BUILDING A TRANSITION: innovative approaches to construction industry transformation towards a safer and more sustainable future

JUNE 2023



ACKNOWLEDGEMENTS

This report has been written by Joana Correia (Master Builders Victoria), Dr Louise Dorignon (RMIT University) and Dr Trivess Moore (RMIT University).

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ACKNOWLEDGEMENT OF COUNTRY

Master Builders Victoria acknowledges the Traditional Owners of the lands on which we live.

Working in our industry, it is essential to recognise that beneath the buildings, the concrete, and the asphalt, this land is and always will be the traditional land of the First Nations peoples.

We pay our respects to their Elders, past and present, and to all First Nations peoples across Australia. Through our work at Master Builders Victoria, we remain committed to a shared future. JUNE 2023

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FOREWORD

Victoria's building and construction industry plays a vital role in shaping our landscape, infrastructure, and communities. We continue to see remarkable growth and development throughout the building and construction industry in our state. However, our industry is dealing with well-known ongoing challenges, including supply chain shortages, price increases, climate-related impacts, mental health issues, skills and labour shortages. But there are also many opportunities in this space. It is these opportunities that our industry needs to continue to build on.

Master Builders Victoria (MBV) has taken the lead in this space by bringing together industry, government, and academia to explore the state of the building and construction internationally – post-Covid. We know if we want our industry to succeed, we must look to best practice as well as identify and consider what hasn't worked.

This report delves into the factors that will contribute to our industry's ongoing strength and resilience. It aims to provide a comprehensive analysis of the building and construction industry examining key trends, challenges, and opportunities.

The report explores four key areas pertinent to ensuring that the Victorian building and construction industry is future-ready and well-placed globally. The report covers the workforce, construction processes and methodologies, climate resilience and industry preparedness and assesses building outcomes and consumers.

We know that our industry needs to continue to evolve, and this report delves into the broader industry's commitment to facilitating growth, encouraging sustainable practices, promoting safety and fostering a diverse and inclusive workforce, ensuring equity, and promoting a culture of excellence.

We know that the building and construction industry goes beyond the buildings it creates; it fuels economic growth, generates employment opportunities, and contributes to the social fabric of Victoria.

I would like to express my gratitude to the research team Rebecca Casson, Joana Correia, Louise Dorignon, Trivess Moore, Liam Timms, Megan Peacock and Tony Bugeja.

Further, I want to thank the Victorian Government. Without their support, we would not have been able to lead such a fantastic innovative project.

Finally, I would like to thank our sponsors, whose contributions enabled our team to achieve our goals and deliver a successful project.

I invite readers to delve into the pages that follow, immersing themselves in the dynamic ecosystem of building and construction. May this report serve as a catalyst, igniting informed discussions, inspiring innovative strategies, and fostering collaborative efforts towards leading a future-ready industry that builds a better world.

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Michaela Lihou CEO, Master Builders Victoria

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EXECUTIVE SUMMARY

This report responds to the multiple challenges currently impacting Victoria's building and construction industry including skills and labour shortages, supply shortages, price increases, significant workplace stress and mental health issues. It sets out best-practice skills, practices and innovation being developed and applied in leading international jurisdictions (EU, UK, US and Canada). It also identifies opportunities and best practice initiatives, tools, projects and instruments that have the potential to inform Victoria's post-Covid building and construction industry.

The underlying aim of this work is to ensure that Victoria's building and construction industry can continue to position itself as internationally innovative. Key objectives of the project were investigating best-practice skills, training and migration; innovation in sustainable building practices; emerging trends in alternative supply chains and materials; and regulatory reform insights; with the aim to assist industry leaders in creating a future-ready industry. The authors recognise that translating key learnings from international casestudy locations into the Victorian context requires several steps involving policy experts, which is beyond the scope of this project. Rather, this report informs policy development, support and industry practices for the State government and other key construction industry stakeholders.

The report is structured in four sections to address key areas of industry transformation through a review of initiatives, tools and case-study projects in the European, UK, US and Canadian construction industry sectors.

Section 1 Workforce:

- Skills shortages in the industry are evident across jurisdictions. The disruptions caused by the pandemic, particularly in terms of limiting immigration, have severely affected the ability to rectify these skills shortages. Lack of investment in training, apprenticeships and measures that retain and builds skills are contributing factors exacerbating skills shortages.
- The building and construction industry is not universally seen as a good career path. The industry is associated with long working hours, harsh conditions outdoors, subcontract labour, and high accident and injury rates. Parents often do not perceive it as a good career, viewing other professions as higher status and with better prospects.
- Engaging more women and attracting a more diverse workforce is a common challenge. However, new methods of construction, such as manufacturing and offsite construction, are seen as an opportunity to attract young people, women and a more diverse workforce. This would help address the skills shortages and lead to a more effective and resilient workforce.
- Mental health issues in the industry continue to be a key challenge. While a common issue across jurisdictions, the reasons behind poor mental health vary depending on different contextual factors in each location.

Section 2 Construction processes and methodologies:

- The building and construction industry is facing supply chain challenges globally, for various reasons, including; material shortages, trade disruptions, increased demand, on-going disruptions from the Covid-19 pandemic, the war in Ukraine, and a housing affordability crisis.
- Design and construction methods are beginning to include modern methods of construction (MMC), such as increasingly sophisticated off-site fabrication. However, the introduction, generalisation and streamlining of these methods present significant challenges and imply significant change within the construction industry.
- With a variety of rationales from sustainability to efficiency, quality and safety, jurisdictions around the globe are striving to

reform their regulations and building and planning codes to assist with generalising, standardising and implementing MMCs.

- Digital disruption is changing construction processes, although the degree to which industry stakeholders and organisations are adapting their systems and upskilling their workforce varies depending on capabilities, scale, resources and motivation.
- The realisation of sustainable construction goals through digital and industrialised construction methodologies is shaped by changing government policies, industry culture and practice.

Section 3 Climate resilience and industry preparedness:

- Across different jurisdictions, policies are being created to support a transition to a circular economy, promote carbon accounting and the adoption of low-carbon and recycled building products and there is a consensus building in the industry that circularity is becoming an essential driver. However, there is still concern over these impending changes, amplified by risk, uncertainty, and insufficient training, regulation and standards aligning and encouraging circular economy building practice.
- The mandatory Energy Performance Certificate (EPC) introduced by the Energy Performance of Building Directive (EPBD) in Europe has proven to be an effective tool to measure building performance and support the development of retrofit upgrades and national policymaking, when applied with rigorous monitoring systems.
- Achieving net zero emissions by 2050 is a common goal across jurisdictions and tackling carbon emissions within the built environment is a priority. Although the EU and the UK have established regulations, policies and initiatives to support this transition, there is still a significant challenge in implementation. New methods and practices require institutional leadership, and clarity and consistency regarding new requirements take time to establish.
- Retrofitting the existing housing stock remains a huge challenge, due to the diversity of the building stock, different housing tenure models and a lack of consistency in programme drivers.
- The lack of financial incentives for consumers and support for builders to undertake retrofit training are constraints that will need to be addressed to support housing retrofit objectives.
 A centralised low carbon retrofit hub coordinating training, demand and information, may help address the matter, although more will be required to regularise low carbon retrofit across all renovation activity.

Section 4 Building outcomes and consumers:

- Regulations are important for ensuring building standards and performance. Compliance checks are required alongside these regulations to ensure they are working effectively to deliver the outcomes intended for society.
- The planning system is also important in shaping more sustainable outcomes beyond those which are regulated in building codes.
 It must strike a balance that recognises industry need for consistency and predictability, and the need to recognise the uniqueness of place and to incorporate diverse community needs and preferences.
- Covid-19 has exacerbated supply chain shortages and increasing construction costs. As a result, fixed price contracts are creating significant financial challenges for many stakeholders. Industry planning and information sharing on supply chain and cost issues may help address this issue.
- Australian society is increasingly committed to climate action whilst also facing cost-of-living pressures. There is renewed pressure to reduce construction costs whilst improving energy efficiency and greenhouse gas performance across the industry and the building stock.
- Banks and insurance companies have a key role to play to help drive quality and performance outcomes. In concert with consistent and increasingly stringent building codes, the risk profile of low carbon and affordable building must be reduced in order to reduce costs and attract entrants into the low carbon construction market.



Implications for Victoria

Given the workforce challenges facing the industry, a range of implications flow for Victoria identified from the study tour and wider research. Addressing the skills shortage could include streamlined visa applications and related initiatives to encourage skilled migration into the industry. In addition, ongoing investment in skills and training and initiatives to improve work conditions to attract a new, diverse, young workforce are needed. Building on the review of training reform, it is evident that significant changes are required in current training and skills programmes to achieve these goals. Fostering greater flexibility and inclusivity to accommodate a diverse workforce, and strategically incorporating cultural and sustainability training at the core of these programmes would help reach new audiences and, ultimately, employees.

Attracting the new skills required for the industry to grow so that it can address the climate emergency and advance modern methods of construction, and other challenges such as supply and affordability, also means taking measures to reframe the way in which the industry is perceived by the public. For example, a more deliberate move to manufacturing and offsite construction, led in partnership with State Government, would likely attract more women to the industry. The controlled environment of offsite manufacturing is more conducive to flexible work arrangements, that suit, for example, people with carers responsibilities and people with disabilities.

Backed by financial, regulatory and training incentives and a policy environment that de-risks the adoption of innovation, the Victorian building and construction industry can embrace modern methods of construction, accelerate the production of affordable housing, and decarbonise construction processes. This will require a collaborative approach between government agencies, industry stakeholders, and research institutions, and could be helped by a broader, coordinated construction innovation consortium to help facilitate this transition. Pilot projects can help demonstrate the effectiveness, potential cost savings and safety of these methods, and build confidence among regulators, builders and future residents. Alongside these, universal approaches to accountability are needed. Building passports are a key opportunity to increase compliance and transparency, while also presenting potential sustainability benefits, ease of maintenance, and benefits to consumers, insurers, and other stakeholders.

The Victorian government's commitment to net-zero emissions and its 10-year policy and action plan towards circular economy demonstrate the State's ambition to eliminate carbon emissions from its economy, and reduce waste and pollution. The building industry has a key part to play, by scaling up energy efficiency retrofit of existing buildings and improving the performance of new buildings, while markedly reducing its consumption of virgin building materials. The shift to a circular economy in the built environment requires new data systems, second-hand material trading mechanisms, trust, risk and legal frameworks, training, institution building, together with research and product declarations to establish transparent, independent building product information. Changes in policy alone will not be enough if the industry does not have the appropriate resources and knowledge in place.

Meanwhile, short-term challenges from price spikes in materials have placed severe pressures on the industry. This report documents initiatives from around the world to help the industry through this period. Mechanisms to track actual supply and demand and create and improve the accuracy of live data (e.g., of material supply and costs), as well as enabling price increase simulations depending on different inflation scenarios, allows evidence-based variations in costs to be ascertained. This would also help identify earlier where additional government support could help address supply or cost chokepoints.

Across the case study locations, the role of policy in driving improved quality and performance outcomes for consumers was noted as critical. However, policy on its own was not enough to guarantee that what is specified is being delivered so it is important that there is a clear and transparent compliance checking across the industry to ensure accountability and protection for consumers. The level, independence and importance of compliance checks needs to be high enough that there is incentive for the industry to ensure it delivers high quality outcomes.

For markets to function well, all stakeholders (including consumers) need access to current, accurate and transparent information about a building and its environmental performance. This will help with ongoing management of buildings, especially in relation to quality and safety, but also help provide a database to help with broader policy development and planning (e.g., retrofit). While a buildings database of this nature is costly to create and maintain, it is cost-effective when considering the benefits in terms of efficient targeting of upgrade programmes, fixing market failures in information asymmetry, and providing a solid foundation for planning and predicting the impacts of investments in net-zero initiatives. The EU has significant experience of independently verified environmental performance certificates generated by building assessments; Victoria should consider investing in this area more and roll out such systems to support the transition.

Given the urgency required around upscaling low-carbon retrofit, opportunities to shift Victorian policy settings whereby proposed construction which goes significantly beyond minimum standards could be fast tracked or follow a more streamlined process could be investigated, as this might also incentivise the uptake of best practice. Banks and insurance companies can also play a key role to help drive change and promote the greater uptake of sustainability, health and safety in housing construction.

Amidst the challenges, the building and construction industry in Victoria currently faces an unprecedented opportunity, to expand, draw in and develop new skills, technology and expertise, and lead the transition of the Victorian built environment. As the case studies in this report demonstrate, this opportunity is only achievable through new partnerships with government, finance, peak bodies, training and research organisations and civil society in addition to innovation in building practices, materials, technologies and regulation.



ABC	Associated Builders and Contractors	GHG	greenhouse-gas
AI	Artificial intelligence	HSE	Health and Safety Executive
AMRC	Advanced Manufacturing Research Centre	HUD	Housing and Urban Development
BE-ST	Built Environment and Smarter Transformation	IBHS	Insurance Institute for Business and Home Safety
BIM	Building Information Modelling	ILO	International Labour Organisation
BPIE	Building Performance Institute Europe	ISO	International Organisation for Standardisation
BSR	Building Safety Regulator	LCA	life cycle analysis
CAD	Computer Aided Design	M&E	Mechanical and Electrical
CCS	Considerate Constructors Scheme	MBV	Master Builders Victoria
CITB	Construction Industry Training Board	MMC	modern methods of construction
CLC	Construction Leadership Council	MTI	Mass Timber Institute
CLT	Cross Laminated Timber	MVHR	Mechanical Ventilation with Heat Recovery
CNC	Computerised Numerical Control	NCC	National Construction Code
СРА	Construction Products Association	NEC	New Engineering Contract
CPD	Continuing professional development	PCPM	Property Construction and Project Management
D&C	Design and Construct	PICF	Participant Information and Consent Form
DfMA	Design for manufacture and assembly	R&D	research and development
DoE	Department of Energy	RIBA	Royal Institute of British Architects
EPA	Environmental Protection Agency	RICS	Royal Institute of Charter Surveyors
EPBD	European Energy Performance of Buildings Directive	SME	Small and medium-sized enterprise
EPC	Energy Performance Certificate	STEM	Science, Technology, Engineering and Mathematic
EPD	Environment Product Declaration	UK	United Kingdom
EU	European Union	US	United States
GFC	Global Financial Crisis		

INTRODUCTION

This report is the result of an international research project conducted by Master Builders Victoria (MBV) and RMIT University in 2022-2023 with the support of the Victorian government and industry partners in Australia. The project identified examples of global best-practice suitable to inform the Victorian context.

Master Builders Victoria

Master Builders Victoria (MBV) represents approximately 6,500 stakeholders from across the building and construction industry. These include large and small builders, tradespeople across the domestic and commercial sector, apprentices, suppliers and manufacturers. With more than 145 years of experience, MBV continues to deliver meaningful industry representation through effective engagement and feedback from our Board and Council of Management, committees and members more broadly. MBV is committed to the delivery of improved practices across the building and construction industry to promote a better built environment for all Victorians.

The building and construction industry is one of the most important sectors of the Victorian economy, being the largest full-time employer in the state and a key enabler for government to deliver on important infrastructure and transport commitments. Our sector delivers housing, parks, infrastructure, schools, hospitals and other amenities for the liveability of all Victorian's, critical to our community's wellbeing and the future prosperity of the state.

School of Property, Construction and Project Management, RMIT University

Within the College of Design and Social Context (DSC), the School of Property, Construction and Project Management (PCPM) is a leading provider of education, research and training in the construction, project management and property industries in the Asia Pacific region. PCPM is renowned for its reputable programmes, strong links with industry, involvement in professional bodies and collaborative approach to research.

While technology is integral to construction, there is also increasing need for high levels of sustainability and digital skills, leadership and management. Virtual reality and building information modelling are now integrated into construction education and research, providing opportunities and capabilities for construction innovation. PCPM provides leading-edge, innovative and applicable research solutions and consulting services to the construction, property and other related industries.

