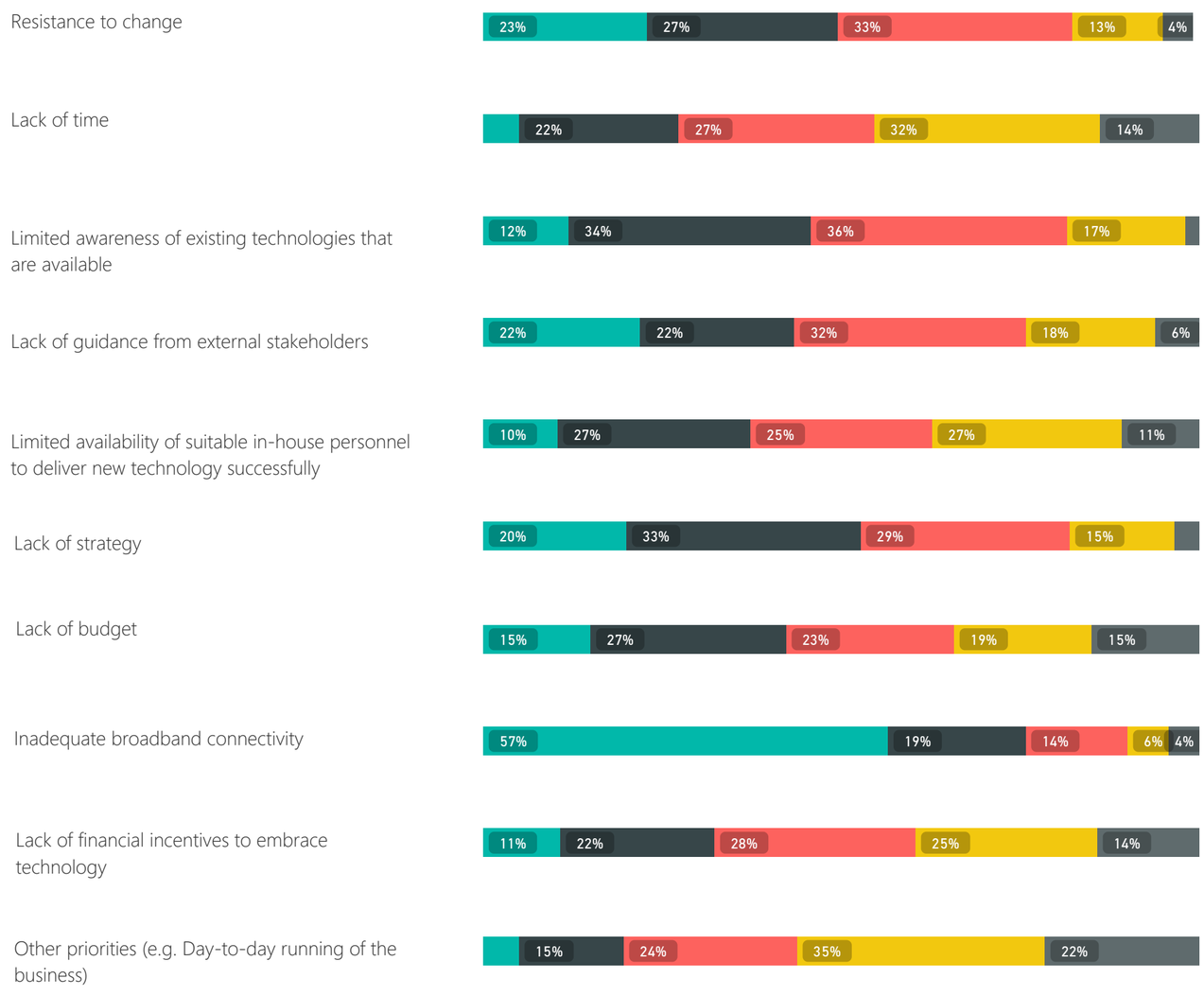
Predominant Activities: All

Membership Groups: All

Q.12 To what extent following information sources are important for firm's innovation



Q.13 To what extent following challlenges exist while implementing new technologies

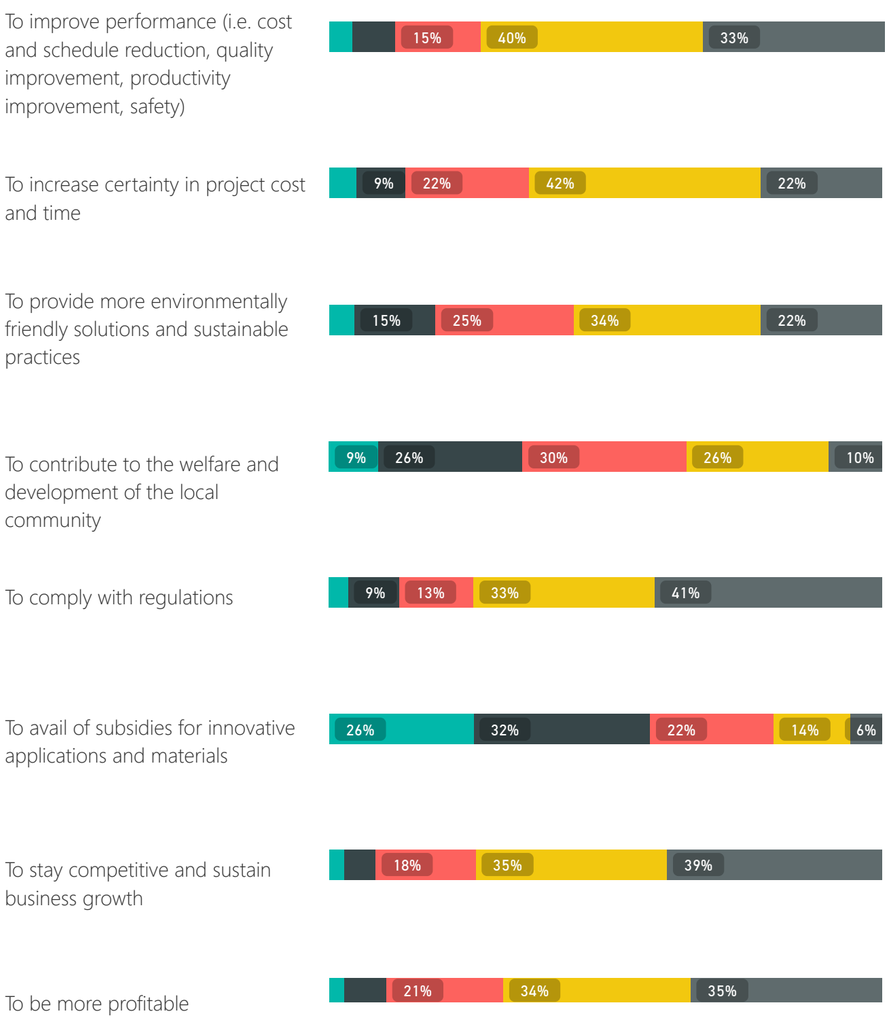


Current Awareness- Technology and Innovation

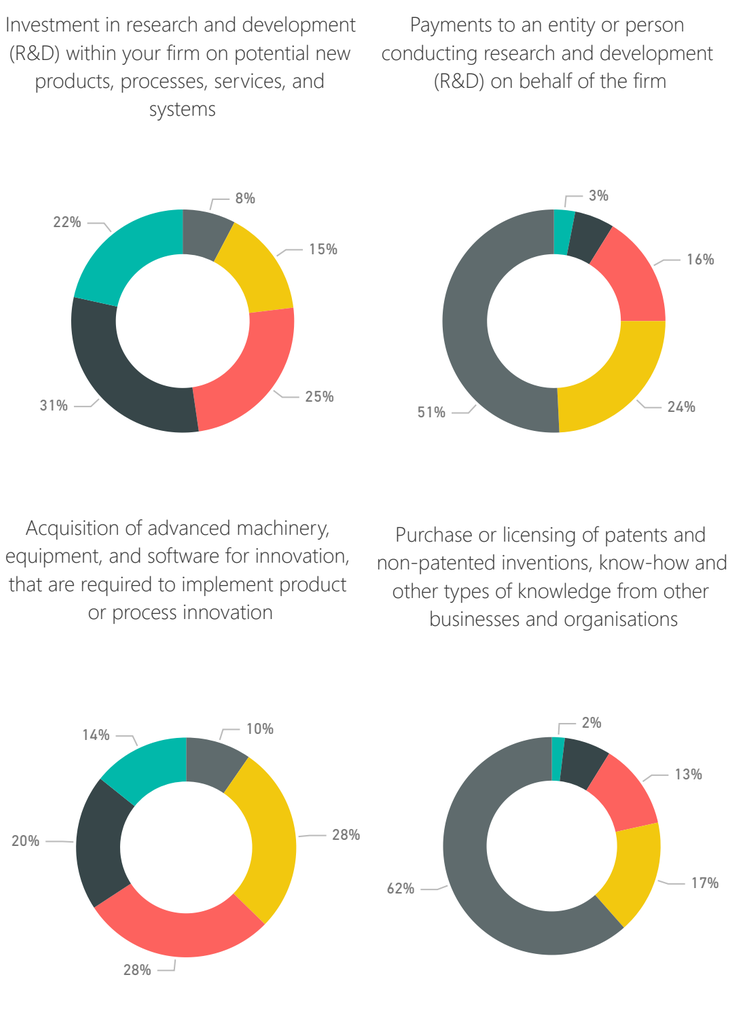
260
No of respondents

Firm Type: All
Type of Role: All
Size of Firm: All
Development Organization: All
Predominant Activities: All
Membership Groups: All