BUILDING A TRANSITION

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Context and rationale

This report seeks to provide inspiration to empower a future-ready building and construction industry that builds a better world through continuous learning and improvement. It responds to the multiple challenges currently impacting Victoria's building and construction industry, namely skills and labour shortages, supply shortages, price increases, significant workplace stress and mental health issues. It also informs the upcoming 2026 Commonwealth Games hosted by Victoria and what is required for the industry to be best prepared by investigating recent experiences of the Games in comparable jurisdictions.

The research upon which this report is based produces an evidence-based understanding of best-practice skills, practices and innovation being developed and applied in building and construction industries across leading international jurisdictions. Numerous best practice case studies inform practice in Victoria, to ensure that Victoria's building and construction industry continues to be an international leader, and produces tangible value for Victoria's broader economy.

The research project addresses the question:

What examples of global best-practice can inform the Victorian Building and Construction industry and policy innovation, in the face of the shift towards a circular economy, climate adaptative building, sustainability and contemporary supply chain, skills, labour, quality assurance and financial challenges?

Given the importance of the building and construction industry for Victoria's economy, it is essential to examine which post-Covid strategies have been developed internationally to respond to similar challenges regarding material supply chains, labour shortages and workforce transformation, in the context of climate change and increased digitalisation. Research on construction innovation has been dispersed and characterised by multiple and competing frameworks ¹. As the construction economy is increasingly recognised as a significant carbon-emitter within the built environment but also as an industry slow to adopt innovation, more research is needed on how the building industry is organised and positioned for a transition towards a low-carbon economy, which encompasses notions of sustainability and circular economy².



2 Shooshtarian et al., "Circular Economy in the Australian AEC Industry."



Research aims

The research aim is to document the development and implementation of pioneering building and construction innovation, and consider potential applications to the Victorian context. The significance of this project lies in its potential to contribute to understanding the barriers and enablers to change in the building and construction industry. A review of literature provides a foundational base to begin to understand the nature and dynamics of innovation. The research was further enhanced through fieldwork investigation that provided a more comprehensive picture and direct experience of the local regulatory, socio-economic and political context of locations around the world. Field investigations can identify and explain weaknesses in the available literature as well as provide an opportunity for professional contacts to be established with key organisations and official personnel who can enhance the research through their local expertise and knowledge.

Key objectives include investigating best-practice skills, training and migration; innovation in sustainable building practices; emerging trends in alternative supply chains and materials; and; regulatory reform insights; which will assist industry leaders to create a future-ready industry. Potential benefits of the project through the report and launch event include informing policy development and supporting industry practices for the State government and other key construction industry stakeholders. Lessons and policy recommendations drawing from the research and provided by the report have the potential to enhance confidence and foster a better Victoria.

To focus on key challenges and opportunities relevant to the building and construction industry in Victoria, the research, and this resulting report targets four research questions:

RQ1: How is the global building and construction industry organised to overcome skill and labour challenges, such as labour/ workforce shortages, gaps in skills and training but also mental health issues and opportunities for underrepresented groups?

RQ2: What are the key innovations (including in the realm of circular economy and sustainability) pertaining to construction methodologies, supply chains and materials use and availability?

RQ3: What key innovations (including quality assurance, certification and compliance) exist to improve building standards and regulations towards climate-adaptative buildings?

RQ4: What innovative and emerging financial tools and contracting practices exist that help manage business risk for the building and construction industry, and can these serve to incentivise the production of affordable housing?

Relevance to policy

The construction and building industry is critical in delivering the changes required in decarbonising the built environment through material circularity and sustainability. Potential benefits of circularity include reducing the use of new resources, zero waste, improved durability, quality and comfort, resilience and fairer employment and better jobs. Sustainability initiatives are needed to respond to contemporary risks such as bushfires, floods, unhealthy housing, and poor thermal performance that undermine the health and well-being of many tenants, owner occupiers and workers in the Victorian built environment. By understanding how to tackle challenges such as skills and labour shortages, supply shortages, price increases, workplace stress and mental health issues, this research project can have wider benefits on social welfare for those working in the construction and building industry by informing future policy-making.

This report contributes to industry in the following areas:

- to inform Victorian building and construction with industry and policy innovation conducted internationally
- to identify current best practice policy innovation in sustainable building
- to identify models for managing business risk in a subcontractorbased building and construction industry like Victoria
- to provide empirical examples of how to ease workforce shortages in Victoria (including hosting career expo-type engagements with potential candidates)
- to enhance training and capabilities, and thus workforce productivity, participation, diversity, equity, and inclusion
- to enhance innovation through understanding of opportunities and challenges of digital transformation.

The researchers undertook 37 semi-structured interviews/focus groups and 9 site visits in October-November 2022. The interviews and focus groups were undertaken with professionals working in the building and construction industry, in government, academia, local councils and private and not-for-profit sectors in the realm of built environment, housing, economic development, education, regulations and sustainability. Interviews were non-compulsory and unpaid. The participants formally consented to their participation and were given the right to withdraw at any time and/or remain anonymous. The relationship between the researcher and the research participants were respectful and reciprocal and provided the participants with the opportunity to contribute knowledge to the broader public interest in the development of a future-ready building and construction industry.

Research methods

The project used an evidence-based methodology consisting of two key steps:

- a map of industry building and construction best-practice examples of innovation opportunities and response to shared contemporary industry challenges (such as building quality assurance, finance and procurement, labour shortages, digitalisation and automation)
- an analysis of these practices through interviews and focus groups conducted with key actors, institutions and organisations responsible for their implementation

Following a selection of cities based on a review of the literature associated with innovation opportunities in this sector, seven cities were identified: Brussels (Belgium), London, Birmingham and Glasgow (United Kingdom), Toronto (Canada), and Washington and New York City (United States of America). Evidence from these jurisdictions were then linked to the Victorian context (Australia) to inform relevant policy and industry insights.

Three main methods were used:

- A desktop review of existing literature (industry, trade and academic) and industry databases was carried out, and innovation practices were documented across the four research questions. This initial research mapped the industry using information available publicly through industry and governmental reports, as well as industry associations media releases and resources.
- In-person interviews/focus groups were conducted with key stakeholders involved in the building and construction industry to provide opportunities to learn about barriers/enablers in relation to achieving key outcomes, including sustainability and affordability objectives. These semi-directed interviews were conducted with industry associations representatives (such as Federation of Master Builders UK, Associated Builders and Contractors, Construction Products Association), local municipalities (such as Sandwell Metropolitan Borough Council, Birmingham City Council), government organisations (such as the United States Environmental Protection Agency, Innovate UK, Department for Levelling Up, Housing and Communities, Ministry of Municipal Affairs and Housing), academic experts (including at UCL Bartlett School of Sustainable Construction, The University of Toronto), not-for-profit organisations (Modular Building Institute) and members of the private sector (including companies such as Lendlease, Multiplex, Laing O'Rourke) on how they have achieved transformational

change in their sector. They assisted in further identifying innovators, innovation 'brokers' and innovation examples and practice.

3. Focus groups were organised to facilitate conversation between stakeholders from different backgrounds and with complementary professional experience, to draw out nuances of understandings and perspectives on innovation questions and gaps in knowledge. Themes pursued in interviews/focus groups were industry organisation; supply chains globalisation; materials use and availability; circular economy; innovation networks; employment, training and skills; building standards and regulations; financial tools and contracting practices; business risk; (affordable) housing and; relationships with regulators and policy agencies. Focus group participants thus also discussed technical issues relating to building and construction innovation which might result in more sustainable built environment and industry practices.

The interviews and focus groups were audio-recorded using a voice recorder. The quotes in this report were transcribed either by the researchers, by a commercial transcription service guaranteeing confidentiality (Pacific Transcription), or by using Microsoft Stream caption functionality. The interviews were conducted either faceto-face or using online software after an arrangement was made between the researchers and the research participant. Group photographs of participants were taken for illustration purposes and consent was obtained through the Participant Information and Consent Form (PICF). Site photographs (e.g., of particular buildings or construction innovations) were taken for illustration purposes. Typically, the interviews/focus groups lasted two hours. Participants were informed by email before they signed the PICF that they were able to review their interview/focus group transcript.

Participants

There were two participant groups involved in this research project: One comprised those study tour delegates who were not part of the research team collecting data (industry representatives, government officials and members of MBV and the other comprised participants who were recruited to be interviewed/participate in focus groups (institutional actors in the local building and construction industry of the visited countries). Both groups participated in focus groups and attended some interviews. Group 1 (Delegation) was between 11-14 people across various stages of the study tour, and group 2 (International stakeholders) was 98 people (with an average of interviews/focus groups with 6 participants a day for 15 days). The total participant population was 105 people.

Selection

Participants for Group 1 - Delegation - were selected based on their strategic understanding of the industry and expertise/role in building and construction innovation.

Participants for Group 2 - International stakeholders - were selected based on their involvement with building and construction innovation, networks, organisations, initiatives or policy matters. They had expertise in materials supply, use, and end-of-use chains, and were drawn from companies, industry associations, government policy making agencies, design and construct professional practices and not-for-profit advocacy organisations.

Recruitment

Group 1 - Delegation: Potential participants were recruited based on their willingness to join the study tour as members of MBV.

Group 2 - International Stakeholders: Potential participants were identified through existing professional networks, professional organisations, industry associations (e.g., MBV), public website searches and professional social networks (e.g., LinkedIn). Contact email addresses or phone numbers were obtained through these same searches.

Participation to the research

Group 1 – Participants in the study tour engaged in the interviews/ focus groups with Group 2, depending on their personal availability, interests and willingness to be present during the interviews. Consent for their participation was obtained before the study tour through a specific PICF with options to opt-out of the research project.

Group 2 - International stakeholders were recruited by the research group and interviewed for a maximum of two hours. Participants were authorised professionals participants working on current and future opportunities for the development of building and construction innovation who were asked to respond to a set of semi-structured interview questions. Questions included the shaping of building material supply chains and building material reuse so that sustainability objectives can be developed and implemented through change processes, including regulation, incentives and information sharing. Participants responded to questions while reviewing documents or walking through a case-study site (often their office, headquarters or project site). These interviews provided opportunities to learn about the opportunities/constraints these professionals encountered in developing innovation towards sustainability objectives. Focus groups were organised according to two criteria, one to maximise researchers time and resource, second when several

research participants interviewed were identified as colleagues/ collaborating on the same/similar project and their contribution recognised as complementary. The researchers recruited between 2-7 participants per focus groups and participants were made aware of who presented at the focus group. The focus groups targeted the same topics as the interviews, e.g., current and future opportunities for the development of building and construction innovation, particularly in the residential housing sector.

Analysis & framework

To analyse the data, an analytical framework was developed. Four overarching themes that emerged from the data were matched with key areas of industry transformation as follow:

Theme	Key areas of industry transformation
Workforce	Health and safety, Equity and diversity, Talent pipeline and migration
Construction processes and methodologies	Supply chains and materials, Design and construction (incl. offsite), Digitalisation
Climate resilience and industry preparedness	Circular economy, Decarbonisation and energy retrofit, Disaster resilience
Building outcomes and consumers	Building quality and performance, Demand and market performance, Housing outcomes and affordability

Across these themes, domains of action (mechanisms, tools, initiatives and projects) were identified and used to analyse the interviews and focus groups transcripts:

- Regulatory change;
- Planning;
- Financial and contracting practices (which included business models);
- Policies pertaining to labour;
- Skills and training and;
- · Industry culture and leadership.

The report was written following this structure and case-studies were developed to illustrate how these different domains are enacted by the construction and building industry across the jurisdictions visited. The case-study, examples and quotes analysed aim to capture three key findings: areas of innovation, successful models/implementation or good practice as measured by tangible outcomes; issues/challenges/barriers as identified by stakeholders and/or established by the literature; policy opportunities for Victoria (incl. partnership with all levels of government and other industry stakeholders).

Each theme is introduced in the report with a review of relevant literature, and implications for Victoria are drawn from the analysis at the end of each chapter.



		Domain of action: mechanisms, tools, initiatives and lessons						
	Areas of industry transformation	Regulatory change	Planning	Financial and contracting practices, business models	Policies pertaining to labour	Skills and training	Industry culture and leadership	
	Talent pipeline and migration	 Fast-tracking of visa applications for international students, Canada Tax benefits for skilled migrant workers, Belgium 	n/a	CITB levy, UK G3 programme, Virginia Community Colleges, US	• Associated Builders and Contractors (ABC) and its approach to workforce recruitment and development, US	 Potential to include building and construction under STEM FastForward programme, Virginia Community Colleges, US 	 Not-for-profit Building Talent Foundation founded by the Leading Builders of America to help address skills shortages, US AC Whyte skills academy, UK 	
WORKFORCE	Equity and diversity	n/a	n/a	• SCAPE procurement framework and public-sector partnership in Lendlease Perry Barr Residential Scheme, UK	 Laing O'Rourke's commitment to reach a 50/50 workforce by 2030, UK Consideration of 'social value' in Sandwell Aquatic Centre, UK 	• Training centre incl. English for construction courses in Lendlease Perry Barr Residential Scheme, UK	• Building Talent Foundation programmes targeting under- represented groups, US	
	Health and safety	n/a	n/a	• AC Whyte financial support for their workforce during Covid-19, Scotland	 Covid-19 safety management on Lendlease site of the Perry Barr Residential Scheme, Birmingham, UK Covid-19 safety management on Wates site of the Sandwell Aquatic Centre, Birmingham, UK 	• ABC's safety management education programmes, US	 Construction Leadership Council (CLC), UK Building a Safer Future Charter, UK 	

		Domain of action: mechanisms, tools, initiatives and lessons					
	Areas of industry transformation	Regulatory change	Planning	Financial and contracting practices, business models	Policies pertaining to labour	Skills and training	Industry culture and leadership
CONSTRUCTION PROCESSES AND METHODOLOGIES	Design and construction	 Construction Playbook (UK HM Government, 2022) Potential for government to lead manufacturing of timber CLT panelled schools, with investment in capability, UK 	 Importance of stakeholders through design processes (local planning) HUD Code for manufactured homes, U.S. Department of Housing and Urban Development 	 Laing O'Rourke's operating model DfMA 70:60:30 Use of Design and Build Contract for offsite construction (UK) Use of 'scope book' for Birmingham Commonwealth Games delivery model 	 Social value of offsite through micro-factories (Factory 2050, AMRC, UK) 	 Willmott Dixon use of light-gauge steel, with a composite concrete floor and modular pod bathrooms, Birmingham Upskilling local subcontractors, Marmalade Lane project by TOWN, UK Net-zero, kit of parts building The Forge, London, supported by Innovate UK Kit of parts innovation through implementation in programmes and/ or catalogues (UK) 	 Product platform Rulebook, Value Toolkit (Construction Innovation Hub, 2022- 2023, UK) Transforming Construction Network Plus, Transforming Construction Challenge, UK (incl. Construction Innovation Hub)
	Supply chains and materials	Ontario's Tall Wood Building Reference (Ministry of Natural Resources and Forestry Ministry of Municipal Affairs, Canada, 2017)	• Refurbishment and/or retrofit, not demolition, UK	 Commonwealth Games-specific procurement portal, City Building Glasgow New Engineering Contract (NEC), UK Forestry Renewal Fund (Ontario, Canada) 	n/a	Corium clickable, mechanically fixed brick system, PGH Bricks&Pavers	• Mass Timber Institute (MTI), Daniels faculty of Architecture, Landscape and Design and Forestry, University of Toronto
	Digitalisation	• Construction 2025 Strategy, 2013, UK	• Harmonisation btw. 2D and 3D planning documents	• Inclusion of BIM in M&E design	 On-site use of digital systems in London's Whiteley project, Laing O'Rourke (UK) Digitising the golden thread (UK) Smart phone e-learning courses 	• Centre for Digital Built Britain, Cambridge University	 Centre for Digital Built Britain Active Building Centre, UK

		Domain of action: mechanisms, tools, initiatives and lessons						
	Areas of industry transformation	Regulatory change	Planning	Financial and contracting practices, business models	Policies pertaining to labour	Skills and training	Industry culture and leadership	
	Circular economy	• Ecodesign for sustainable products, EU	n/a	• Inflation Reduction Act, US	n/a	 Use of rammed earth as building material, BC Materials, Brussels, Belgium 	n/a	
CLIMATE RESILIENCE AND INDUSTRY PREPAREDNESS	Decarbonisa- tion and energy retrofit	 EPA Smart Sectors programme, US Whole Life Carbon Road- map of the European building sector, EU National Retrofit Strategy, UK Energy Performance Buildings Directive (EPBD) and Energy performance certificates (EPCs), 2002, Europe Department of Energy (DoE) programmes, incl. Zero Energy Ready Homes Building Construction, US 	• Renolution, Bruxelles Environne- ment, Belgium	• Green Homes Grant scheme 2020, UK	• Birmingham 2022 Commonwealth Games carbon- offsetting programmes, UK	 Educational programmes led by Element 5, with Wood-Works, the Canadian Wood Council, the Mass Timber Institute, Canada BE-ST Low Carbon Learning, CONVERT and Offsite ready programmes 	 Active Building Centre, UK Laing O' Rourke use of low- carbon concrete (2023) Built Environment and Smarter Transforma- tion BE-ST, Scotland 	
	Disaster resilience	n/a	n/a	n/a	n/a	n/a	• Insurance Institute for Business and Home Safety (IBHS), US	

		Domain of action: mechanisms, tools, initiatives and lessons						
	Areas of industry transformation	Regulatory change	Planning	Financial and contracting practices, business models	Policies pertaining to labour	Skills and training	Industry culture and leadership	
BUILDING OUTCOMES AND CONSUMERS	Building quality and performance	 Rethinking Construction: the report of the construction taskforce, 1998, UK National Regulator for Construction Products, Office for Product Safety and Standards, UK Code for Construction Product Information and assessment process (UK) 	 Building Safety Reform Legislation Policy, Safer Greener Buildings Group, Department of Leveling Up, Housing and Communities (UK) Bill 124, Ontario, Canada 	n/a	 Considerate Constructors Scheme (CCS), UK Building Safety Regulator (BSR), created under the Building Safety Act 2022 (UK) 	 CPD certification system and processes need to be made more rigorous in the UK Built environment – proposed construction product competence standard – white paper, CPA, UK 	 'Identify' and 'Lexicon', CPA (Construction Product Association), UK Independent Review of Building Regulations and Fire Safety: Hackitt review (2018), and Transition Board, UK CIC Building Safety Committee, UK British Standards Committee, UK Product Availability Group, CLC, UK Setting the Bar, 2020, CIC, UK 	
	Demand and market performance	n/a	n/a	 Ontario's private market driving changes ahead of regulation, Canada Building product assurance framework, UK 	• Education and tools for builders towards net zero energy ready homes, DoE, US	 Peer-to-peer learning and exchange around retrofitting, Belgium 'Homegrade', Brussels region, Belgium 	Home Innovation Lab, National Association of Home Builders, US (incl. Advanced Housing Technology Programme)	
	Housing outcomes and affordability	• Requirement that rent rises must be tied to quality and performance requirements, to incentivise housing improvements, Belgium	 Affordable low-rise housing recommend- ed by the Mass Timber Institute (MTI) to the Ministry of Municipal Affairs and Housing, On- tario, Canada Regenera- tion of parts of Glasgow, 2014 Com- monwealth Games, UK 	 Loans and financial incentives towards energy efficiency upgrades, US, EU Engagement with financial and insurance institutions towards greater recognition of the benefits of sustainable buildings, DoE, US 	n/a	n/a	• Legacy built in 2022 Birmingham Common- wealth Games model, UK	

JUNE 2023

PART 1: WORKFORCE

Introduction

- Skills shortages in the industry are evident across jurisdictions. The disruptions caused by the pandemic, particularly in terms of limiting immigration, have severely affected the ability to rectify these skills shortages. Lack of investment in training, apprenticeships and measures that retain and builds skills are contributing factors exacerbating skills shortages.
- The building and construction industry is not universally seen as a good career path. The industry is associated with long working hours, harsh conditions outdoors, subcontract labour, and high accident and injury rates. Parents often do not perceive it as a good career, viewing other professions as higher status and with better prospects.
- Engaging more women and attracting a more diverse workforce is a common challenge. However, new methods of construction, such as manufacturing and offsite construction, are seen as an opportunity to attract young people, women and a more diverse workforce. This would help address the skills shortages and lead to a more effective and resilient workforce.
- Mental health issues in the industry continue to be a key challenge. While a common issue across jurisdictions, the reasons behind poor mental health vary depending on different contextual

This section of the report addresses the following key areas of industry transformation: talent pipeline and migration; equity and diversity; and health and safety. It responds to RQ1: *How is the global building and construction industry organised to overcome skill and labour challenges, such as labour/workforce shortages, gaps in skills and training but also mental health issues and opportunities for underrepresented groups?*

Globally, the building and construction sector employs around 7.7 per cent of the world's workforce, and in 2020 projections expected the sector to contribute to 13.4 per cent of global gross domestic product ³. As the Covid-19 pandemic spread through the world, affecting peoples' daily lives and disrupting economies and markets, building and construction industry stakeholders were affected at different levels, depending on their locations and the measures implemented to control the pandemic. The industry was considered an essential activity and for that reason did not have the same disruptions as other sectors. However, the impact of the pandemic on the broader economy severely affected global supply chains and the availability of labour⁴. As a sector extremely responsive to economic cycles, the building and construction workforce is more vulnerable to the economic decline caused by the pandemic than other industries⁵. In Australia, the Covid-19 pandemic, along with the lockdowns enforced to control it and the impacts on the economy, have constrained the supply of available workers across the building and construction industry. The National Skills Commission⁶ identified that almost half of the occupations in the Technicians and Trade workers group were in shortage in 2022. While some skills shortages were occurring pre-Covid-19, the developments of the last couple of years exacerbated these shortages. During Covid-19, the building and construction industry alerted the federal and state governments to the pressure that skills shortages was placing on the industry. This was not only due to the lack of skilled migrants but also due to low completion rates of trade apprenticeships occurring during that period⁷.

In Victoria the building and construction industry is an essential component of the state's economy. In August 2022, 337,971 workers were employed within the industry, equivalent to 9.6 per cent of the total workforce of the State⁸. Despite being the third largest workforce in Victoria and the second largest full-time employer⁹ the industry is facing a severe and ongoing skills shortage. The Victorian Government predicts that by 2025 the construction workforce will require an additional 19,200 workers, in line with its 1.99 per cent expected annual growth. Considering that by 2025,

⁹ idem



ILO, "Impact of COVID-19 on the construction sector"
 Deloitte, "GPoC 2020 | Global Powers of Construction

 ⁵ ILO, "Impact of COVID-19 on the construction sector".

⁶ Australian Government, "2022 Skills Priority List Key Findings Report".

Master Builders Australia, "New Skills Priority List unsurprising given ongoing skills shortage pressures"
 Australian Bureau of Statistics, "Labour Force, Australia, Detailed".

the industry is also expected to lose 14,900 workers to retirement, in total there is a demand of about 34,100 new workers. However, this estimate does not account for people leaving the industry for other reasons¹⁰.

The challenges for the industry within Victoria are multiple. Enhanced by constraints to migration of international skilled workers during the pandemic, several occupations currently have significant skill shortages, and this is greater in regional areas. An ageing workforce, poor workplace conditions, lack of diversity in entrants (such as women), and low enrolment numbers in some trade courses are some of the obstacles that have been identified by the Victorian Skills Authority. Recent high wage inflation is also preventing employers from retaining workers. Adding to these, the industry has identified a change in the skill set of workers is needed and a demand for new job roles are emerging. This transformation is driven by the rise of new technologies, such as building information modelling (BIM), computer aided design (CAD), digital twin technology and asset management software, but also due to the rise of renewable technologies and recyclable materials being used in construction, and the demand for more sustainable practices.¹¹

The majority of these challenges are not specific to Victoria or Australia. Many are current across the industry at a global

scale. When analysing youth employment trends globally, youth employment has shifted out of construction into market and nonmarket services, and young women are practically absent from the sector.¹² This second point is an ongoing challenge. Over the last couple of decades, women in the construction industry have accounted for between 5 and 15 per cent of the workforce globally. This is linked to a reputation for construction sites being potentially hostile workplaces in general, and for women in particular.¹³ Mental health and well-being issues are also prevalent in the construction industry around the world. These negative health impacts have been attributed to high levels of stress induced by unrealistic project deadlines, long working hours, and toxic workplace cultures, among others.¹⁴ In Australia the issue is severe with the suicide rate among construction workers being higher compared to workers of other industries¹⁵.

Based on the data gathered through the workshops and interviews carried out during the study-tour, this section provides an overview of the skills shortages in the industry across jurisdictions, presenting an understating of specific challenges and some of the measures and initiatives to address these.

- 3 Turner et al., "Resilience in a hostile workplace: the experience of women onsite in construction".
 4 Hosseini, Loosemore, and Fini, "Construction Workforce's Mental Health: Research and Policy Alignment in the Australian Construction Industry".
- 15 Maheen, LaMontagne, and King, "Suicide in the construction industry: 2001–2018"



Victorian Skills Authority, "Victorian Skills Plan Construction Industry Insight".
 idem

¹² ILO, "Global Employment Trends for Youth 2022: Investing in transforming futures for young people"

1.1 Talent pipeline and migration

Global skills shortages in the industry

The loss of capacity and skills within the building and construction industry is evident across the western world. The pandemic has exacerbated the skills shortage, but it is not a recent phenomenon. Some of the participants pointed to the Global Financial Crisis (GFC) of 2008 as a key event that disrupted the industry. This followed some 15-20 years of low interest rates and housing booms. Indeed, a cyclic history of boom/bust in the housing construction industry reinforces already splintered subcontract arrangements. During boom times, there is limited capacity for upskilling as the industry is at full stretch. During bust periods, skilled and experienced people leave the industry. Then, when the market picks up again, new skills have to be acquired quickly when there is once again limited capacity for upskilling as the industry is at full stretch:

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about 15 years ago when we had the big financial crash in the US and worldwide, the industry lost about 75 per cent of its construction capacity... They closed up and we have been struggling to get the capacity back to where it was... Even though we're not producing at the output we were in the mid-2000s, still we don't have enough capacity. (Housing market expert, US)

It started in 2008 with the financial crisis. If you look at all the statistics, you see it's not a slope, it's like a sheer drop. It was a slow recovery... and then, of course, Covid hit. (Construction products lobbyist, Belgium)

While this indicates a broad global issue, there were also local conditions that exacerbated the skills shortages, for example, in the United Kingdom (UK) around Brexit. In the years that led the UK to leave the European Union (EU), the country was already struggling with a decline in the workforce:

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before the pandemic, we had Brexit... 11 per cent of workers came from the EU, and of course, that percentage has dropped. The skill shortage was already there, so you can't attribute all of it to Brexit, but it hasn't helped the situation... we still have a serious shortage of all the key trades, plasterers, bricklayers... and that's the bigger problem of the two, compared to the supply of raw materials. (Construction association senior executive 1, UK)

The dominant view of participants on the severity of the skills shortage was a lack of attention to the growing problem by multiple actors, including Government, with limited support and intervention to provide a consistent skills base and labour supply. In the United States (US), it was noted that the government-registered apprenticeship programmes only graduate 45,000 people per year, in comparison to the estimated labour shortages of 650,000 in the industry. Participants argued that multiple skilling-up pathways into the industry needed to be supported and fostered to increase the number of apprenticeships.

In the UK, in addition to current skills shortages, the Construction Industry Training Board (CITB) estimate that 800,000 people will leave the industry in the next 10 to 15 years through retirement. The government has taken a minimal approach to training, skills and certification, opening the labour market and bringing predominantly an eastern European workforce. While this is welcomed in many quarters as a relief to the labour shortage, the approach has also depressed wages, and contributed to a view of the industry as an uncertain career path. Despite evidence of the need for an industry training policy and programme to build skills, careers and consistency of demand for the industry, there has been negligible effective action to date in the UK.

This view was broadly expressed and indicates that the construction industry skills crisis cannot be addressed by the industry acting alone, nor through the operation of the market. Deliberate and carefully designed programmes are required if the construction industry is to match the levels of skills changes seen in other industries, and if the industry is going to modernise and attract younger skilled workers:

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We really have to retool the whole market from a building official standpoint but from a trades perspective too, because if we want to build smarter and faster, we're using antiquated methods. (Senior building regulator, Canada) For the moment, not a lot of people are leaving Belgium. They're just leaving construction... the younger generation is more thinking about wellbeing, and what do I want to do in my life? (Project manager, Belgium)

Reliance on immigration

Immigration was also considered as a solution to alleviate the workforce shortages, but the general view was that it would not solve it completely. Additionally, immigration brings its own political and workforce complications. In the US, construction gets a small quota of the visa intake, and although building industry representatives argue for flexibility of entries based on demands and economic needs, it is not enough to alleviate the labour shortage. Canada also relies on immigration for its skilled workforce, with federal government fast tracking visa applications of international students who have completed their studies in the country, to address the immigration gap from the pandemic. Despite government efforts to facilitate professional entry requirements for skilled migrants, often the complexities and differences of the regulatory system within provinces in Canada, hinder the efforts to address shortages:

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There's been a lot of focus over years about trying to make entry into the profession that they were doing from wherever they came... we're even trying to figure that out if a building official wants to move from one province to another. We have this qualification system, but not every province does. (Senior housing policy maker 2, Canada)

In Belgium, where the skills shortage is also an issue, a leading construction company decided to focus their efforts by recruiting in countries where people also spoke Dutch. Although the company does all the preparation work, and has to provide evidence to government that they need to recruit internationally to fill their gaps, the Belgium government provides tax benefits for skilled migrant workers.

However, illegal migration represents a complex problem within the industry. In Europe, it was noted that it is an issue rarely mentioned, but that there are accounts of people working on building sites, being paid \pounds 4 per day (around A\$6,60). In the US, the general view was that illegal immigration was a well-known issue in the country and common within the industry, as many illegal migrants work as labourers. Undocumented construction workers are more prevalent in the residential market, as it is less regulated than commercial, but they can be found throughout the construction industry, constituting a human rights' issue:

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There's all kinds of discussions about the underground economy, how to fix that, because a lot of the construction workers who are undocumented are exploited. They work f or a lower wage. Their employer can be shady and can say stuff like, I'm just not going to pay you your full wages. What are they going to do?

(Construction association senior executive, US)

Negative perception of the industry

There was a universally expressed view across the research participants that the building and construction industry is not well perceived by the public and is not considered an aspirational career. When it comes to justifying this view, partly is attributed to a constant narrative of recent decades, that for young people to succeed they should pursue an academic degree. Vocational studies are often seen as a path to young people who have failed in pursuing a university degree. This emphasised through the educational systems in different jurisdictions.

It is perceived that guidance counsellors throughout the US highschool system disregard the skilled trades as a career and often do not provide, or do not have access to, the right type of information when it comes to career options in the construction industry. The same lack of knowledge from school advisers around the variety of career paths within the building sector has been found in the UK. In addition, funding for technical schools has been reduced overtime, which means that often the equipment at learning facilities is outdated and unattractive to a new generation. While in the US, 'shop classes' – courses to learn a trade or craft, currently part of the Career Technical Education – have practically disappeared in recent years.