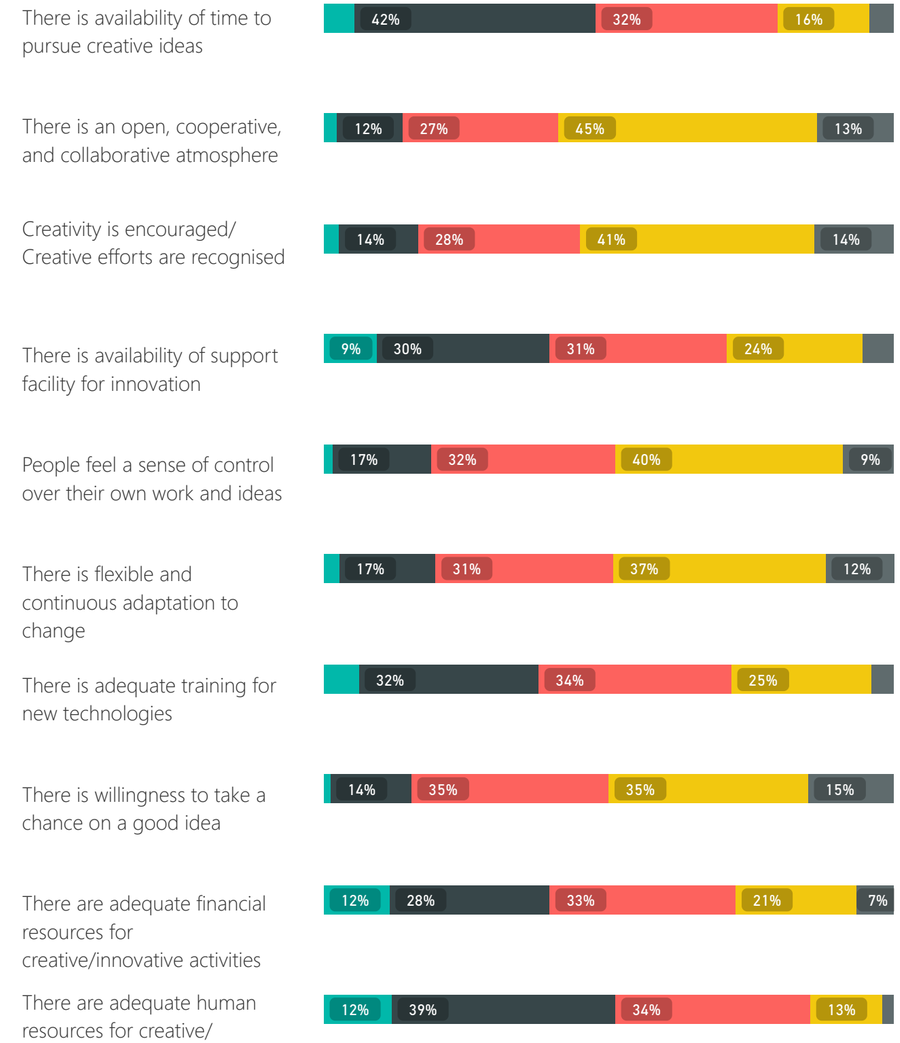
Q.14 To what extent following innovation drivers exist in your firm



Q.15 To what extent your firm invests for purpose of innovation



Q.16 To what extent following statements about the overall culture of the firm are true



Appetite for Technology and Innovation

260
No of respondents

Firm Type: All

Type of Role: All

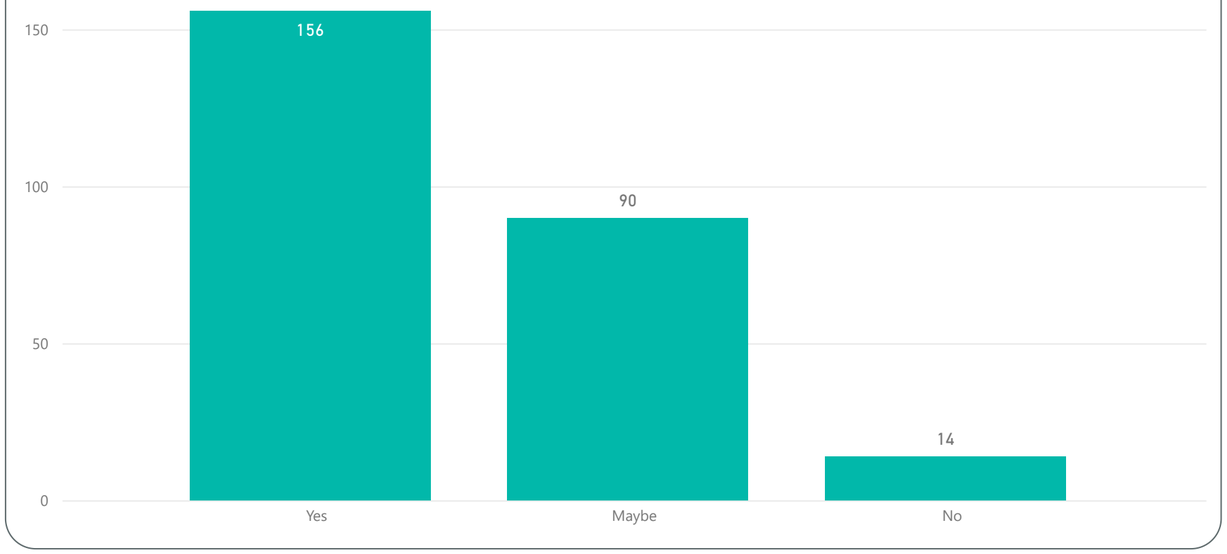
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q17A. Willing to collaborate with other organisations for research, development or innovation initiatives



Q18A. To what extent your firm has the capacity to allocate funds

Capacity to allocate funding to undertake collaborative research and development relevant to your company

Q19A. To what extent your firm has the capacity to allocate personal time

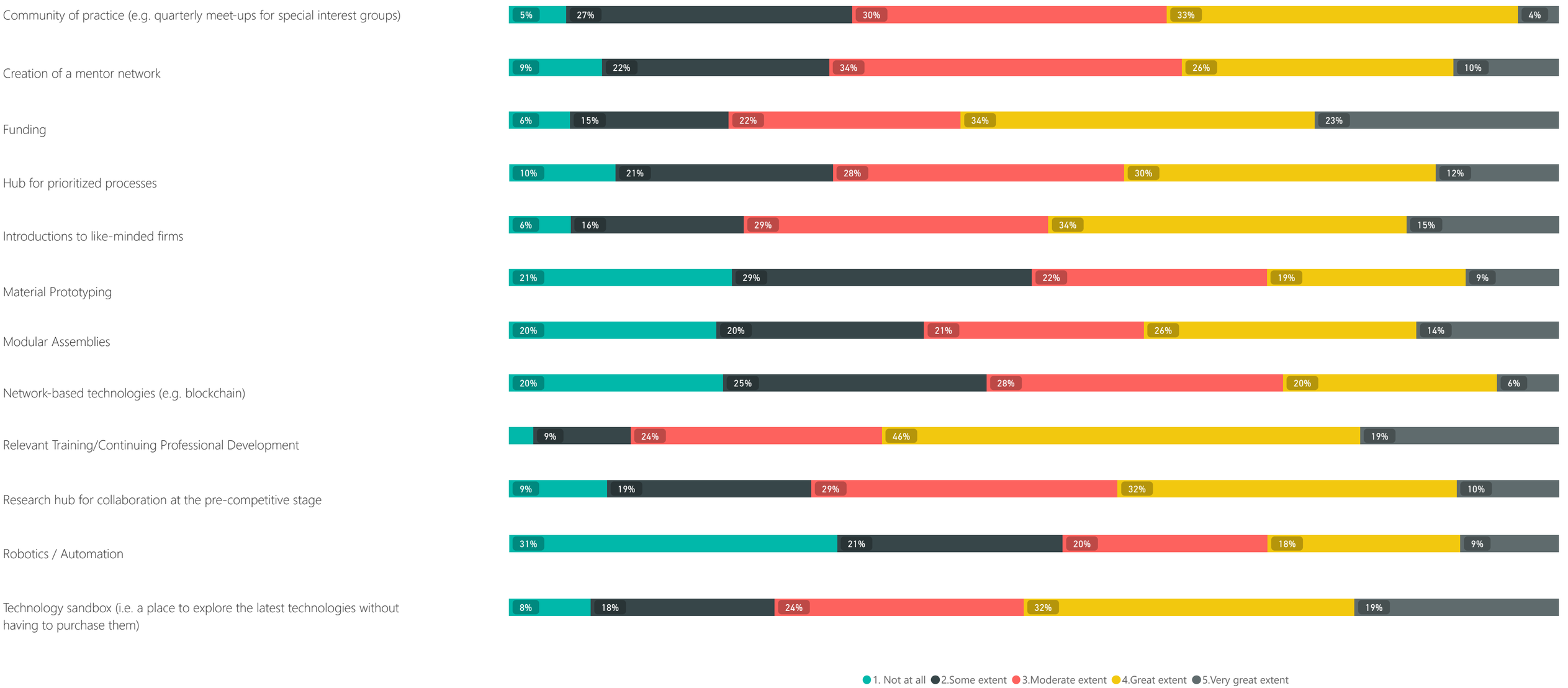
Capacity to allocate personnel time to collaborate on research relevant to your company

Appetite for Technology and Innovation

260
No of respondents

Firm Type: All
Type of Role: All
Size of Firm: All
Development Organization: All
Predominant Activities: All
Membership Groups: All