As previously mentioned, the reluctance in investing in trades and apprenticeships over recent years also contributed to a view that the construction industry is not a prestigious career path. This view is prevalent across jurisdictions although it varies, and in some countries there have been initiatives to (a) position the industry as a means to secure employment, (b) tackle gender imbalances and (c) build and broadcast the need for new digital skillsets. The negative view of construction careers is further enforced by challenges transpiring from the industry's culture, particularly around mental health and well-being:

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I'm a mum and dad, I'm hearing about suicide deaths, opioid deaths, injuries, a short career, you know, all these other issues facing in the industry, I'm thinking construction maybe isn't the best place to put you guys into. Let's get you into something else. (Construction association senior executive, US)

In the US, some construction industry representatives have started to engage directly with young people, from kindergarten to elementary and middle schools, organising fairs or career shows, bringing equipment for children to engage with, and distributing books aimed at people as young as five years of age to address some of these aforementioned issues. Additionally, efforts are made for workers in the industry to engage with young people through school visits, to share their passion for the work they do, as it has been identified that young people respond to role models. Some companies are providing grants to fund technical classes in high schools.

It was suggested that part of changing the perception of the industry needed to be a rebranding of construction programmes

in schools. For example, using terms such as 'building science and technology' in programmes. It was also noted that, perception-wise, construction would benefit if it fell under the Science, Technology, Engineering and Mathematics (STEM) educational category:

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it would help a lot if construction was under STEM. It is not. Because that's really applied STEM, right?... It's science. It's building science. It's technology. It's maths. Why wouldn't it be considered? (Senior construction training executive, US)

In the US, participants referred that recent data on financial debt incurred by university students indicates that people with university degrees are not necessarily getting jobs. The private cost of education has been seen as an opportunity by peak industry bodies to illustrate that if people want to pursue a university degree, they can learn a vocational skill, start working and continue to study, without incurring debt.



CASE-STUDY 1:

Virginia's Community Colleges supporting people to join the job market quicker, US

In the US, Virginia's Community Colleges have been trying to provide a rapid response to training needs of the industry, while focusing on retaining people in the State to address the current workforce challenges. Although Virginia has outstanding colleges and universities, historically, a high percentage of graduates leave the State. Virginia's Community Colleges cater for a more local future workforce who stay in the State, meeting the needs of local industry and businesses:

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Talent usually leaves the state... Eighty per cent of our students, 80 per cent of our graduates stay in the state. They're educated in their communities and they're looking for job opportunities in their community. (Senior academic executive, US)

In Virginia, it is estimated that there are between 300,000 to 350,000 unfilled jobs across the state since the pandemic. Therefore, Virginia's Community Colleges' main focus is on training people to meet the needs of trades, construction and other industries that constitute this skills gap. Focusing on trades and construction, they conducted a survey in 2020 that revealed:

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81 per cent of the firms said that we cannot fill trade or even managerial positions in our companies. 72 per cent said that the labour shortage is the biggest challenge that they are facing. The other challenge that we are facing is just the ageing of our workforce. The average age in that [manufacturing/construction] industry is 50. (Senior academic executive, US)

The need for a capable workforce in the industry is further reinforced by the investment that Federal Government has committed to building infrastructure in the US:

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this infusion of federal dollars to build up the infrastructure. The bipartisan act will put a trillion dollars into the economy, about \$10 billion of those we're expecting to come into Virginia and we've got to be prepared to have the workforce to support the needs. (Senior academic executive, US) Virginia's Community Colleges developed specific initiatives. FastForward is one of those initiatives aimed at accelerating participation in short term – from four to 12 weeks – training credentials. It is partially funded by the state, and partly predicated on successful completion:

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The first third is charged to the student but can be scholarshipped, the second third comes from the state when the student finishes the credential and the third comes from the state when the student actually receives that credential from the trainer. (Senior academic executive, US)

Some organisations are incentivising students further:

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So once the student completes [their credential] there is an entity called RA Virginia, Ready Virginia, that will give them \$1000 in cash. In exchange that entity now brokers those students with companies that are part of that organisation. A student graduates, gets the \$1000 and then those companies now have first access to interview and potentially employ those students. (Senior academic executive, US)

The FastForward programme has provided pathways for new entrants into the workforce including representing women and minorities, thus diversifying the industry and benefitting the community:

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what we're seeing in that particular programme is it's really addressing a demographic. We're seeing larger numbers of minorities, we're seeing a greater number of women who are engaged... we had something in the neighbourhood of a 90 per cent completion rate with short term credentials, and it's because it's short term. Students are committed, they've got the resources. They know that in 12 weeks or less they will be able to enter the job market. Average age is about 34... Two-thirds of the students who are enrolled are just new to the community college... These are folks who are in the community who now are thinking about retooling or upskilling to enter into a trade or industry. ((

the average student saw about an \$11,000 increase in wages post-completion... 81 per cent now say they're satisfied with their work schedule and I'm looking at the salary increases by industry, skill trades plus \$13,000 in wages, welding and manufacturing almost \$17,000 in increased wages... 75 per cent now have paid leave, 75 per cent have health care insurance and 83 per cent say they are satisfied with their jobs. (Senior academic executive, US) Another initiative, G3, provides financial aid and an incentive grant for students that meet certain financial criteria¹⁶, and who enrol full-time in courses in five high-demand sectors, which include skilled trades, construction and manufacturing. The programmes start with a training component, followed by general studies. Since the programmes stack, it also allows people to return and earn an advanced credential to support career progression.

To Total household income of less than or equal to 4005 of the Federal Poverty Level (roughly US\$100,000 or less for a family of four).



Training within the industry

In the US one participant pointed to a disconnect between what is taught in schools and what employers in the industry are looking for. Although most schools have advisory committees, it seems that construction experts who sit on these committees are often timepoor. Improvements could therefore be made on how education institutions and industry collaborate in this matter.

Some construction organisations or peak bodies, in both the US and the UK, deliver their own training programmes. In some cases, these are shorter and faster programmes, often making use of rich content that allows for a component of online learning. Others have developed programmes covering the specific needs of a particular trade or association, allowing these companies to access a pipeline of workers with the skills they need. In Canada, building officials remarked that for tradespeople to learn how to install particular elements, such as wrapping around a foundation or encasing windows, creating training videos could help overcome language barriers and also be more effective. The same applies to specifics around building codes and how building officials are being trained:

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Hey, tradespeople, if you have a question, go to this site and you can see and train your staff, whether they have language barriers or not. Just watch the video - this is how you install this, this is how you install roof trusses - because that's how they learn... Throwing a code in front of them I don't think helps anyone, so we have to change the way we teach ourselves in this industry... when you look at our industry, the majority of us learn by doing. We look up plans and we go build something. (Senior building regulator, Canada)

In the UK, some larger companies have developed their own sustainability training. This is partly in response to constraints upon such training from government funded programmes.



EXAMPLE:

AC Whyte¹⁷ developed their own skills academy, providing training focused on sustainability. They found that some guidelines constraints make the delivery of training through colleges harder:

> The parameters of the funding haven't worked with our skills academy. So other than diversity element, that individual being paid for, we don't get any additional support. So, we've got all the expenses of the individual because it's part-time in college, part-time out on site. So, we need to support them with expenses to get them to whatever site. We supply material, PPE [Personal protective equipment]. We supplement their wages.

The one-year course is 80 per cent on-site practice, learning on the job, while having this reinforced with classes, with a pathway to employment once they pass their training modules:

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They're a college student throughout the year and then we guarantee employment on the end of that. Once they're then employed with us, then their training doesn't finish. They're still for the next three to six months building up their skills. Then when we feel they're ready, we then do an onsite assessment to qualify them for their NVQ [National Vocational Qualification].

(Housing redevelopment director, UK)

In the US, associations and industry peak bodies favouring their own individual initiatives is associated with fragmentation that then contributes to lack of transferable skills and credentials, exacerbating skills shortage and training requirements and their communication. As one participant remarked, the construction associations in the US operate in silos, one representing the housing market Small and medium-sized enterprises (SMEs), another the larger multiregional and national players, and another the commercial builders. Fragmentation is not only noticeable through peak bodies representation but also through different certification requirements across states or provinces. In Canada, a participant noted that the qualification system varies between provinces, making it harder for building officials to move across. While in the US, some states adopt the federal requirements and apply them to their certification and apprenticeship programmes; other states establish their own requirements. For contractors working across different states and dealing with different apprenticeship rules, it can be a cumbersome process.

The UK has been working on creating different pathways for students to access university, including doing T-levels¹⁸, a two-year practical course in any industry, but enabling students to learn skills that would then lead them to perhaps an apprenticeship or a higher-level apprenticeship. This two-year course can be done in construction, however when compared to other industries, the Department of Education is having difficulties in finding placements:

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the department of education... agreed that actually construction was a bit of a problem area... some of our members say, that they've asked me to increase my insurance if I take [young people] on. Others say, it's a young person, 16 years old, I've got to have somebody alongside them, checking their vulnerability. (Construction Director, UK)

Therefore, they are exploring the possibility of creating training hubs instead of having these young students on construction sites. Regardless of these challenges, in a similar manner to what is happening in the US, this path is being presented to young people to develop a career in which they can progress their studies while learning a skill and working. This means they do not have to expose themselves to debt while they progress in their careers. On the other hand, it can also take focus away from studies. I think the CITB and the levies are a complete failure. But the argument with government on that is really about how would you replace it? Or how would you come up with an alternative?... A number of the payees are now beginning to ask very serious questions about the longevity of it. (Construction association senior executive 2)

it's not effective in training the industry... from our view, we train when we need it from a business point of view... But what you replace it with needs to be right for SMEs... 70 per cent of the apprentices are trained by SMEs. So, it's no good having a system that's working more for the larger organisations; it's got to be relevant to SMEs and they need to have a voice in it. (Construction Director, UK)

In summary, there is a perception that a new approach is needed regarding training and how careers in the industry are presented:

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if you come into government you're going to have to come up with a completely different approach to how you bring the right people through the industry and create the right careers in the industry. Have a look at innovation, digital and the changes in the industry, people who will change career, mid-career, as well, to come in. Procession assembly, build offsite, there's some great careers in the industry... construction managers in the industry are far better paid than architects, but a lot of people wouldn't believe that. (Construction Director, UK)

01 WORKFORCE

Several participants noted problems with access to training through the mechanisms available in the UK. The UK has two types of apprenticeship levies that apply to construction; one led by the government for all large companies with a payroll of millions, no matter their industry, and another led by the CITB. Contribution to the CITB is dependent on the company's income and is mandatory above a certain threshold. It is then paid back in the form of a grant when a company decides to use it for training or upskilling of workers. However, there is a consensus that the process to access these funds is extremely bureaucratic, and often only larger companies with more resources can benefit due to the bureaucratic barrier. This is of concern because it is perceived that SMEs train most apprentices:

T-levels are equivalent to A-levels.

Associated Builders and Contractors (ABC) and its approach to workforce recruitment and development, US

The Associated Builders and Contractors (ABC) is an American construction industry trade association, representing more than 22,000 members. They engage with members of Congress, the White House, regulators, state and local policymakers on behalf of small businesses in the construction industry. As a peak body, their 68 chapters offer registered apprenticeships programmes, along with workforce skills and development programmes, from craft level to senior executive workers in the industry.

Their approach to workforce development is a three-phase process, looking at growing the workforce, developing the workforce and supporting career paths. The first phase aimed at growing the workforce aims to identify, create and promote diversity at entry point level into the construction industry. The ABC's strategies to grow include the development of programmes with prisons and military veterans:

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We have programmes we call them re-entry and second chance programmes... with federal prisons where we train people who are actually incarcerated to learn a trade, so that when they come out, they have a welder's license or carpentry or something, and then they can jump into a career that will hire them and that will allow them to have homes and have a stable life and reduce recidivism in a lot of the prison populations... they can even talk to the employees while they're still in prison and line up jobs...

The other group we recruit from is military veterans. A lot of people serve their time, but they're still young when they come back and they're looking for a career. A lot of people do a lot of electrical work or construction type... we want to try to match their skills up with employers and training programmes. The military folks that come back that work for our member companies are outstanding employees. They're physical, they know how to be disciplined and show up early in the morning and be on time. (Construction association senior executive, US)

Another group they target is people looking for a career change, that already have some work experience or a degree that is not fulfilling their needs: "

They've tried something, they've gone into marketing, they've got their expensive college degree, and they realise I can't make any money, I can't find a job and I have to be stuck in some area. Whereas if I'm in construction, I can go from job to job and I can work anywhere I want in the country and make strong wages... Lots of people we're recruiting I know in some of our apprenticeship programmes, we don't have a lot of young people. We have kids in their like late 20s and 30s, so it's not like getting them right out of high school or college. These are second careers. (Construction association senior executive, US)

Regarding workforce development, they provide four to fiveyear, time-based apprenticeship programmes, consisting of a combination of practice and classroom learning. They also have federal government registered apprenticeships programmes, and many of their members provide in-house training, tailored to the specific skillset required by the company. Pre-apprenticeships are being offered more regularly as a way of testing people before they fully invest in training:

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a trial really, a six-week programme, you know, spruce up their math skills, their reading skills, their safety skills, and then see if they're ready for the next step. I'm always nervous about adding another layer of gatekeeping into the industry, but this seems to have some usefulness in terms of getting certain populations in that may not even know of constructions for them. (Construction association senior executive, US)

In terms of career path, ABC's focus is on supporting the growth of industry workers, by creating and promoting a construction career development ecosystem in which employer needs are aligned with employee aspirations. In 2021, ABC's members invested US\$1.6 billion in workforce development.

1.2 Equity and diversity

New skills and a more diverse workforce

Participants spoke about the lagging gender gap in construction, even compared to other outdoor industries, such as mining. To quote one participant, this was particularly associated with the idea that 'it involves turning up in a muddy field and building something'. However, linked to this is the idea that the industry is low on skills, hard physical work, unexciting, and lacking significance and meaning. A UK participant talked about how new construction processes and methodologies are a way to attract a new generation of people to the industry, including women:

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When you're talking more about delivering value to society, that's where a lot of younger people want to be delivering a kind of role... you've got a generation growing up who know how to design things in 3D in digital because they're all playing – what is it, Minecraft?... the more flexible you can make the jobs, that's one of the benefits of offsite. (Construction innovation expert 1, UK)

Others talked about how the industry needed to be better at projecting its image to would-be new recruits:

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What they want to be talking about is how a career in construction and infrastructure can really deliver benefits to society, can support a faster path to net zero, can deliver better services, and articulate in that way... as we move into advanced manufacturing and digital, there's a more sellable message than trying to make crap jobs sound good. (Construction innovation expert 2, UK)

You all know teenagers, right? [Hands up] if you know teenagers who want to become steel fixers. (Senior engineer, UK) The latter talked about market leaders within the industry currently working on creating a future construction industry with different careers and working conditions that are designed to attract new recruits, including women. In this manufacturing approach, the workforce of the future will be multiskilled and, meanwhile, the existing, 'older' generation construction workforce should also have training:

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It's training the likes of me, or us in the industry to make sure we bring them [new generation] all into the right environment (Senior project lead, UK)

One US participant noted:

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The construction industry is very White and very maledominated... We do have a very large population of Hispanic and Latinos as well. A lot of them are migrants that are here legitimately and some of them are illegal as well, so we wrestle with that. But we're trying to bring all these different people into the industry. We're trying to increase the number of women on job sites. We've had a big jump in women in the construction industry in various trades as well as in management, you know, white collar jobs as well. (Construction association senior executive, US)

The move to manufacturing and automation may imply significant reductions in jobs, and, although this may actually translate to greater capacity rather than fewer jobs, the important point was made by tier 1 construction firm representatives that trade unions should play a key role in the transformation. This included partnering on pay and conditions, as well as on gender and diversity.


CASE-STUDY 3:

Social value in practice - lessons from Glasgow 2014 and Birmingham 2022, UK

As a once-in-a generation infrastructure spend, this event enabled a focus on the community benefits as well as timely project completion. Benefits in contracts such as number of local employment of new entrants/apprentices on a particular project, were tracked carefully and assessed as part of contract fulfilment regarding social value:

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part of the assessment criteria for any bids on the portal for securing the tenders to do the supply contracts, the weighting of the legacy of employment opportunities was lifted above the default position, because it was such a special one-off type thing that says, okay, we need to make this work... so that we can at least say it's not just about the legacy, the physical infrastructure, it's the legacy of the people who didn't just get employment for the period of time that the games were on, but they actually entered employment that lasted them a lifetime. (Government official 1, UK referring to the Glasgow Commonwealth Games 2014)

We've always worked very closely with Sandwell Council and their in-house team around social values, skills and employment, so we had to set KPIs [key performance indicators] right at the very beginning around what kind of goals we needed to achieve on ... That's been a big part of the delivery as well, working with our supply chain to deliver various skills and employment metrics... In terms of skills shortage, we ran loads of training programmes to give people access to construction skills, apprenticeships, school engagement, anything that would increase the number of people... They put the infrastructure in place and then we were able to sort of tap into that. (Project director, UK)

Comment in relation to Sandwell Aquatic Centre (Wates) for Birmingham Commonwealth Games 2022

For Perry Barr Residential Scheme, Lendlease qualified for the SCAPE procurement framework which follows best practice in line with PAS91, that enabled them to complete their procurement due-diligence checks pre-contract and set-up a number of KPIs around social value:

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The reinvestment into local economy, invigorating younger local workforce, being out in the community, and just really, really pushing that quite hard. Again, in order to do that ... we still have to keep people here. (Project director and senior executive, UK)

The social - it's worth pointing out the social value KPI around local labour for instance, the spend around local labour, that was a two way win really because these people are much more invested if they're coming from the local community, aren't they? We saw real benefit from that. (Senior project manager 2, UK)

Both comments in relation to Perry Barr Residential Scheme (Lendlease) for Birmingham Commonwealth Games 2022

For the recent 2022 Commonwealth Games in Birmingham, UK, Lendlease set up a dedicated training centre:

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The lady that you see in the middle there, she was one of the first people through the training centre. She went on to be a dumper driver out on site.... 168 local candidates have been through that training centre and that's resulted in 54 placements on this site. As well as that, we've held English for construction courses in that training centre. We've had just over 20 different nationalities, maybe over 30 different nationalities working in this project.... one of our supply chain partners, who are doing the infrastructure in the public realm works; they've taken that a step further now. They've actually invested with Birmingham BMet [Birmingham Metropolitan] College into a longer term strategic partnership around training. They really see the benefit of that investment in this region. (Senior commercial manager, UK)

Gender equity targets and practice

Victoria has gender equity targets through the gender equity policy. In the US the system is more diffuse, with local ordinances (e.g., city) placing conditions on contracts such as major infrastructure builds:

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They'll put a little percentage of the workforce to be local, minority and women. They might say it's got to be two per cent of the labour hours worked on the job, or they might say there's got to be a certain number of people on the job that get hired, that kind of stuff. It just depends on where you are. It's a contract by contract [basis]. (Construction association senior executive, US)

There are increasing numbers of women in the construction industry generally, but they tend to be in roles typically more associated with females. This illuminates further the challenge in getting genuine equity and diversity across the industry. Market leaders are making commitments in this regard, for example, Laing O'Rourke has a commitment to reach a 50/50 gender equity by 2030:

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The way we'll do that is by building off-site, we will redesign jobs. The vision we've got for employment in 2030 is we've got to create job roles that people want to do. (Senior engineer, UK)

The question was raised about processes for following up, evaluating what works, and sharing best practice. It is not clear that there is any model across the Western world where best practice is shared across a traditionally competitive, contract-driven, undercapitalised construction industry businesses. This indicates a clear role for government.

Other accounts were less about targets for gender equity, and more about cultures and emphasising the benefits. A participant from a tier 1 construction firm stated:

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More flex work – we have looser rules for holidays, and things like that... We have a lot of flexibility and we offer a lot of different kind of jobs, so we attract...women...we look for them, as well, just to have a better mix of people...once there is a woman on site, you experience another dynamic in the team.

We have a programme, not for women, but for all diverse groups, to have more recognition for them, and to bond them together...because we've got different nationalities, religions, women, men. We have different kinds of LGBTQ [lesbian, gay, bisexual, and transgender], the whole range. We're working to get it to everyone on the... payroll to have the same mindset. (Project manager, Belgium)







Flexibility afforded by innovations such as well-located off-site manufacturing facilities is an important mechanism to attract primary carers and lower income workers who do not have private transport options:

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because no day-care is open at 5:00 a.m. in the morning. You've got to travel like usually weird distances in the middle of nowhere for like new developments and there's just not mass transit available. There's a lot of different reasons why people don't get in the industry... The problem with construction is there's so many subcontractors on a job. They might be in and out on a job for 30 days or less, so, setting all that up just for that 30 days of return, it just doesn't make a lot of sense for some. (Construction association senior executive, US)

In the UK, the move towards off-site manufacturing means new workers are already in evidence:

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They're also more flexible, as well, aren't they? So, you can have a much more inclusive workforce. You could work short shifts, or you can make adjustments for people who wouldn't be able to work onsite. The factory up in the northeast, most of that workforce are not ex-construction. They're butchers or post office workers and all sorts of things. (Construction innovation expert 1, UK)

Others gave examples of potentially game-changing twists on otherwise regular-looking materials and practices, that were designed to reach a new, female audience:

> There is a book - The House She Built - that was specifically designed to attract more girls and young women into construction. So, this is also something to consider - how do we break that stigma and the misconceptions about that women are not built for construction? (Senior construction training executive, US)

Building Talent Foundation working towards a sustainable workforce, US

The Building Talent Foundation is a non-for-profit organisation, initiated by the Leading Builders of America – an association of large home builders in the US – to address skills shortages. Building suppliers and manufacturers have also committed this organisation that aims to create a sustainable workforce in the industry, ensuring they focus on targeting young people and underrepresented groups.

They have identified three main challenges faced by the industry when it comes to its workforce: talent supply, talent training and talent retention.

In terms of talent supply, the Building Talent Foundations argues their research shows there is a weak and not diverse enough pipeline in the sector, mainly due to the perception of what the industry entails:

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Young people are not choosing construction classes as their orientation and the perception is four Ds - that it's difficult, dirty, dangerous and dead-end... We had a group of 47 young people who we were talking about the potential of these careers. They were 17, 18 years old and... they got excited and they wanted to explore. A lot of them raised their hands yes, I want to try this. I would consider an internship. They went home over the weekend. After the weekend only three of them signed up. (Senior construction training executive, US)

To address this challenge, the Building Talent Foundation is putting efforts into reframing perceptions by providing effective and accurate information and engaging young people with role models. Furthermore, they are focused on identifying different sources of talent, with a strong focus on attracting women and people of diverse backgrounds, since they consider that traditionally the industry tends to replicate itself.

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We created a new project...It's a four day very intensive orientation to the industry for people who have never imagined they could be a construction manager or a sales consultant for a building company or... a building inspector... They start seeing themselves and the transferable skills that they can bring to the table... It's also very diverse.

We bring talent that's 30 per cent women, 60 per cent people of colour through the boot camp, which means that we are infiltrating the construction companies with a different type of individual. (Senior construction training executive, US)

The training challenge refers to the lack of alignment between employers and education providers, but also fragmentation of employers. The latter, due to a lack of sophistication in terms of human capital management, particularly around human resources practices. The foundation is working on strengthening the linkages between employers and schools and creating effective training models aligned with their accelerated skills training while leveraging technology to deliver this training.

Engagement studies done by the Building Talent foundation also make evident that retaining workers is a major challenge within the industry, with many of the people interviewed planning to find another job.

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It's not about money only. Yes, money is important but upskilling and bad bosses came very high on why people leave jobs or why they stay in the job...we need to do much better job with professional development of immediate supervisors, crew leaders, owners and managers. On the other side, we need to identify and disseminate best practices for those – for the employers so that they can better engage and retain their workers. (Senior construction training executive, US)

The Building Talent Foundation has developed its programmes to address the workforce supply challenges identified in the industry. They implement them through partnerships, acting as a labour intermediary between employers and individuals, providing posthire support for up to six months and using an online platform to promote career pathways and showcase industry. Their long-term goal as an organisation is to bring 100,000 new workers into the industry, 25 per cent female, 60 per cent people of colour, with a retention rate of 75 per cent by 2030. "

if we do this right, the idea is that we will address the challenges and create a different talent culture and that talent culture would lead us to sustainable workforce in construction. But we cannot skip any of these steps We cannot do just one thing. It's only a comprehensive solution that can lead to true change... It just needs to be a comprehensive and collaborative process of all actors. (Senior construction training executive, US)



1.3 Health and safety

When the pandemic was announced, jurisdictions took different approaches to lockdowns. Most participants noted that safety became the first and foremost issue on construction sites. Across countries, measures were put in place and construction companies adapted; from smaller teams to on-site testing, from working from home, to requiring all staff to take leave over a period of time. Participants in both Belgium and the UK mentioned how it impacted their workforce, particularly immigrant workers:

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The first year after Covid, the first year was the most difficult. We had a lot of issues, also with supply, also with people, because we depend on a lot of ... foreign workers... They couldn't get here. When they got here, they had to be quarantined for two or three weeks, but normally, they go home each six to eight weeks; they go home, they come back, but when they did that, they had to go in quarantine, in their home country, and back here, so they lost a month, and that means a loss of money. So, they stayed here for longer, but that is a problem, because, mentally, that becomes difficult. (Project manager, Belgium)

When discussing the issue of mental health within the industry, participants agreed that the pandemic made it more evident, and there is renewed attention given to the matter across the industry and in the media. In Belgium, it was mentioned that every construction company must provide well-being support for their workers. This is mandatory, legislated by the government, with the cost falling on the company. In the UK, a participant involved in the delivery of the Commonwealth Games 2022 stated how, during the pandemic, they had drop-in forums and trained mental health first-aiders within the organising committee to help run well-being programmes for staff. Simultaneously, their supply chain partners were mirroring this through social value commitments established in their contracts.

Some companies were able to go further to ensure the well-being of their staff.



EXAMPLE:

mid-June. AC Whyte, a 50-year-old family business, delivering predominantly energy efficiency and retrofit that period, without any productivity, as the government

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Our business model is to employ our operatives them. We knew what everyone was going to go work... We knew that when they came back, we needed them to be motivated and happy to work.

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family circumstances? So we really tried to pull the everybody was happy to come back to the work.

A Tier 1 representative mentioned that in recent months they have seen a shift in the awareness of their younger workers around well-being, saying that they are more conscious about what they want and the work-life balance they aim to achieve. The shift in the industry towards modern methods of construction, including offsite, may also be avenues to create a better work environment in terms of health. In both the UK and the US, participants referred to how offsite manufacturing can reduce the amount of physical labour needed at the project site, often in challenging conditions:

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it is fundamentally wrong that we ask a person to work at the limit of their physical ability, eight hours a day, five, five and half, six days a week. (Senior engineer, UK)

In the UK, the focus on health and safety has been reinforced by the development of the Building a Safer Future Charter. This scheme was established almost three years ago as a response to the Independent Review of Building Regulations and Fire Safety, after the Grenfell tragedy. Initially, under the responsibility of the Considerate Constructors Scheme (CCS) and later transformed into a not-for-profit independent organisation, the charter focuses on providing tools to help the industry transform its leadership and culture, putting building safety first, for everyone working and living in the built environment, through in-depth audit and assessments.



CASE-STUDY 5:

Covid-19 safety management on site - Birmingham 2022, UK

The 2022 Commonwealth Games in Birmingham faced the unprecedented challenge of having to be completed during the pandemic. This meant they had to find innovative ways of working.

The Perry Barr Residential Scheme became a legacy project, as the pandemic made its original planned use as the Athletes' Village unattainable. After this setback and readjustment, safety on site became a key focus:

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closed environments, site officers, welfare officers out on site, if they working together, they had to look after first and foremost their own workforce. If they were going to have to lay workforce, then they had to do other things within their own business to look after that. So there was a kind of mixed approach. There wasn't a unified approach. Each individual business at the time took its own decision whether or not to take a 24 hour stand down, a 48 hour stand down, a three week stand down. Across our programme... we had around about 12 to 14 major tier one contractors involved all at the same time... They all had different approaches. Lendlease were overseeing all - as a management contractor... All global risk policies and procedures to deal with as well. (Project director and senior executive, UK)

Productivity levels decreased but this was expected in order to be able to provide safety onsite. Work continued throughout, albeit under strict conditions, and once all the contractors were back on site they were able to understand what kind of productivity levels they were able to achieve with all the restrictions that were in place:

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We had a new saying... which was 75 per cent is the new 100 per cent. That's the norm. We can only ever achieve 75 per cent of what was our original 100 per cent productivity level. That became an acceptance... Which meant that that had an impact on programme and cost and everything else. (Project director and senior executive, UK) This new norm effectively impacted the programme and cost of everything, including cost of running the site with new Covidmanagement initiatives:

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That 75 per cent was affected by extra spaces that we needed... The canteen was set up with four chairs around a table to allow all the workers to go in. When you recalculated if you put only one person on a table... we'd need an extra welfare space which meant we had to shift everything around in this place... it just had so many different knock-on effects.

We had one-way systems all set up around here. We had extra measures with testing on site. We put on site testing on all of our sites and make them enforce that everybody had to get a Covid test before you come on site. That had a cost impact as well which we kept trying to forecast in. It did have an impact but we never stopped. We were determined never to stop and everybody signed up to that agenda that we would never stop. (Project director and senior executive, UK)

Similar dispositions had to be adopted for the delivery of the Sandwell Aquatic Centre that also delayed the delivery of the project. However, throughout the pandemic the site was only closed for one day:

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Covid kicked which made or gave us problems onsite, obviously with social distancing and the people being able to work together... the whole programme was delayed, however bearing in mind that the Commonwealth Games had a fixed date, we couldn't delay the contract. We had to put a mitigation regime in place, we've had to use acceleration of the works, bring in more contractors, better qualified contractors trained to work... Originally we were due to finish onsite in February 2022, even with mitigation we didn't finish until mid-April. (On-site project manager, UK)

The Perry Barr Residential Scheme ended up winning the Royal Institute of Charter Surveyors (RICS) residential award, and also, from a health and safety perspective, Lendlease won a gold medal award from the Royal Society for the Prevention of Accidents for the project, demonstrating their commitment to wellbeing of their workforce.

The issue of mental health in the industry

In the US, the legalisation of marijuana across different States, for medical purposes or for recreational use, along with an increasing opioid addiction in the male population, has become a convoluted problem for the construction industry. Peak bodies are advocating for more efficient and sophisticated testing methods to understand and judge impairment, but also for exemptions to allow for random drug testing of workers, as they consider this to be a common public safety issue. Several trade associations have gathered to create a construction coalition to push for zero tolerance for drugs and alcohol in the workplace, urging companies to sign pledges towards it.

This effort is closely tied to the industry's need to tackle the issue of mental health and suicide in the industry. One participant alluded to Australia's leadership in this space, and explained that in the US, workers in the construction industry are 3.5 times more likely to die of suicide than the average population. Addiction to opioids seems to be a contributor to this, as it is widely prescribed to workers with injuries and veterans, sometimes suffering from post-traumatic stress disorder, who make up a large percentage of the industry workforce. The workforce demographics – mainly white men – and the 'macho' culture that still prevails in the industry were also described as contributing factors. One participant explained how industry peak bodies are working on several fronts to try to tackle the issue. They help employers understand the positive role they can play for workers by providing insurance, employee assistance programmes and guidance counsellors. They work with different levels of government to ensure that mental health and suicide prevention in the industry are recognised and funding is allocated for research and prevention. A lot of effort is put into encouraging leaders in the industry to normalise and respect the discussion around mental health. Additionally, they strive to raise awareness among healthcare practitioners, about the profile of construction workers and the likelihood of being at a higher risk of developing mental health issues to enable early intervention.