Q.20 To what extent following elements of centre could assist your firm

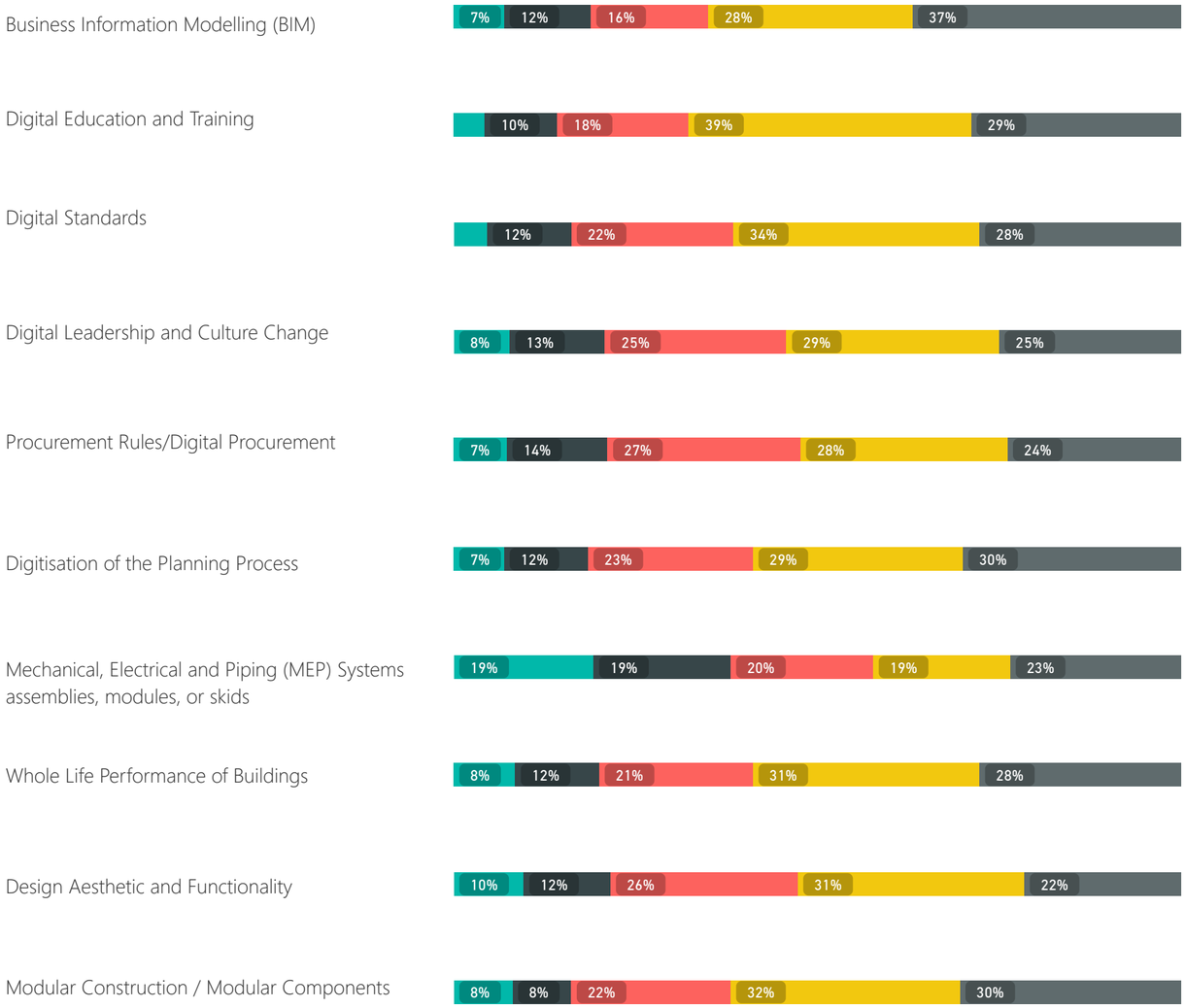


Construction-Specific Technologies

260
No of respondents

Firm Type: All
Type of Role: All
Size of Firm: All
Development Organization: All
Predominant Activities: All
Membership Groups: All

Q.23 How important following factors will be to your firm in next 10 years



Construction-Specific Technologies

260
No of respondents

Firm Type: All

Type of Role: All

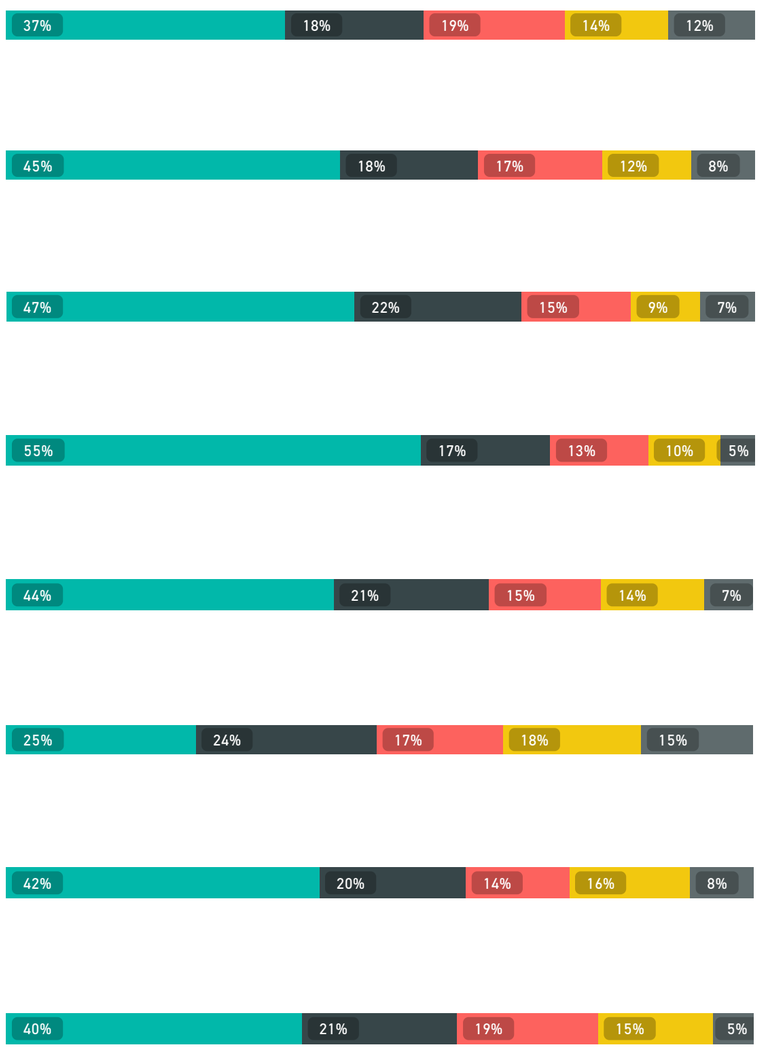
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q.24 To what extent following automated technologies are utlized for current activities



Construction-Specific Technologies

260
No of respondents

Firm Type: All
Type of Role: All
Size of Firm: All
Development Organization: All
Predominant Activities: All
Membership Groups: All

Q.25 To what extent following modern methods of construction are utilized by your firm

Sustainability

260

No of respondents

Firm Type: All

Type of Role: All

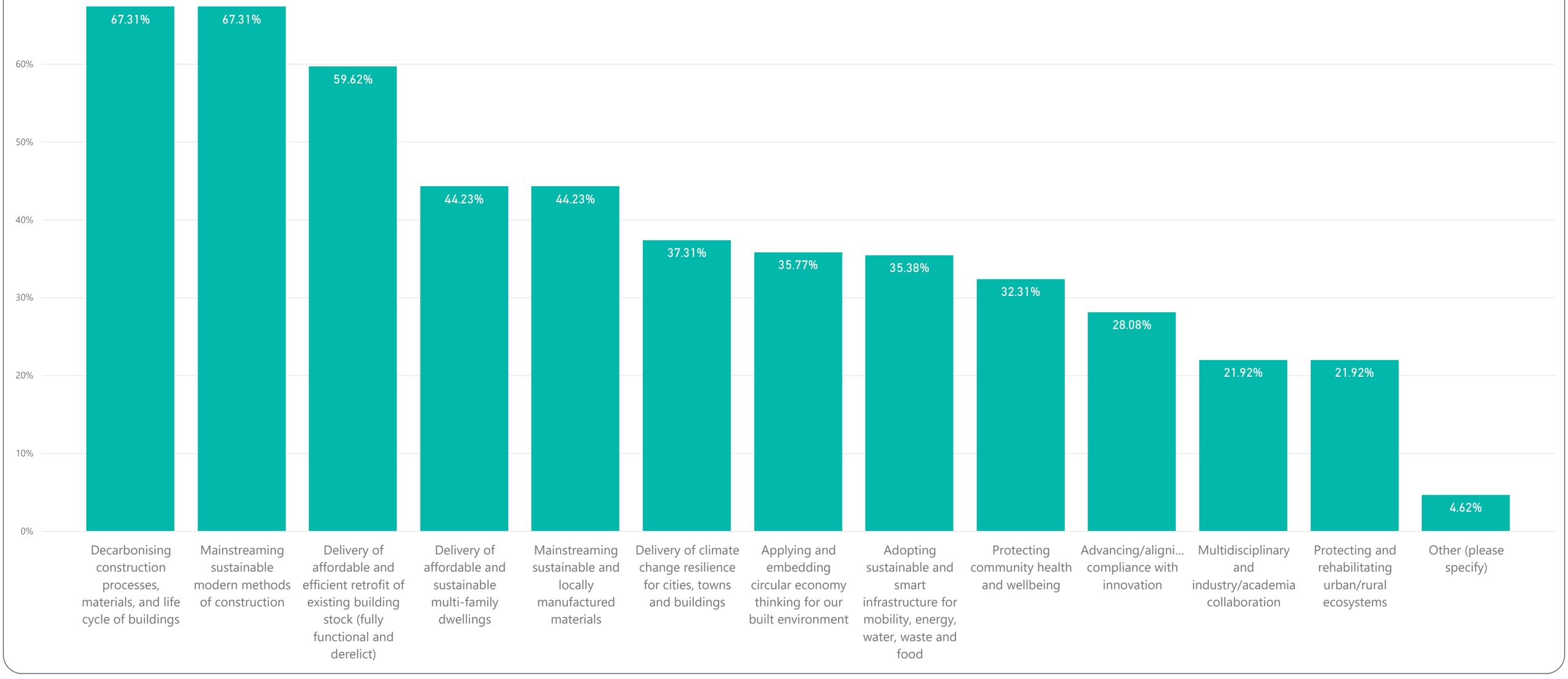
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q26. Challenges regarding sustainability that should be prioritised by centre, dedicated to research, development, and innovation for the built environment and construction sectors