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This is just putting in perspective, that five times the industry average of overall fatalities are a result of construction worker suicide, which is pretty crazy to think about because we spend so much time and money protecting a worker. They've got hard hats, goggles, gloves... all kinds of harnessing. But if we're not spending time on total human health and taking care of their mental wellbeing, we might as well just have them run out, you know, with no protection because this is the bigger killer in the industry. (Construction association senior executive, US)





IMPLICATIONS FOR VICTORIA

The halt on migration imposed by the Covid-19 pandemic was felt globally, and various initiatives are now underway to rebuild skilled migrant flows. In Canada, the federal government has streamlined visa applications of international students that have completed their degrees. In all locations, participants also agreed that migration alone would not solve their labour shortages and that the skills agenda is linked to wider changes the industry faces. In the UK, the Covid-19 pandemic and Brexit together accelerated already-existing problems stemming from under-investment in skills and training. Research participants in the UK discussed how, in the years before Brexit, the country relied on foreign workers, often highly qualified, to fill their workforce gaps. This pegged wages and helped to conceal an ageing workforce and the industry's inability to attract sufficient young people locally.

In Victoria, these agendas are also relevant. There is a need for additional skilled labour, including the new skills required for the industry to address the climate emergency and advance modern methods of construction. There is also a need to reframe the way in which the industry is perceived by the public and attract an environmentally-social conscious, diverse new generation to the workforce. A more deliberate move to manufacturing and offsite construction, led in partnership with State Government, it is also seen as a means to attract more women to the industry. For example, the controlled environment of offsite manufacturing is more conducive to flexible work arrangements, that suit, for example, people with carers responsibilities, people with disabilities, and people with various reasons to prefer the consistency of indoor manufacturing environments on static sites.

Building on the current review of training reform, it is evident that significant changes are required in current training and skills programmes to achieve these goals. Fostering greater flexibility and inclusivity to accommodate a diverse audience, and strategically incorporating cultural and sustainability training at the core of these programmes would help reach new audiences and, ultimately, employees.

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PART 2: CONSTRUCTION PROCESSES AND METHODOLOGIES

Introduction

- The building and construction industry is facing supply chain challenges globally, for various reasons, including; material shortages, trade disruptions, increased demand, on-going disruptions from the Covid-19 pandemic, the war in Ukraine, and a housing affordability crisis.
- Design and construction methods are beginning to include modern methods of construction (MMC), such as increasingly sophisticated off-site fabrication. However, the introduction, generalisation and streamlining of these methods present significant challenges and imply significant change within the construction industry.
- With a variety of rationales from sustainability to efficiency, quality and safety, jurisdictions around the globe are striving to reform their regulations and building and planning codes to assist with generalising, standardising and implementing MMCs.
- Digital disruption is changing construction processes although the degree to which industry stakeholders and organisations are adapting their systems and upskilling their workforce varies depending on capabilities, scale, resources and motivation.
- The realisation of sustainable construction goals through digital and industrialised construction methodologies is shaped by changing government policies, industry culture and practice.

This section of the report addresses the following key areas of industry transformation: design and construction; supply chains and materials and; digitalisation. It responds to RQ2: *What are the key innovations (including in the realm of CE and sustainability) pertaining to construction methodologies, supply chains and materials use and availability?*

The multiple supply chain challenges facing the building and construction industry warrant accelerated innovation in processes and methodologies to improve efficiencies and maintain profitability. Furthermore, increased scrutiny over building defects¹⁹ is driving the industry to rethink and enhance its quality controls and processes. While the development of manufactured construction may enable safer²⁰, more productive and sustainable²¹ construction processes and workplaces, the capacity of businesses to innovate through automation and digitalisation varies widely²².

In addition, renewed sustainability agendas and the urgent need to reduce the construction sector's significant contribution to greenhouse-gas (GHG) emissions to meet the Paris agreement have opened pathways to transform the industry while also presenting important challenges. The construction industry in Victoria operates within this global context. A significant issue is that the building and construction ecosystem (from design, materials manufacturing, construction, use to deconstruction, of residential, commercial buildings and infrastructure) is not changing or innovating fast enough to respond to such challenges.

The pandemic established conditions that led many in the industry to consider accelerating their use/adoption of digital systems. However, a variety of challenges include the constraints in the regulatory system and the fragmented nature of the industry, translating to a lack of capacity required for changes to harness the benefits of digital innovation. Similar observations can be made with regards to upscaling offsite manufacture²³. Further government incentives and financial support are needed to de-risk and upscale technological and social innovations. Additionally, knowledge and practical gaps still exist in the workforce and training of construction professionals in terms of digital twins, circular supply chains and zero carbon²⁴. The realisation of sustainable construction goals in Victoria is shaped by government policies as much as by cultural and practice change.

21 Kamali and Hewage, "Life Cycle Performance of Modular Buildings."

Within design and construction methods, a raft of changes is increasingly included under the umbrella term modern methods of construction (MMC). MMC can be defined as 'a range of approaches which spans off-site, near site and on-site pre-manufacturing, process improvements and technology applications'²⁵. It thus describes a range of offsite manufacturing and onsite techniques that provide alternatives to traditional construction methods.

Typical MMC systems include timber frame, steel frame, and precast concrete. A seven-part²⁶ framework was developed by a specialist sub-group of the UK government²⁷, with the intention to 'to regularise and refine the term 'MMC' by defining the broad spectrum of innovative construction techniques being applied in the residential market, both now and in the future'28. Design for manufacture and assembly (DfMA) is also being widely discussed in the industry. Like Lu et al. write, 'DfMA is a new and mixed 'cocktail' of opportunities and challenges to improve construction productivity with the advancement of construction materials, production and assembly technologies, and ever-strengthened logistics and supply chain management'29. Similarly, platforms (organisations, products or ecosystems or market intermediaries) are increasingly being discussed in the construction industry as they present cost-savings and flexibility benefits but require a 'a shift in focus from a construction mind-set to a manufacturing mind-set'³⁰.

How to improve supply chains management and planning while maintaining industry performance goals is another challenge that the industry is currently facing. Procurement is integral to the industry and the procurement professionals have to respond to multiple and conflicting objectives while managing supply chains³¹. Recent McKinsey research³² highlights that the construction industry is lagging behind when it comes to best-practice procurement, which is partially caused by complexities in project specification, complexities in supply chains, and an industry structure built around individual projects and the temporary organisations they require.

Digitalisation (i.e., the increased use of digital technology) and Industry 4.0 (i.e., the industrial use of digital technology) are increasingly being developed to respond to these challenges and present significant opportunities for the building and construction industry. The convergence of circular economy and off-site

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¹⁹ Oswald et al., "Construction Defects, Danger, Disruption and Disputes."

²⁰ Ahn et al., "Comparison of Worker Safety Risks between Onsite and Offsite Construction Methods."

²² Müller, Kiel, and Voigt, "What Drives the Implementation of Industry 4.0?"

Gad et al., "Regulatory Barriers Associated with Prefabricated and Modular Construction - Interim Report."
Clarke, Sahin-Dikmen, and Winch, "Overcoming Diverse Approaches to Vocational Education and Training to Combat Climate Change."

²⁵ MHCLG Joint Industry Working and Group, "Modern Methods of Construction Working Group: Developing a Definition Framework.

²⁶ The categories of MMC were established as follows: Pre-Manufacturing - 3D primary structural systems; Pre-Manufacturing - 2D primary structural systems; Pre-Manufacturing - Non systemised structural components; Pre-Manufacturing - Additive Manufacturing; Pre-Manufacturing - Non-structural assemblies and sub-assemblies; Traditional building product led site labour reduction/productivity improvements; Site process led labour reduction/productivity improvements.

²⁷ This framework was established by a specialist sub-group led by Mark Farmer of Cast Consultancy, the chair of the wider MMC working group, supported by representatives of Buildoffsite, Homes England, National Home Building Council (NHBC) and Royal Institute of Chartered Surveyors (RICS).

²⁸ MHCLG Joint Industry Working and Group, "Modern Methods of Construction Working Group: Developing a Definition Framework."

²⁹ Lu et al., "Design for Manufacture and Assembly (DfMA) in Construction," 77.

³⁰ Mosca et al., "Platform Thinking for Construction," 5.

³¹ Fayezi, Zomorrodi, and Bals, "Procurement Sustainability Tensions."

³² Marques, Ribeiro, and Sjödin, "The Strategic Era of Procurement in Construction."

construction processes towards waste mitigation has been associated with life cycle assessment, BIM, circular business models, deconstruction and supply chain management ³³. In particular, Industry 4.0 may be used to measure the carbon footprint of products used in new constructions or retrofits, improve coordination alongside the supply chains, support information sharing, reduce waste and create accurate 'track and trace' systems such as material and building passports. Digital twins offer great potential by providing virtual replica of the physical world (buildings, sites etc.) and enabling better monitoring and coordination of the supply chain³⁴.

However, there are many challenges associated with the digitalisation of the construction industry, such as the training of the workforce to use digital tools and systems (in the context of long-established paper-based practices on site), especially in the case of small and medium-size business who have limited training and research and development (R&D) capabilities.

In this section we set out the current state of play regarding construction processes and methodologies through a series of international case-studies, and through three areas of industry transformation: design and construction; supply chains and materials and; digitalisation.



³³ Rosa et al., "Assessing Relations between Circular Economy and Industry 4.0"; Obi et al., "Establishing Underpin-ning Concepts for Integrating Circular Economy and Offsite Construction." 34 Boje et al., "Towards a Semantic Construction Digital Twin."

2.1 Design and construction

The construction industry largely runs project-by-project, and each project is transferred from client to contractors. A UK innovation expert summed up the nature of the relationships that are formed when different actors collaborate to design, fund and construct projects: 'a project is just an inconvenient process that sits between a funder and an owner and an operator and a user. If we focus on trying to do that thing wrong or do the wrong thing better, we're going to fail':

"

You have multiple buildings, multiple projects, which are all very different, delivered differently, and because of that disparity, you have to effectively create the team, the site, the project from scratch every time... Construction is a sector, but it's actually lots and lots of different subsectors with different clients, different responses (Construction innovation expert, UK)

This is the context for making changes to design and construction that have the potential to shift the way the construction industry has developed as 'a best fit response to the things that are being asked for' (Construction innovation expert 1, UK). An academic suggested that the UK government is considering how a fragmented industry could be helped by the procurement processes of offsite manufacture, not 'expecting the industry to change how they do it... but actually changing what they're being asked for' (Senior academic 1, UK).

Towards greater integration and standardisation

Using off-site manufacture requires for that decision to be made by the architect and client at the inception of a project, thus accelerating the process and increasing efficiencies. This 'gives a signal to the supply chain that this architect will be buying all these things' (Senior digital innovation expert, UK). It also means that 'the institution of procurement' needs be changed: 'if you want to change how we operate as an industry, you need to change how it's procured' (Senior digital innovation expert, UK). This has ramifications for the ways off-site manufacturers position themselves in the market: "

if you are doing an offsite based building, you almost go to the point of saying the first decision the client needs to make is who to build it, because they all have their different kits of parts....But actually some of the key players broke away quietly and started developing their own platform so they could then sell it as a platform to their clients. (Senior digital innovation expert, UK)

There is a need to move towards standardisation in delivering products to improve outcomes, which would still allow for variety across sectors, as explained by a senior digital innovation expert:

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We did research on hospitals a few years ago and we discovered that most hospitals have a 4.2 metre floor to floor height... if we just said that we just mandated that height, then all of a sudden like companies making staircases, could confidently, maybe they would get steel mould, they would invest in new equipment to because things of all of a sudden the standard site. So just standardising floor to floor heights means the cladding company stair companies can also start to make products geared to those floor-to-floor heights and they don't need to be the same for every sector. (Senior digital innovation expert, UK)

Standardisation should a drive competition and cooperation, where production frameworks (of bathroom pods for instance) could be shared amongst manufacturers. Building facades, requiring more customisation, could be treated differently. In the UK, important progress has recently been made in the design of joints used to join manufactured construction modules so that buildings have structural integrity and are waterproof:

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a lot of offsite schemes have done a compromise where they do offsite boxes to come together, so volumetric. and then they do a traditional facade. There's quite a few companies do that, so that's the kind of a hybrid, where they're saying, well, we're not quite sure if we can get this to work. But I think the one piece of headway I think we've done in the in the UK is the zipping detail as we would call it. If you received a 30 storey building where you got repetition, you obviously don't want it to look like it's like hundreds of boxes that have just been put on top of each other. The detailing of that joint between the boxes is absolutely crucial and I think some of the buildings that have been done recently have actually begun to smash that whole kind of paradigm, if you like, because they're now getting the detailing. (Senior digital innovation expert, UK)

This means that time is saved in the design process where drawings are done for every single project, although some designs may not differ from one project to another: 'the first thing is looking away from the single project to programme of work for one client. But then the next level up is then trying to say, well, how do we standardise things at an industry level." (Senior digital innovation expert, UK):

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Get the core of your building the look and feel that you want, and then just use that on every single time and then just get the architect to focus on the massing and elevations and how the building's going to appear in the public realm (Senior digital innovation expert, UK)

In the UK, it is not common practice for the architect to stay involved across the duration of the whole project, as opposed to models of integrated project delivery where the architects work with the contractor and the client.

Planning systems can also add complexity to the task of standardising procedures. In London, every borough has its own scheme which will often specify the types of materials to be used, noting that Greater London Authority manages projects above a certain scale. As a participant noted:

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We used to say in England that it took 20 years to build a new road - it took one year to design it, 17 years to get it through planning and one year, and two years to build it. (Senior academic 4, UK)

Building projects such as hospitals or healthcare centres were identified as a challenge in standardising construction to reduce cost in production. An academic in the UK explained how better decision making for government involves: an overarching strategic direction; organise appropriate support; leave space for customisation but outline rules/boundaries and constrain choice on. To summarise, 'things can look different but have the same building blocks and the same interface standards... which allows those standardised elements to be brought to the fore' (Senior academic 2, UK).

To address these challenges, a group was formed in the UK government in HM Treasury called the Infrastructure and Projects Authority which plays a role in infrastructure particularly, governance, asset management, organisational structure and system integration.

CONSTRUCTION PROCESSES AND METHODOLOGIES



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Case-study 6:

UK's Construction Innovation Hub

The Construction Innovation Hub was funded in 2018 by UK Research and Innovation through Innovate UK and the Industrial Strategy Challenge Fund (Transforming Construction Challenge):

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the idea was to bring together government and industry to look at how we can help various sectors either transform or grow from a low base... The construction sector in the UK threw its weight behind this and it was roughly £180 million more than they've ever invested in construction before. It was match funded by about £250 million from the industry. It essentially finished last month, but we're moving into a different phase here now. (Construction innovation expert 1, UK)

The aim of the Construction Innovation Hub was to support a transformation in the built environment sector by providing examples and demonstrators, of better procurement practices for instance:

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The idea really is focus on procuring the value, so what a piece of infrastructure does, not where we were stuck before, delivering the cheapest asset. That's the system we're stuck in here, is that the whole system sets up that way, nobody wins, but within the programme, everybody who was involved in that system were working together to move to a different place. (Construction innovation expert 1, UK)

The Construction Innovation Hub works across government, policy-makers and industry partners 'to help them build appetite and capability and capacity to be able to respond' and also 'to share risk' (Construction innovation expert 2, UK):

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How do we de-risk the investment for government clients who want to build 40 hospitals? How do we help them realise the benefits of an approach and how do we sort of accelerate how they take that forward with their supply chain? ... We're going to be deployment and diffusion led now, so we want to see things coming forward. We'd like to see some wider transformations happening. We want things to move at pace and scale. We want to make sure that we keep it as a coordinated programme. (Construction innovation expert 2, UK)

Another part of the agenda is to develop solutions that 'support greater levels of productivity, greater levels of digitalisation, a move to more manufactured solutions, and all the things that sit out those broader social, economic, and environmental ambitions we have from the around about £65 billion that are invested in economic and social infrastructure each year' (Construction innovation expert 2, UK)

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Our programme is about helping government, helping clients, and helping industry to transform so it can be more sustainable, more productive, and introduce innovation much earlier and accelerate its adoption, so we don't carry on doing the wrong thing a bit better. We try and do the right thing and really support that change. (Construction innovation expert 2, UK)

More broadly, Innovate UK aims to deliver value to the construction industry, through research, innovation and by removing extra costs to the builder:

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The way to do that was really to bring in a lot of the knowledge that we had from manufacturing... We'd had decades of reports saying we should be more like a process centre. We should do more with digital. Because Innovate UK works across these sectors, we could bring in the best of digital, the best of high value manufacturing. (Construction innovation expert 1, UK)

Collaboration is key to realising this ambition:

If you put everybody in a room that has part of the solution, between them, they can get there. How fast is how well they communicate and work together. The Construction Innovation Hub is a big part of that... This is a direct economic impact but building all that into the design thinking takes collaborations across disciplines and knowledge that we don't really have easily right now. (Construction innovation expert 1, UK)

Innovate UK also leveraged its own network of centres to bring together knowledge and facilities to support innovation within the building and construction industry. These centres are part of the Catapult Network and are funded by Innovate UK. For example, the Centre for Digital Built Britain was able to bring digital expertise to construction innovation programmes. Similarly, the Building Research Establishment was another government entity which focused on standards and accreditation around construction within the UK. Pooling resources and knowledge across these organisations turned out to 'bring in the right kind of expertise to think about these challenges differently':

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You're taking an idea that kind of works in a lab, usually, and moving it up to something where it's kind of a free prototype, which is quite hard to do in construction, but we're taking some of those ideas forward. (Construction innovation expert 1, UK)

Without a centralised entity such as the Construction Innovation Hub, there is a risk that further fragmentation occurs in the industry, with competing interests and systems being developed:

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every client, every part of industry will develop their own contradicting solution, and we'll move forward much more slowly and in a less joined-up way. The opportunity is to try and bring things together and make sure that government, clients, industry are working together to try and collaborate on the rules, compete on the game, and just push forward a coordinated range of approaches within the operating parameters that are set. (Construction innovation expert 2, UK)

More recently, Innovate UK has focused on three challenges: a healthy and stable society; digital technologies and sector growth and; a net-zero economy: 'to do that, a lot of it is changing the sectors that exist at the moment' (Construction innovation expert 1, UK):

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Genuinely, we believe the best thing to do is for the projects themselves to own the IP and exploit it. We do check... If you get support from us with public money and you don't exploit the IP, you're not going to get funding from us again. (Construction innovation expert 1, UK)

Innovate UK is also looking at how to make companies or projects more attractive to investors:

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There's very good data to show that companies that have been supported by Innovate UK are more likely to get investment, more likely to last longer and be successful and exit well... We have programmes where we will coinvest with investors to ease that mood. If you're prepared to invest, we'll stick a bit of money in, as well, which shares some of your risk. We've got some good programmes like that, as I said, and going into – moving all the way into loans, but equity would be the kind of next step. (Construction innovation expert 1, UK)

Reducing risk for government to invest in transformational change and standardisation is key:

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if we move down to manufacturing timber CLT [cross laminated timber] panelled schools, for example, government could invest, rather than in the school project, invest in a capability for mass timber production in Scotland that would make those sort of things. There's nothing in the rules that says they can't. The investment where the government has put it in has been in projects, not in products or in capabilities, the capacity to do that. That's potentially an opportunity that standardisation brings that bespoking won't. (Construction innovation expert 2, UK)

Implementing modern methods of construction (MMC)

Across jurisdictions, a transition to MMC was presented as offering significant benefits, from speed of construction, sustainability and reduced waste (see Part 3) to financial benefits from the reduced labour on site. Offsite construction refers to the process by which a building or an infrastructure is planned and designed in a modular format. Those modules are then fabricated offsite in a factory, transported to the site and installed together to assemble the structure:

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General contractors see that as a huge benefit, especially with interest rates and the cost of financing construction projects going up, and the cost of labour going up... it also helps them with their safety, insurance. (CLT manufacturer, Canada)

The argument was also advanced that 'proper' manufacturing and offsite construction processes support more sustainable approaches to construction (See Part 3), particularly in the context of the environmental disruptions caused by construction:

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the two largest things we transport to construction sites by volume is waste and air... for every house we build in England, we deliver five tonnes of waste to site, we move it around four times, then drive it to landfill. That doesn't strike me as sustainable or economic or efficient in any sort of way. If we start to think about the process... we should be transporting less waste, less air, and therefore we'll have less vehicles on the road and we'll have less emissions (Construction innovation expert 2, UK)

A holistic approach to design and construction was highlighted by many experts, one that encompasses every stage from design to post-occupancy evaluation in a 'process driven way' and that focuses on adding socio-economic and environmental value:

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We've got the technology to do a lot of this. We've got the experience to do it and supplying it. Again, removing those steps that add cost, don't add value. Delivering waste and moving it around is not adding value. (Construction innovation expert 1, UK) However, national/local jurisdictions are unevenly positioned towards MMC approaches and diverse barriers to its implementation are analysed below.

MMC in the UK

In the UK, MMC are developing faster than the regulatory framework is. Building residential buildings with cross laminated timber (CLT) was described as a 'learning curve' (Architect, UK). Overall, there is a need to understand what manufacturing is in construction; it does not mean simply 'offsite', whereby traditional construction may take place in factory, as a participant put emphatically 'so we have people arguing about how to do completely the wrong thing a bit better' (Construction innovation expert 2, UK). Instead, there was a huge emphasis by construction innovation experts and by off-site manufacturers that off-site construction is not a product but rather a process:

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We need to talk about how we get the advantages of proper manufacturing process. Manufacturing isn't about a standardised product. It's about a standardised process... so we haven't got traditional construction trades working in a shed. (Construction innovation expert 2, UK)

The benefits of moving to offsite manufacturing were emphasised in the UK from the strategic perspective of adaptability and flexibility in terms of geographical location. Upscaling offsite manufacturing would also enable employers to 'open up the labour pool':

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The UK just now has only 2.7 million construction workers. Now if you imagine 20 per cent of those workers are all of a sudden not going directly to their sites, but going to a factory, you know that's close to 600,000 people now... We could put that in the deprived communities. We can put that in the north of the country, the South of the country. We can put it where it's going to create the least amount of carbon for transportation. (Senior digital innovation expert, UK)

Once construction breaks its reliance on specific sites and becomes offsite, 'you can actually start to look at a completely different strategy for how you make buildings' (Senior digital innovation expert, UK). A Senior digital innovation expert responded to the argument that each building is a unique prototype and that off-site manufacturing leads to 'cookie-cutter architecture': "

the whole essence of construction is that you can move things millimetres every single time... there's a lot to be done to shift the culture that's geared to construction, to the culture that is moving towards manufacturing... you'll hear people say well why is the construction industry not more like the car industry.... design or off site for construction is very different. We use different materials... So I think there are lessons to be learned from other industries, but they're probably not the lessons that we think that we might learn, because of things like materials and size. I see a paradiam shift around the corner. (Senior digital innovation expert, UK)

An important dilemma in the UK for the growth of manufactured construction is its application to residential projects with differences between the apartment and detached housing industries. While certain contractual mechanisms offer a degree of choice in the design and manufacture of apartment buildings, a cut-off date is needed where the contractor will be able to use a default plan. For detached housing, giving customers the ability to choose MMC is key: 'we need to give clients things that they that they're not asked of course they're not asking for them implicitly, but they certainly want better outcomes' (Senior digital innovation expert, UK).

Too much choice does not necessarily lead to good outcomes, not only because volume builders already hold agreements for residential products (parts such as taps, doors, kitchens etc.) but mostly because it increases the work required to make parts come together. According to a participant, 'even in a simple interface between a sink and a tap there's about 30 different conditions that may or may not work depending on the tap and sink... That's one of the reasons why construction is so inefficient: so many things coming together that weren't meant to be.' (Senior digital innovation expert, UK).

EXAMPLE:

Planning is not necessarily a barrier to the delivery of modular residential buildings in dense inner-cities such as London:

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[Planners] are no barrier to MMC or modern methods of construction... we've just built one of our citizenM Hotel which spans opposite the Tower of London, so we're facing a World Heritage site with a Roman wall put in right beside it. Very, very sensitive site, 100 per cent modular. So, there's no barrier to townscape, quality and environment. We always argue that it opens and adds a bit of architectural richness, more interest, and with that, more beauty and responsiveness to the township. (Architect, UK)

However, an increases use of MMC requires improved training and adequate regulations:

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Knowledge of MMC in particular, is pretty lacking and how you how you certify that... We have the tallest modular residential tower in the city, in Croydon for a year, whilst we're trying to get all of our site fire certificates, empty. (Architect, UK)

CESSES AND METHODOLOGIES



Case-study 7:

Marmalade Lane's use of offsite manufactured components, Cambridge, UK

Marmalade Lane is a residential project in Cambridge designed and built by TOWN, a London based profit-forpurpose developer (see Part 4) that works in partnerships with landowners, funders, community groups and councils to deliver socially responsible and sustainable projects. The use of MMC in the project enabled TOWN to achieve a low-carbon 'fabricfirst' design, with high-level of air tightness and triple glazing throughout the residential precinct. It also included Mechanical Ventilation with Heat Recovery (MVHR) and air source heat pumps for space and water heating.

Marmalade Lane was built on a site initially to be developed privately, but then impacted by the 2008 GFC. After the original proposal and developer fell through, a local co-housing group approached the council and proposed a scheme using innovative construction, providing significantly less car parking spaces and improved sustainability outcomes. The site took a significant amount of time to go through the planning and construction process (12 years). The development used off-site manufacturing processes. During the process key stakeholders worked with future residents as well as suppliers:

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Inevitably in our work, we have to challenge what people think they want and what estate agents say that people want... We had two different systems of off-site manufacturer. One was a CLT panel-based system and the other one was the timber frame... By involving people right from the outset, it really gives ownership in the product but you also have a better product as a result of it. (Head planner, UK)

The project incorporated near Passivhaus standards through the choice of materials and carbon impact. There was no certification because the developers felt that the perceived benefits of Passivhaus would not exceed costs: 'there's a large risk premium at the moment... because we don't have that understanding at a design level, at a process level and a construction level' (Development manager, UK). This is partly because the culture of design and build contracts in the UK are seen as a barrier to contractors choosing to build at Passivhaus standards, because of the perceived added costs, challenges to deliver and lack of unified process across contractors.

The project used off-site manufactured closed timber panels and CLT timber through a partnership with a Swedish housing manufacturer. Five main difficulties were encountered. First, while good outcomes were realised through MMC, the project management team experienced challenges with upskilling the local workforce on doing things differently. Second, the subcontracted housing manufacturer 'under-estimated some of the challenges of the UK market and the complexities of our procurement construction processes' (Development manager, UK). Regarding installation of services for instance:

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There were some things that were very good about it but there was still some of those sticking points around clarity of responsibility. (Development manager, UK)

There were also difficulties coordinating the procurement and installation of the MVHR system, even though key players were involved early, 'it's a mindset thing there's no real excuse for that with enough of the key players around the table early on but it's a mindset thing. It's a procurement process thing' (Head planner, UK). There were also issues in the way the planning system is structured in the UK which added complexity to the project. A development manager gave a blunt analysis of the situation:

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We've got all the capacity to do it, to have complete digital twins... A lot of structural things in the UK prevent that, especially as we're a relatively small developer, we don't have huge swathes of capital. That trying to align your land supply, your pipeline... it's very difficult to neatly smoothly run a process that allows for these more sophisticated approaches, so we end up stuck with the lowest risk thing. (Development manager, UK) The estate was built according to 'good' design and environment considerations, which increased by an estimated 10 per cent the value of the development compared to surrounding residential areas:

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the common house has family rooms that members of the community can share. There's less that they don't need, that extra bedroom to use six times a year. So that saves on overall floor area, and it means it gives us more opportunity to do things with the internal layouts and with the common areas as well. All of it is a modular scheme. All of the internal layouts were custom built. (Head planner, UK) One of the outcomes of the design is the ability for residents to adapt and change the layout of their homes over time but in the end fewer households designed their homes:

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About 40 per cent of the residents actually designed their interior spaces in this way. We would have liked it to have been higher and/or hopefully it will be 100 per cent but... the way this worked was very traditional... the residents bought from [housing manufacturer] on a conventional mortgage basis. (Head planner, UK)



MMC in the US

In the current housing affordability crisis in the US, manufactured housing is seen by some as having the potential to deliver homes guickly and at a lower cost than traditionally constructed homes. Nevertheless, according to the Modular Building Institute (MBI)³⁵, projects using modular construction accounted for a modest 6 percent of the total square footage for new construction in 2022 in the US³⁶. The US offsite construction market is projected grow significantly by 2031. According to the US Census Bureau data and the National Association of House Builders, the share of non-site built single-family homes declined to 3 per cent of single-family completions in 2019. The apartment sector remained the largest market for the modular industry, accounting for about one-third of all factory output according to the BMI. There are currently two main barriers to the development of manufacturer housing communities: government regulations (zoning) and negative perceptions (stigma):

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If it's built in a factory then you can't afford a real house so to speak... Most of us don't agree with that. But that thinking still is entrenched... local zoning jurisdictions in the US tend to zone lower cost housing out. There may be some changes coming up with the current administration. (Housing market expert, US)

Such perceptions are evolving, from 'cheap, shoddy, wobbly boxes' to a process with 'a higher degree of quality control' that is 'starting to catch up with end users' (Modular construction expert, US). Modular construction still requires education and outreach, but according to experts its use is currently increasing in the US through demonstration projects led by large residential or shortstay accommodation developers. For hotel chains, offsite can improve their speed of occupancy and increase their revenue considerably by shortening the construction project schedule 'by six to eight months', which represents significant cashflow and revenue:

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they're seeing that the safety and some of the other benefits are nice, but the time is money is what drives it a lot of the times. (Modular construction expert, US)

Location matters in the regulation of off-site manufactured housing. Manufacturers of relocatable homes are regulated differently than traditional builders working on-site, with application of different local regulations across the US through the Department of Housing and Urban Development (HUD) code Manufactured Home Construction and Safety Standards ³⁷. This means that manufacturer require a certified inspection of their factories to ensure their quality in accordance with the HUD code. In the US, New York and California have their own building codes, and other States tend to either apply the national Building Code locally or a variant thereof. However, this gives rise to interpretations at the local county or municipality level across the country. For a housing market expert, 'one of the biggest hindrances to innovation is that the building code doesn't create a level playing field. It's very irregular' (Housing market expert, US). These different regulations across States are also creating barriers to the uptake of modular construction, which the Modular Building Institute is striving to reduce.

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We are in 50 different states, and that means there are 50 different ways to review and approve a building. We are trying to standardise that process, so [the ICC] can know that it's reviewed and approved for quality control the same way in Florida, as it is in Texas or California. (Modular construction expert, US)

Off-site construction requires specific regulatory arrangements. Usually, manufactured housing in the US consists of 'one or two boxes, or two units built separately in the factory and then bolted together at the job site' (Housing market expert, US). Panelisation methods involve building panels such as walls in a factory before they are transported and lifted by crane and set on-site, where traditional 'site-built' methods are used. Panelisation is growing in the US but concrete slabs remain dominant in some regions because of climate conditions (e.g. hurricanes in Florida).

'Turnkey framing' (defined by having a single framing/carpentry contractor who supplies both materials and labour) was described by a Housing market expert in the US as a 'preliminary to off-site construction'. This is because turnkey framers often recognise the benefits of incorporating a shop or factory in their production, whereas builders who purchase material and hire contractors may not benefit from the systemisation of housebuilding.