Sustainability

260

No of respondents

Firm Type: All

Type of Role: All

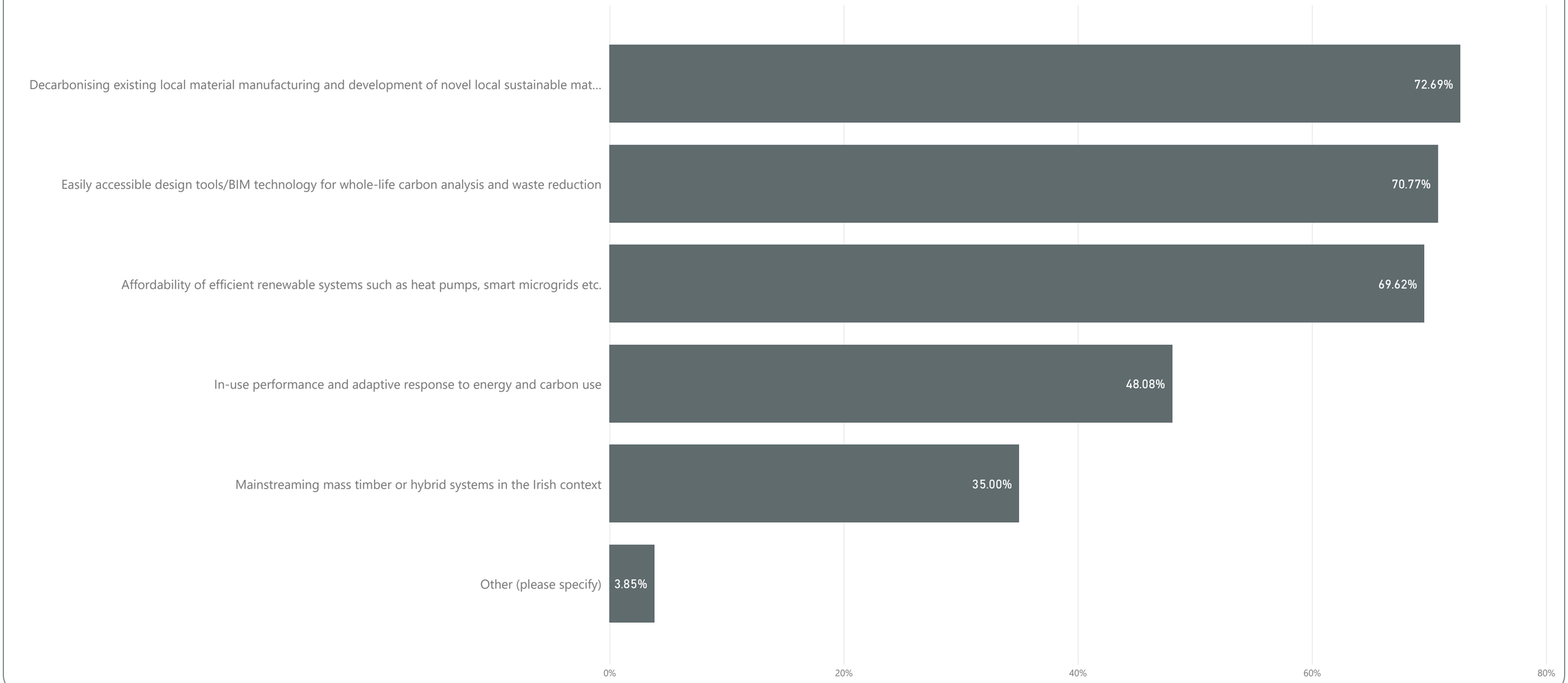
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q27. Areas of decarbonisation research that should be undertaken by centre dedicated to the research, development and innovation needs of the built environment and construction sectors



Sustainability

260

No of respondents

Firm Type: All

Type of Role: All

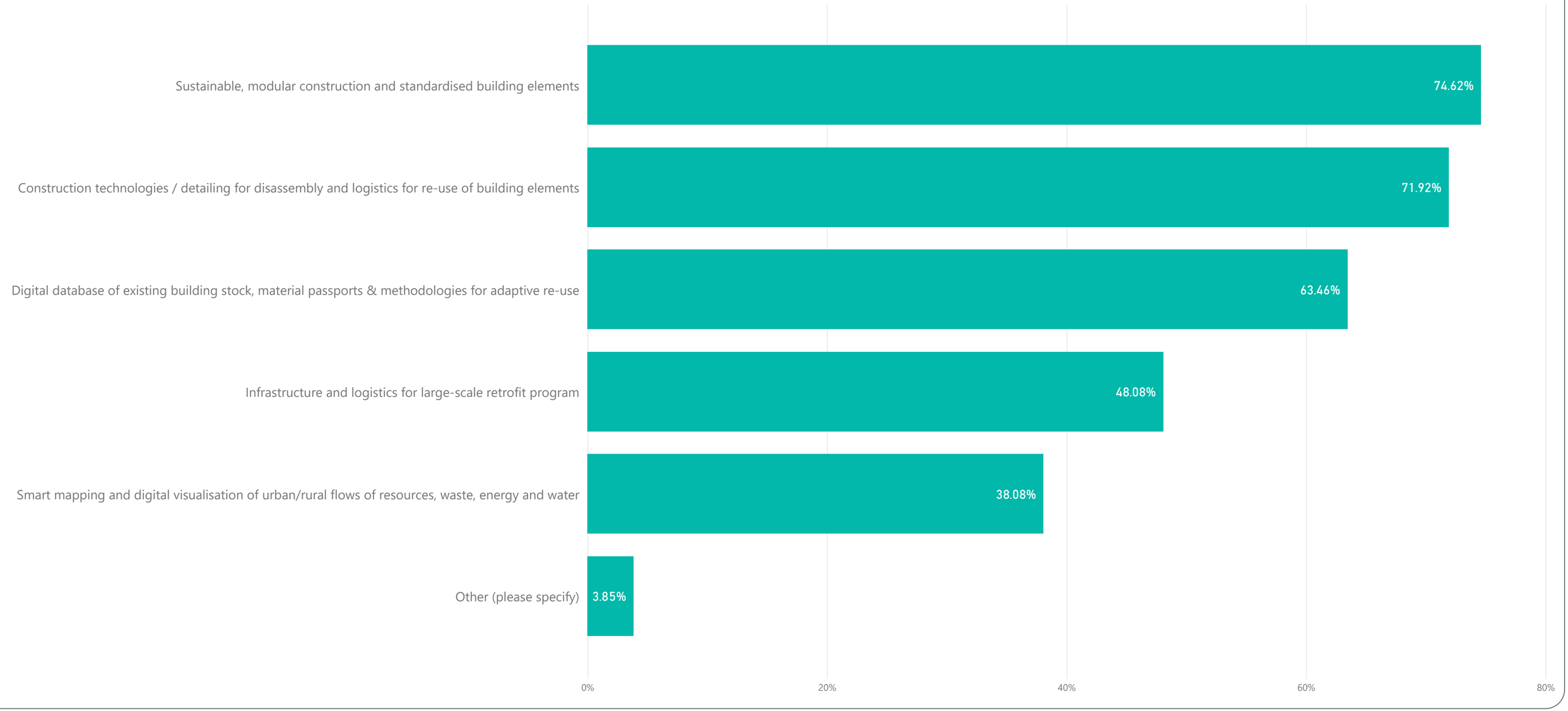
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q28. Areas of circular built environment research that should be undertaken by centre, dedicated to the research, development and innovation needs of the built environment and construction sectors



Sustainability

260

No of respondents

Firm Type: All

Type of Role: All

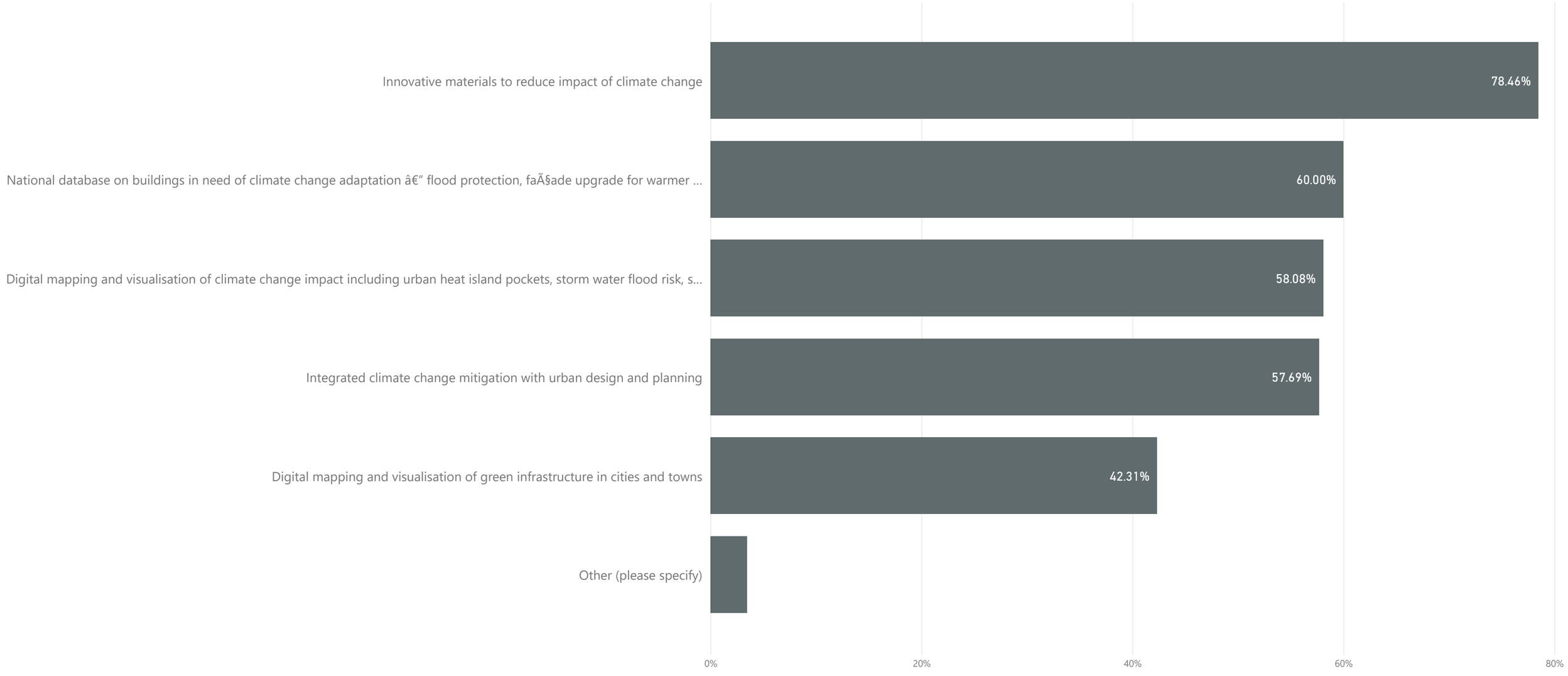
Size of Firm: All

Development Organization: All

Predominant Activities: All

Membership Groups: All

Q29. Challenges in climate change resilience research that should be undertaken by centre, dedicated to research, development and innovation needs of construction sector to drive innovation for sustainability and climate action in the sector



Appendix 6b

Survey Results: Stakeholders

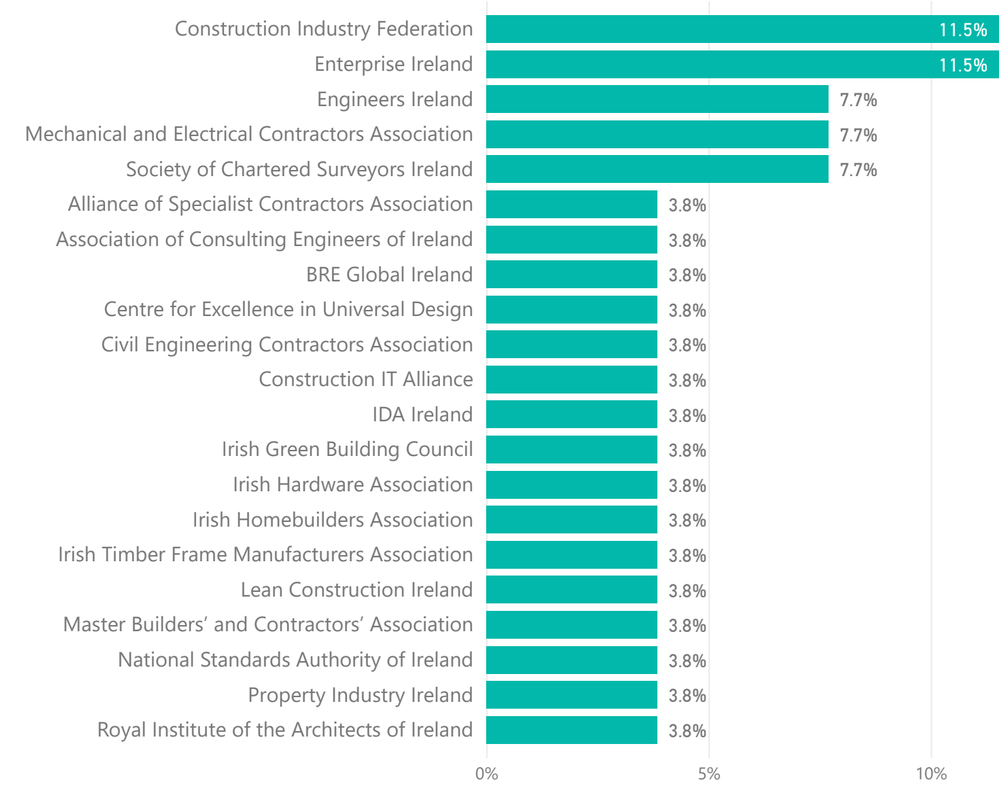
EY / Enterprise Ireland Survey - Stakeholder Groups

Building a better working world

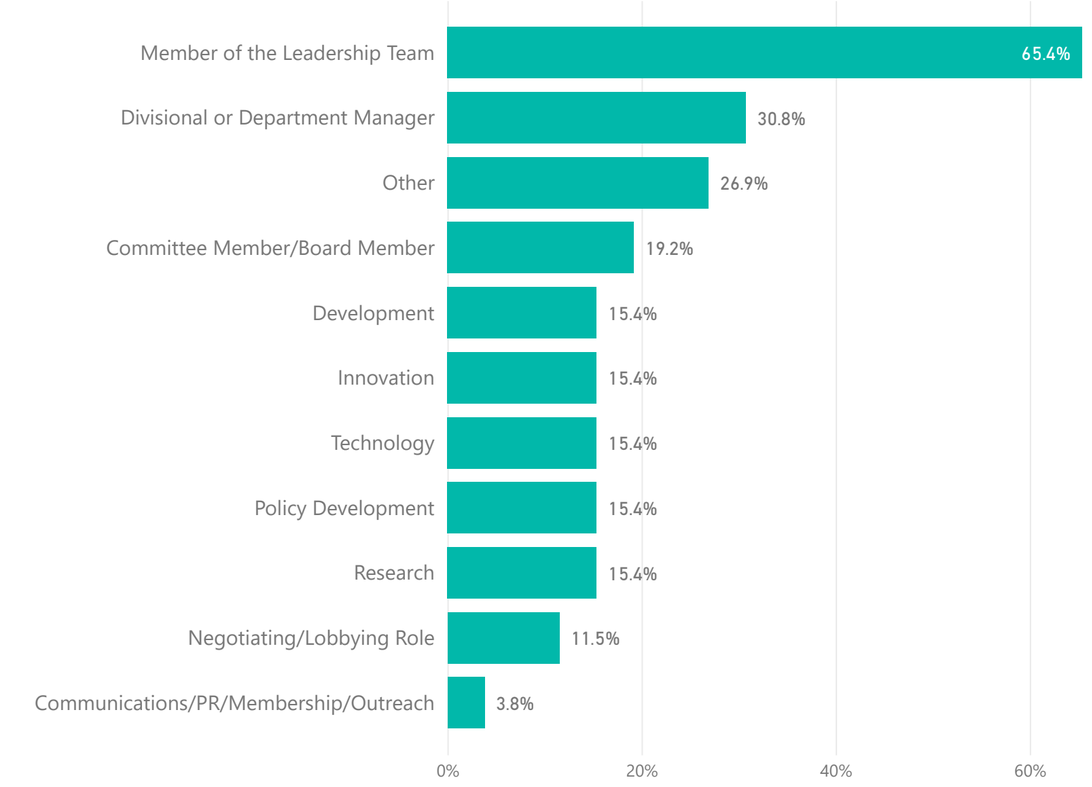
26

No of Respondents

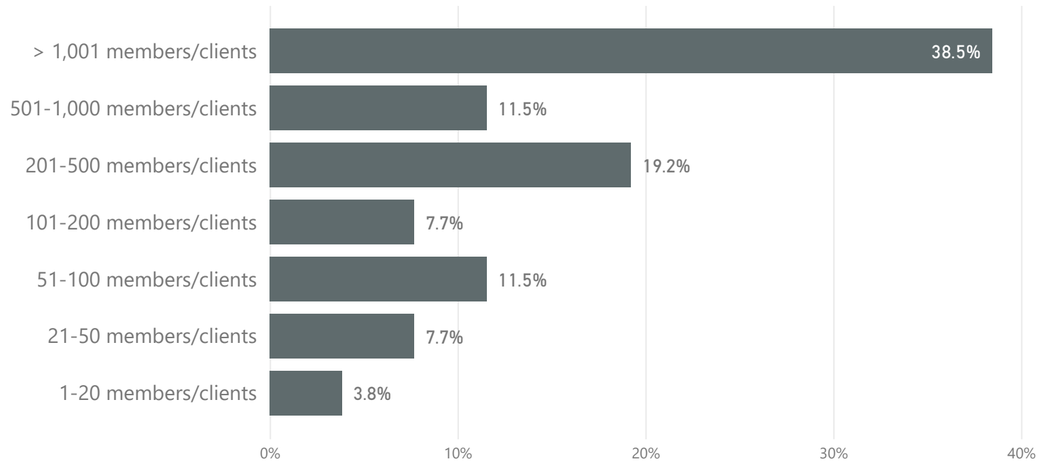
Q.1 Distribution by Membership Groups



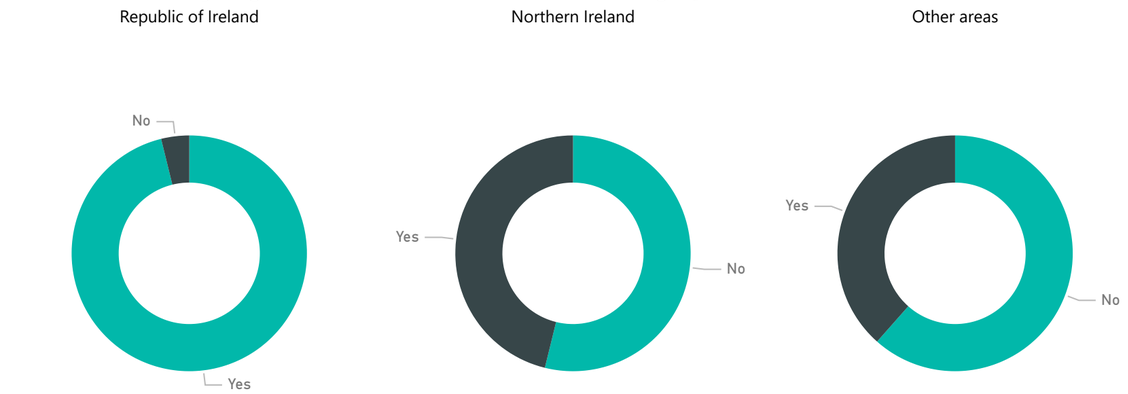
Q.2 Distribution by Role



Q.3 Distribution by Number of Members/Clients



Q.4 Distribution by Organisation's Clients in Different Geographical Area



Engagement with members

26

No of Respondents

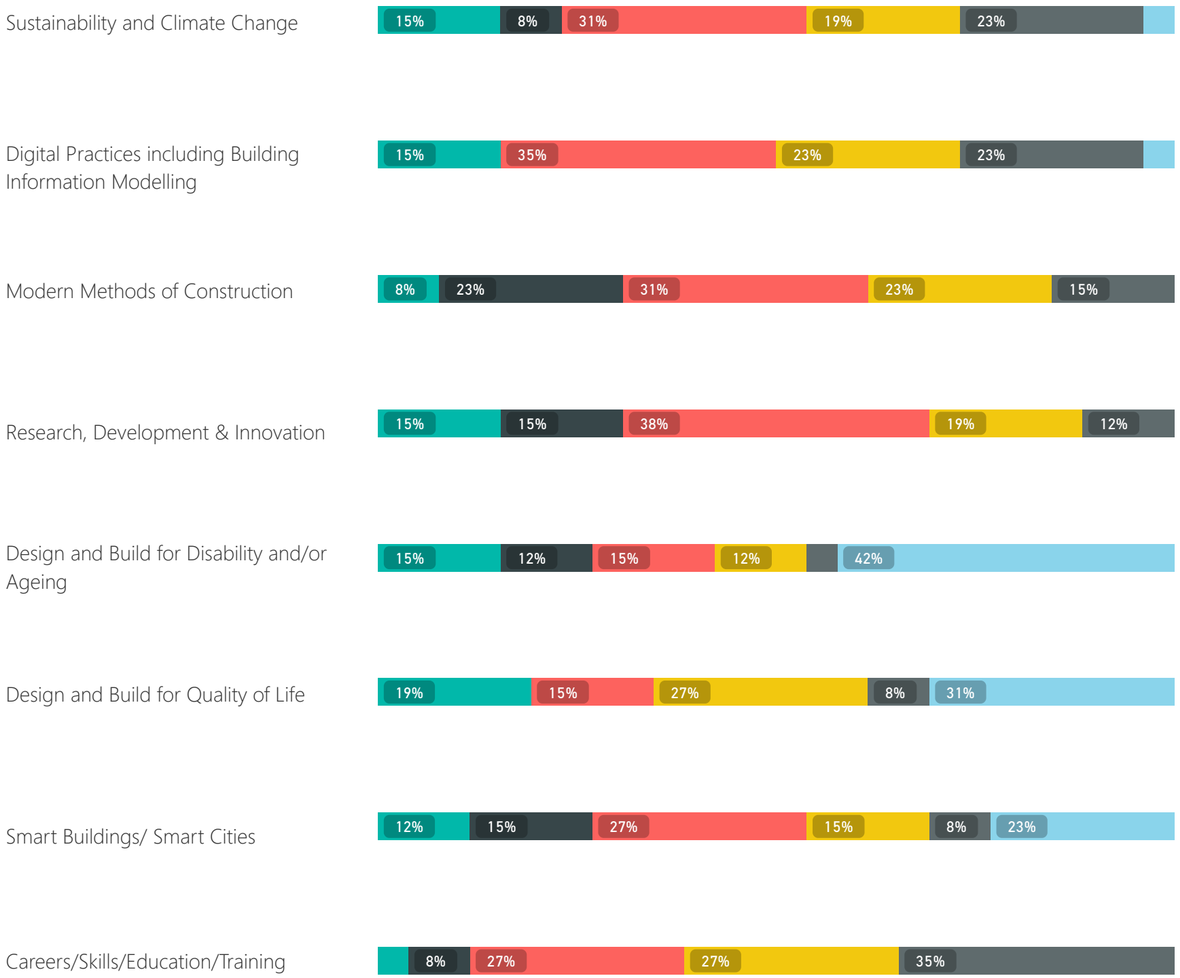
Membership Group: All

Number of Members/Clients: All

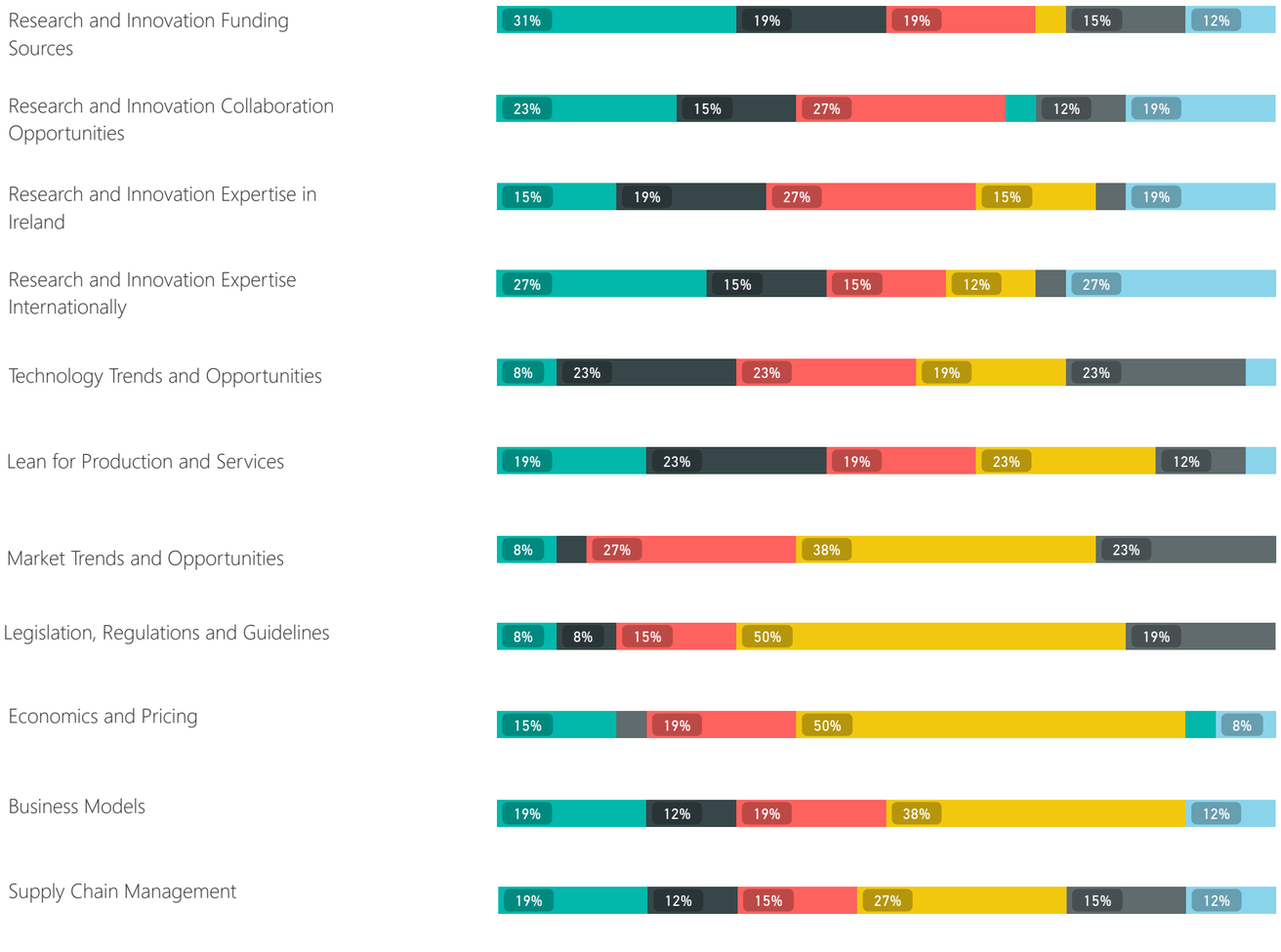
Type of Role: All

Organisation's Clients by Geographic Territory: All

Q.5 How frequently your organisation engages with its members/clients, in the built environment and construction sectors, about the following



Q.6 How frequently your organisation engages with your members/clients in the built environment and construction sectors about the following



Existing awareness of technology and innovation

26
No of Respondents

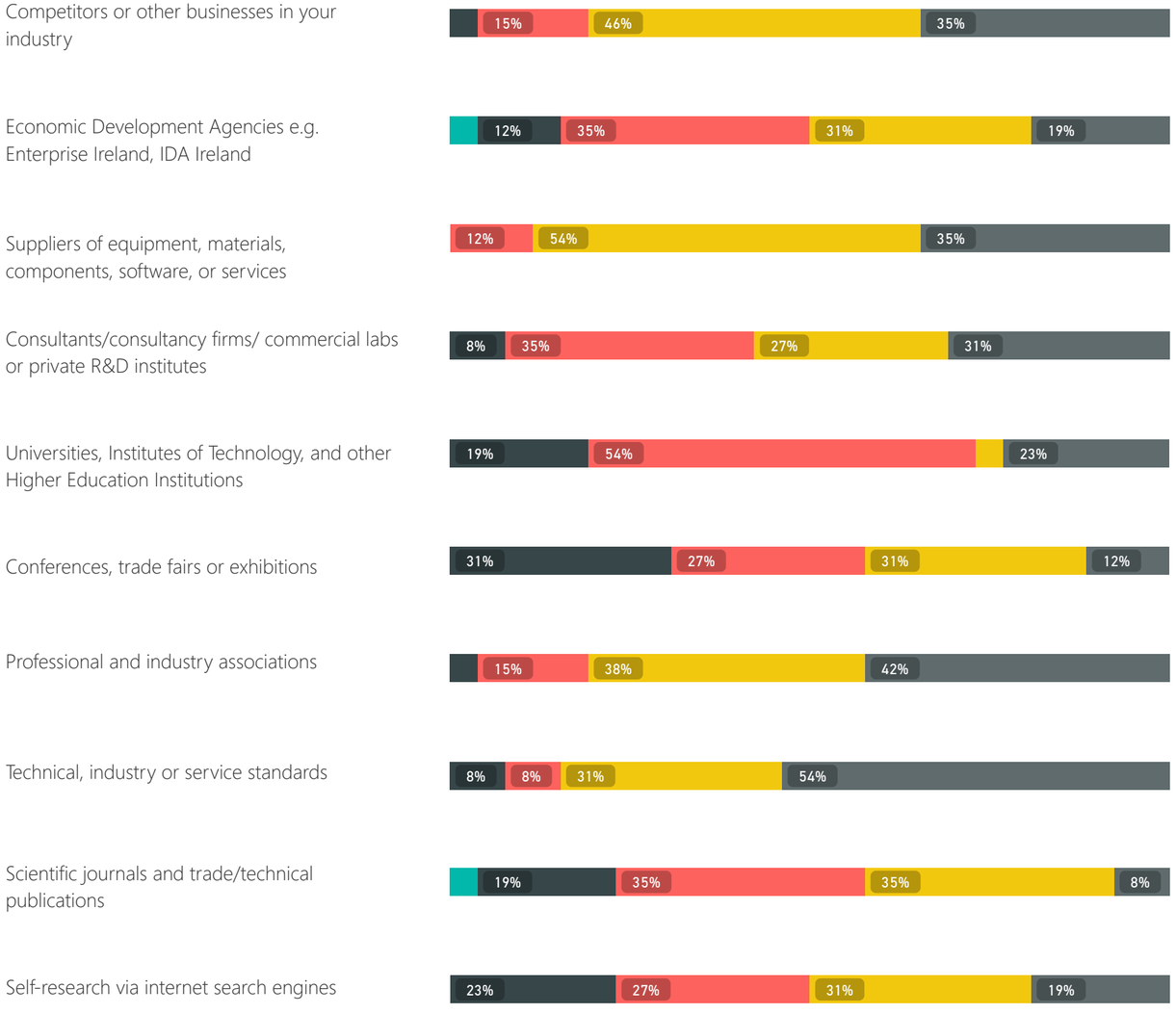
Membership Groups: All

Number of Members/Clients: All

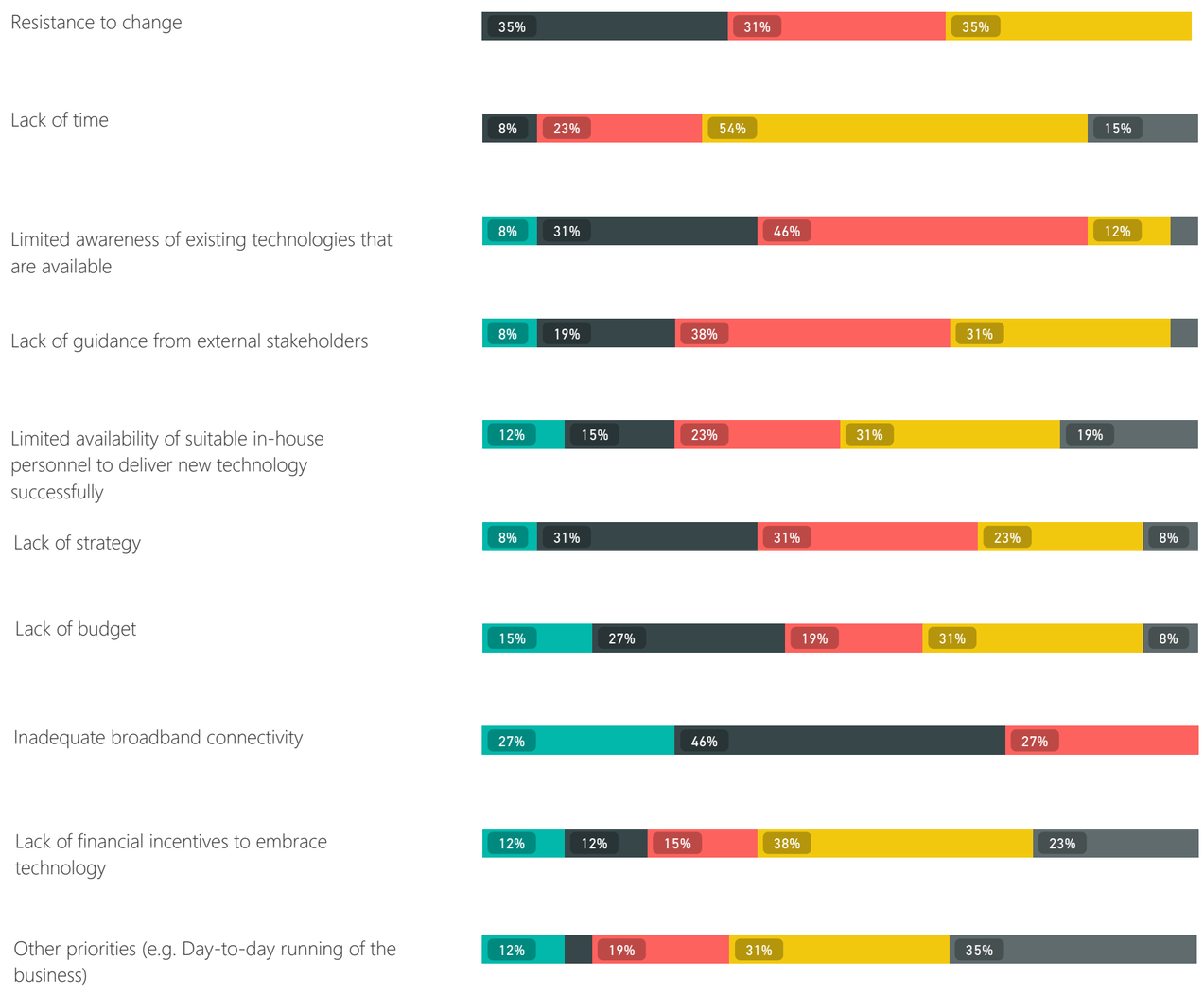
Type of Role: All

Organisation's Clients by Geographic Territory: All

Q.7 To what extent following information sources are important for your organisation's clients



Q.8 To what extent following challlenges exist for your organisation's clients while implementing new technologies



Existing awareness of technology and innovation

26
No of Respondents

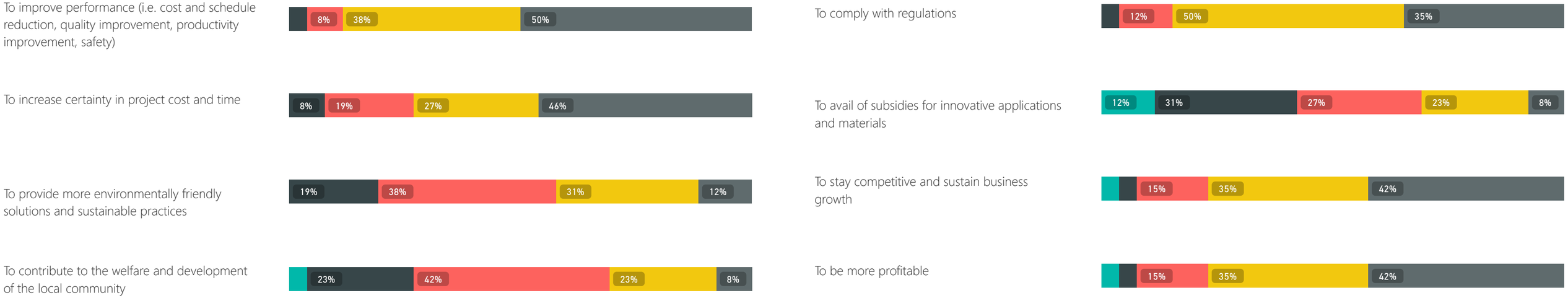
Membership Group: All

Type of Role: All

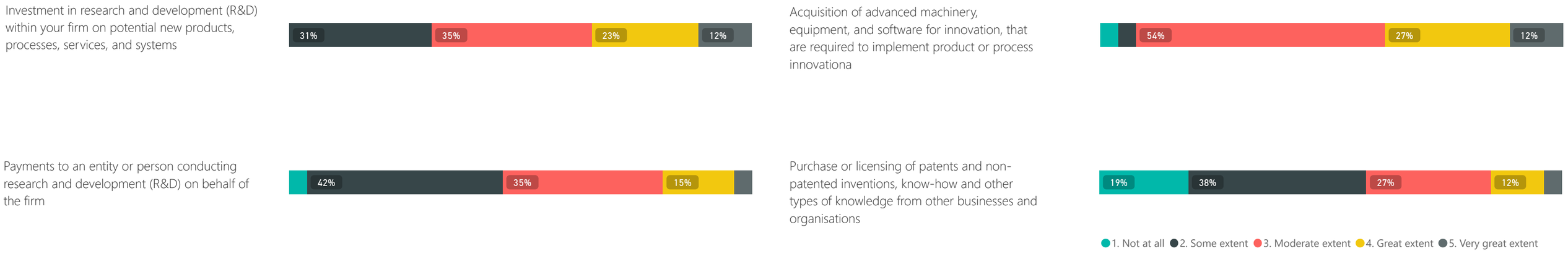
Number of Members/Clients: All

Organisation's Clients by Geographic Territory: All

Q.9 To what extent following innovation drivers exist in your organisation's clients



Q.10 To what extent your organisation's clients invests for purpose of innovation



Appetite for further Technology Advancements and Innovation

26
No of Respondents

Membership Groups: All

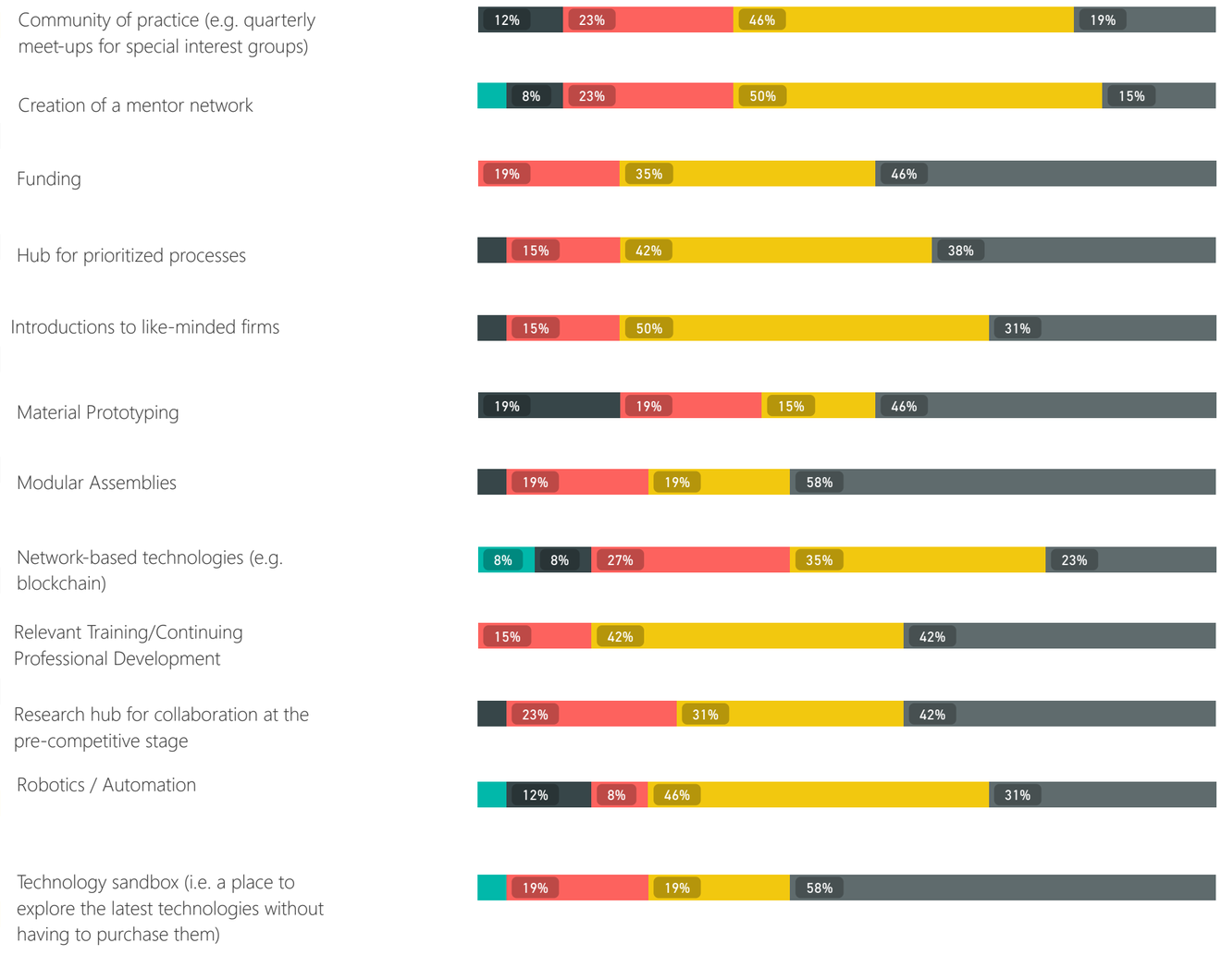
Number of Members/Clients: All

Type of Role: All

Organisation's Clients by Geographic Territory: All

Q.11 To what extent following statements about the overall culture within your organisation are true

Q.15 To what extent following elements of centre could assist your organisation's client



Appetite for further Technology Advancements and Innovation

26
No of Respondents

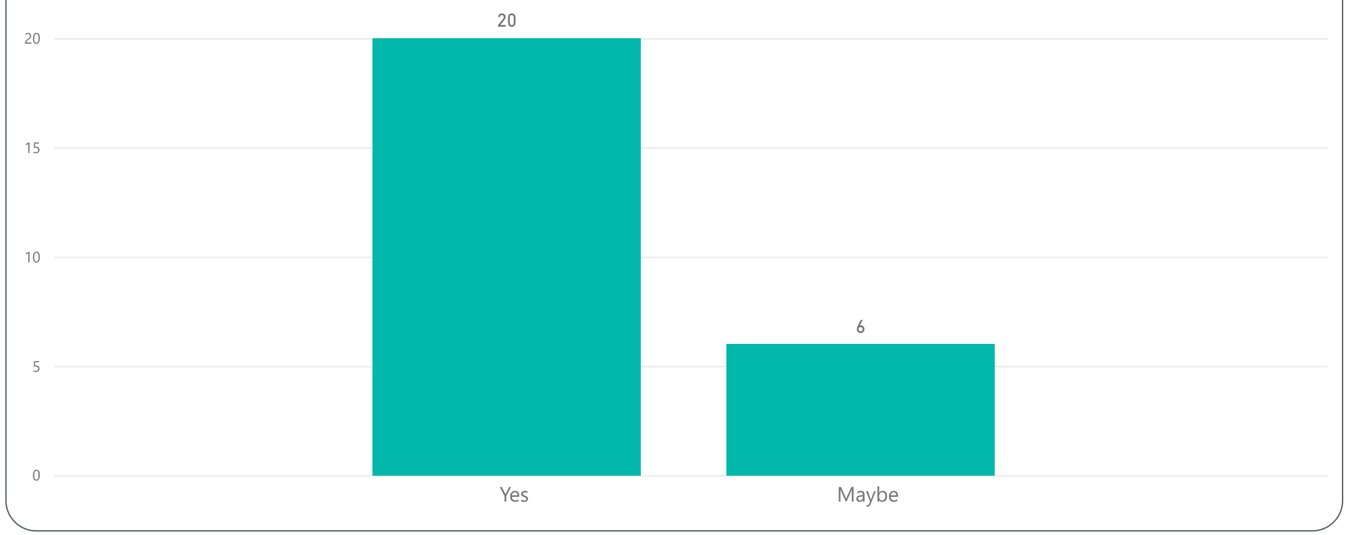
Membership Group: All

Number of Members/Clients: All

Type of Role: All

Organisation's Clients by Geographic Territory: All

Q12A. Organisation's clients willing to collaborate with other organisations for research, development or innovation initiatives



Q13A. To what extent your organisation's clients has the capacity to allocate funds

Capacity to allocate funding to undertake collaborative research and development relevant to your organisation's members/clients

Q14A. To what extent your organisation's clients has the capacity to allocate personal time

Capacity to allocate personnel time to collaborate on research relevant to your organisation's members/clients

1. Not at all 2. Some extent 3. Moderate extent 4. Great extent 5. Very great extent 6. Not sure of extent

Future developments in the construction sector

26
No of Respondents

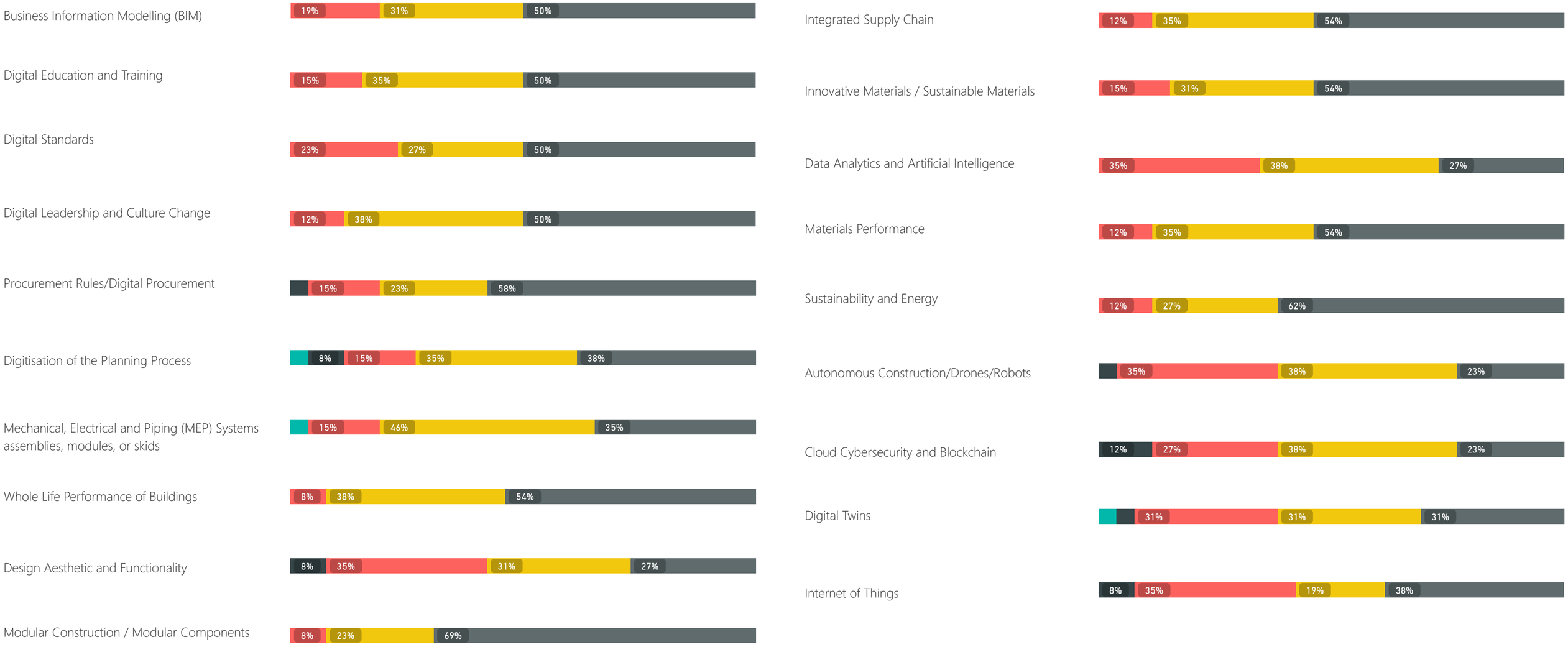
Membership Group: All

Type of Role: All

Number of Members/Clients: All

Organisation's Clients by Geographic Territory: All

Q.17 How important following factors will be to your organisation's clients in next 10 years



Future developments in the construction sector

26
No of Respondents

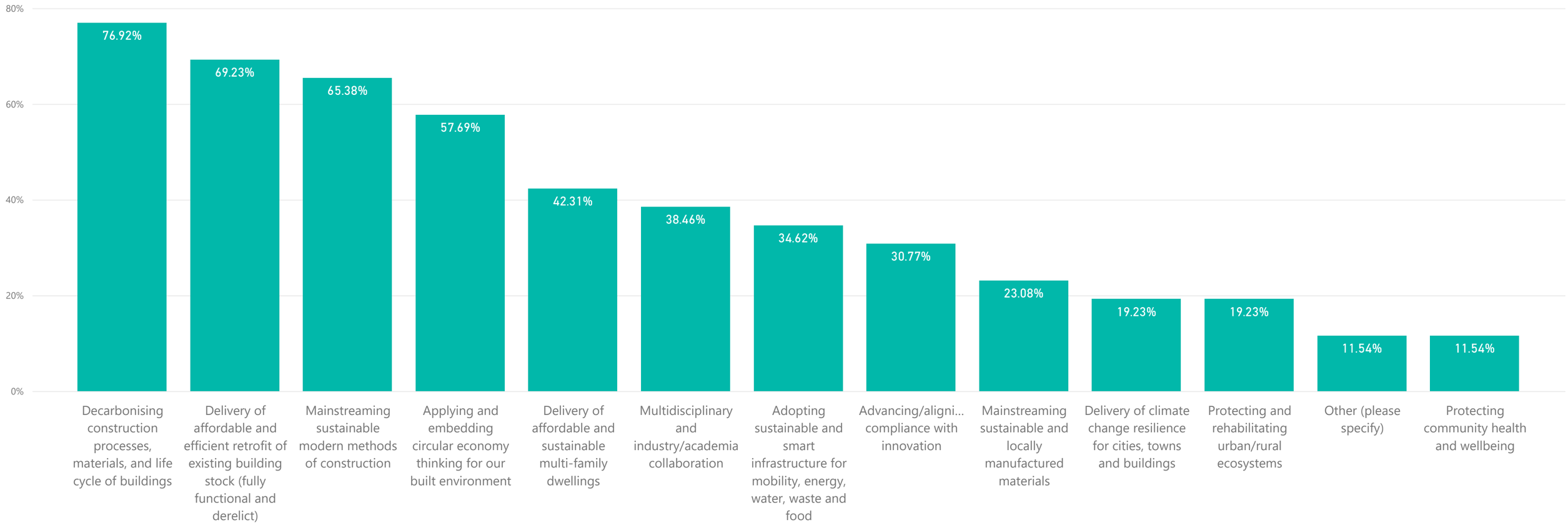
Membership Groups: All

Type of Role: All

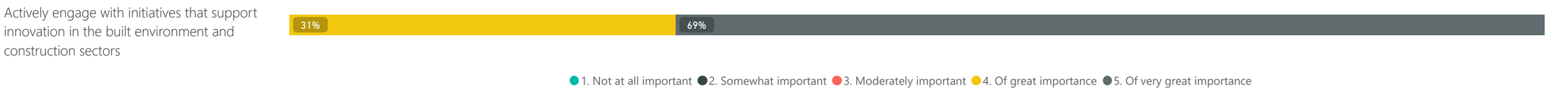
Number of Members/Clients: All

Organisation's Clients by Geographic Territory: All

Q18. Challenges regarding sustainability that should be prioritised by centre, dedicated to research, development, and innovation for the built environment and construction sectors



Q19. To what extent your organisation would actively encourage your clients/members to engage with initiatives that support innovation in the built environment and construction sectors.



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