³⁵ MBI is a membership-based and international trade association serving the construction industry. Founded in 1983, MBI advocates for modular construction in North America, promoting the advantages of volumetric offsite construction. Members are manufacturers, contractors, and dealers in two distinct segments of the industry: permanent modular construction and relocatable buildings. Associate members are companies supplying building components, services, and financing. Source: <u>https://www.modular.org/history-mission/</u> 36 <u>https://www.modular.org/industry-analysis/</u>

³⁷ Manufactured homes (formerly known as a mobile homes) are built in the controlled environment of a manufacturing plant and are transported in one or more sections. The HUD Code, unlike conventional building codes, requires manufactured homes to be constructed on a permanent chassis. Modular homes are constructed to the same state, local or regional building codes a site-built homes. Other types of systems-built homes include panelized wall systems, log homes, structural insulated panels, and insulating concrete forms'. Source: https://www.hud.gov/program_offices/housing/mra/mhs/faqs

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[Turnkey framing] is kind of a precursor... an intermediate step between full modular to completely site built...it's even surpassed panelisation and prefabricated floor structures, or basically floor panels that are built off-site. (Housing market expert, US)

For the CEO of a successful offsite company in the US, a crucial part of off-site manufacture is to assume that architectural drawings are incorrect, to allow for any potential mistakes to be dealt with before the parts arrive on site. To do so, the automatic method of Computer Numerical Control (CNC) is used to precisely cut holes in wall/floors:

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All the hardware that we can actually fit in the factory will be fitted into the walls. The walls are fully sheathed³⁸ on the outside... so that will be nailed in accordance with the seismic conditions that that building's being built in. (CEO of offsite company, US)

The creation of a comprehensive 3D building model at the very start of a project allows for off-site manufacturers to control and review drawings before the delivery:

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Effectively we have what's called a digital twin, before it ever hits the job site, so we have it built twice, the first time on the computer and the second time it gets built on the job site (CEO of offsite company, US)

These control mechanisms also drive better quality and accuracy on-site. The change is driven as part of quality assurance, especially for concreters that prepare the site by pouring a slab:

"

If the concreters put the slab in wrong and we've scanned it, we go back to them and say, you put it right... Very quickly after it arrives on site, the whole attitude changes. (CEO of offsite company, US)

Enhanced regulations about off-site manufacturing would lead to better quality control by regulating the manufacturer through factory inspections, which are more effective than on-site ones 'when you're using advanced automation, you can tell exactly what has been done at what time of the day' (CEO of offsite company, US): ³⁸ Regulations in California, US, prevent to clad buildings in the factory. "

We have a project underway where AI is being developed, so that it actually can compare the image from the 4K camera against the CNC file. (CEO of offsite company, US)

This confirms Cao et al.³⁹ observation that 'for CNC machining, the improvement on intelligence by Digital Twin is to monitor the real machining process in the virtual environment'.

Offsite construction faces regulation challenges with the major constraint being regulations defined at a State level. Traditionally, building officials conduct periodical inspections on site-built construction (reviewing floorplans, quality control etc.), which means that for off-site construction, construction standards and State codes need to be considered for both construction and assembly site:

"

our whole goal is that we want to make sure that that factory can build those units and they can be conforming to the code without us watching them put every part and piece together... Some of the states in the United States allow us to reduce that inspection down to one unit... California is a state where we have to look at every unit, in every phase of production even after we've completed the certification. (Building product safety expert, US)

These geographical variations require local building officials to travel to perform factory inspections, which creates additional costs on top of the state officials still performing built quality review.

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that's why most states use a third-party inspection agency to do their plant review, and do their inspections, make sure everything is in compliance, and then once we do find that those units are in compliance, we will put a label on those units... that helps bring in revenue for the state so that they can pay for the programme. (Building product safety expert, US)

This issue of regulating offsite is shared across jurisdictions, as, 'modular issues tend to be similar... the code officials generally don't understand it at first, the local contractors like building the way they've built for 100 years' (Modular construction expert, US). With these barriers to growth, modular construction in the US is being driven mostly by labour shortages, material availability, and significant demand for housing.

02

³⁹ Cao, Zhao, and Xiao, "Digital Twin–Oriented Real–Time Cutting Simulation for Intelligent Computer Numerical Control Machining," 6.

The building and construction sector thus appears resistant to change but in fact faces messy and variable regulatory barriers, despite which, a fledgling industry has developed rapidly in recent years:

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We're taking baby steps along there to say we were only 2.5 per cent of the market five years ago, so we've doubled our market share, but it's still relatively small here. Much more widely accepted in the UK, and Japan, and Switzerland and some other parts of the world. (Modular construction expert, US)

Another issue in the US is the question of risk and responsibility regarding defective works in offsite construction. The modular manufacturer acts as a subcontractor in the US and has liability for the quality and construction that they build and deliver to the site. However, the on-site manufacturer also carries responsibility for the project, giving rise to various questions:

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What happens when that box leaves the factory? Who is liable for it? What's my role once it shows up on my site? Are you going to install it, or am I going to install it? Whose insurance does it fall under? We have standard contract templates for those relationships... these projects require a lot of upfront communication. (Modular construction expert, US)

According to a building product safety expert in the US, 90 per cent of legal issues emerge from on-site installation issues. More education is required to ensure that building officials have a robust understanding of the modular process and what should happen on site, to avoid technical issues down the line.



Building capacity towards MMC

Skills and training

Advanced manufacturing in construction has implications for skills, training and labour distribution (see Section 2), as it requires less workers with a different blend of skills onsite. For a construction innovation expert, this means that 'we'll probably see fewer wet trades, less bricklayers, less plasterers, because a lot of this stuff is going to come fitted or finished...The sort of roles we'll need on site will be different' (Construction innovation expert 2, UK).

At a higher level, a transition from traditional methods of construction onsite to factory or assembly work environment means that there is no longer a need for a mobile and itinerant labour workforce in dense urban centres. However, this 'flip in the workforce' will require changes in the way training is delivered and a transition period where traditional and MMCs will co-exist before advanced manufacturing will become the dominant model (Construction innovation expert 2, UK). This change requires collaboration and support to businesses from industry associations and professional institutions.

An emerging landscape of labour and job opportunities is likely to emerge from the growth of advanced manufacture:

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There will be new entries in the market. They will be coming from different sectors. We have got certain regions in the UK which have traditional heavy industry that have declined over the years, but they have the workforce there. (Construction innovation expert 2, UK)

The transformation of labour structures and well-established economic systems in cities and regions in the UK necessitates the involvement of government to support a just transition. Several initiatives have been set up to achieve this goal: manufacturing hubs; micro-factories; government-backed demonstration projects and; support mechanisms.

 Manufacturing hubs or manufacturing centres were described as a key strategic instrument to develop in regions where there is both workforce available (through long-term unemployment) and infrastructure. This requires crosssectoral approval, where workers from sectors outside of the construction industry might be brought to it:

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As people retire, we'll probably end up increasingly having less traditional site roles and more cross-sector or offsite roles, and we have to work in a portfolio to try and do that.... (Construction innovation expert 2, UK) According to experts, such hubs could in effect support economic growth and social inclusion. This will assist in addressing the productivity gap:

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You're moving a lot of the jobs into what you might call sustainable industrial manufacturing centres in industrial regions... So, we can deliver schools and hospitals that are going to be here in London, you know, from factories in the northeast or the northwest of England. (Construction innovation expert 2, UK)

 Micro-factories⁴⁰ are explored for their potential social value (creating jobs in disadvantaged communities) as well as their contribution to a wider national network (Senior digital innovation expert, UK):

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if you can create sustainable manufacturing and assembly of technical jobs in an area, then you are not relying on people having to work so much out onsite in perhaps more challenging working conditions. (Construction innovation expert 2, UK)

- Exemplars are useful to show the way towards labour organisation and good building outcomes: for instance, Innovate UK supported The Forge⁴¹, a net-zero office building built with kit-of-parts.
- 4. Support mechanisms are crucial to assist a transition towards MMC. Government has a role to play to ensure that through the transformation of the building and construction industry some businesses are not left behind:

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a lot of businesses and sectors in the UK are going to be completely irrelevant in five or ten years' time and they have to change the way they work. We're helping them do that quicker, and that can only happen from bringing in innovation (Construction innovation expert 1, UK)

⁴⁰ Such as the AMRC Factory 2050, 'UK's first state of the art factory, entirely dedicated to conducting collaborative research into reconfigurable digitally assisted assembly, component manufacturing and machining technologies and is capable of rapidly switching production between different high-value components and one-off parts', and located on the University of Sheffield's new Advanced Manufacturing Campus. Source: https://www.amrc.co.uk/facilities/factory-2050

⁴¹ See https://www.brydenwood.com/projects/the-forge/s93059/



Opting to build through MMC is also driven by the availability of skilled workers in the UK, particularly in the housebuilding sector (for both private and social housing) which is impacted by an ageing workforce and the effects of Brexit on work-related migration (see 1.1). MMC makes 'better use of the skilled workforce' (Construction innovation expert 1, UK):

"

the very simple thing is build the roof on the floor, then lift it into place... so that gets that out of the way so the bricklayers don't have scaffolding in their way with a roofer climbing up and down it, so they spend more time doing what their skilled role is. (Construction innovation expert 1, UK) With this improvement in scheduling, experts estimate that 40 per cent more homes can be built with the same workforce:

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We've got some really powerful examples of where some of the companies have done that and... thinking about the value end, getting them to meet the end customers and be invested in delivering something for those users. (Construction innovation expert 1, UK)



EXAMPLE:

Πa

An emerging methodology and subset of MMC is the kit-ofparts approach, which enables not only flexibly and efficiency in manufacture but also demountability, disassembly, and reuse. Such an approach has the potential to extend a building's life and reduce environmental impact. As Brütting et al. suggest, 'one strategy to reuse structural components is to design structures that can be assembled, taken apart, and reassembled in new configurations^{1/42}. A UK-based engineering professional services consulting firm is now making the transition 'from proof of concept to real projects around kit of parts and catalogues' (Senior digital innovation expert, UK).

Specific approaches emphasise 'prescriptive forms of design', ultimately 'designing buildings like a Swiss watchmaker' (Senior digital innovation expert, UK):

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Geometrically, it's not now just about doing what we used to do... we're putting in much more detail... so we set the catalogue and then we use the catalogue on the project, which means that the design process is super-fast. (Senior digital innovation expert, UK) The reuse of the kit-of-parts design in a multitude of projects (as opposed to a single project) is key to its success and efficiency.

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All of those machines we've invested in, have we got to the point where we're fully automated going from one to the other? We need to find clients that want to build things exactly the same going through to be able to achieve that, so we're not quite there yet, but we are getting more and more automated every day (Operations Director, UK)

There is a fine line to balance in the design process between clients commissioning projects, architects and development team engaging with the catalogue and enabling a certain degree of 'customer configuration':

> we're seeing that trend now that we're helping to figure out, how can the contractor build things when we're trying to hold things back for the customer to configure eventually (Senior digital innovation expert, UK)

Leadership and culture change towards MMC

One important challenge to lead the construction and building towards MMC is the disconnect that exist between the manufacturing industry on one hand, and the construction industries on the other hand, when brought to work together:

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It is hard because you do have - the manufacturing guys have a very clear idea of what they think the solution is. The construction guys have an idea. It's probably somewhere in the middle. Over time, you're trying to get them to work more closely together. (Construction innovation expert 1, UK)

Innovate UK is working to remove cultural barriers within the construction industry to 'blow myths away' and change perceptions about manufacturing, using government platforms to share stories and successful case-studies, and drive collaboration:

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You don't beat them with facts. You beat them with a better story, and we looked at that narrative and every story we collected from projects fed into that bigger story. As we repeat the examples, it starts to switch people's minds about what's possible. So that was how we tried to have an impact beyond the funded projects that we had. (Construction innovation expert 1, UK)

One of the strategies employed is to shift conversations and narratives within the building and construction industry from processes to delivering 'value' to society:

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You spend so much time worrying about the process, not talking enough about the benefits you deliver to society.... When you start to think about delivering value, outcomes for the people... that's a cultural shift to say you're delivering benefits. (Construction innovation expert 1, UK)

Another strategy to drive cultural change and support industry transformation is deployed by the Construction Innovation Hub through a three-part system approach:

- Assist the development of innovative products and solutions (e.g. in the fields of manufacturing, digitalisation);
- 2. Work with government, policymakers and regulators to create a supportive, enabling environment to allow these

innovations to thrive, 'create appetite on the demand side... to see the benefit from a manufacturing solution, for example' (Construction innovation expert 2, UK) and;

3. Build capability and capacity with industry to deliver these solutions.

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Getting those three things working in harmony – and again, thinking about it from a UK perspective, we're quite keen to build industrial, productive capability and capacity in UK businesses to service the market. (Construction innovation expert 2, UK)

Collaboration between research, government and industry has been a key way forward:

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we forged quite a lot of strong relationships with industry associations and industry players, and with government and with policymakers, to make sure that what we were producing was something that people genuinely believed would support that transformation, that would really be something that would help deliver those outcomes around productive growth, around a faster path to net zero, greater social impact, all of those good things we want to achieve, and get industry behind it... We are a market enabler to try and support the transformation to deliver those outcomes. (Construction innovation expert 2, UK)

The kit-of-parts approach is held back by a lack of acceptance associated with it being irregular and therefore problematic:

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the hardest thing for me is... getting people to understand [new ways of doing things, i.e. kit-of -parts] and then use them. They say ' it's not applicable to me', which is which is just a lot of nonsense most of the time it's just resistance to change. (Senior digital innovation expert, UK)

Perceptions of the benefits of using off-site construction methods can evolve quickly ('as soon as clients get it, they will not go back', Senior digital innovation expert, UK), however a key barrier remains how to incorporate investment confidence into the development of off-site factories. "

that whole capitalisation that is the challenge... we're not going to get all of [the construction activity] into the factory overnight. (Senior digital innovation expert, UK)

This dilemma was presented as a 'chicken and egg' problem:

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the reason offsite doesn't work just now is that there's just not enough reputation... So how do you do something different unless you've done it before... that's the role of the government to try and get the roadmap to the case studies... otherwise you just end up in limbo because no one wants to move until and people say that all the time they go... (Senior digital innovation expert, UK)



Case-study 8:

Irish early development of manufactured housing

Offsite manufacturing may be set to play a significant role in the future transformation of Ireland's construction industry. Published in December 2021, the report 'Modern Methods of Construction' produced by the Construction Industry Federation⁴³ labels MMC as 'a modern industry response to future policy and societal needs'. The report notes that timber frames currently make up approximately 25 per cent of the Irish market, with offsite manufacturing facilities generally located close to large cities such as Dublin or Cork. Providing housing and sustainable urban development is a key priority of the national planning framework, Project Ireland 2040, and of Ireland's national 'Housing for All' strategy. The promotion, development and support for innovation and MMC using digital and manufacturing technology is central to achieving these objectives.

Early offsite producers in Ireland have sought to demonstrate the benefits of the manufacturing sector for residential construction. This was in the context where Ireland was growing rapidly and needed additional labour to deliver housing while increasing the energy efficiency of the housing stock. As a result of a significant growth in housebuilding activity, new techniques were adopted to meet energy standards, maximise productivity and build housing efficiently:

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Hence we came along and set up this offsite company right at the beginning of this... (CEO of offsite company, US)

Working to Irish codes and regulations which were very pro-concrete at the time was a significant challenge.

However, the industrial context in Ireland was geared towards off-site manufacturing:

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our regulations were basically formed after World War II, on the basis of everybody thinking about factory construction, as opposed to people thinking about stick framing... and obviously it makes so much more sense and it's much easier to go and inspect a factory building 3000 houses a year than it is to go to 3000 individual job sites. (CEO of offsite company, US)

At the time offsite companies in Ireland received the support of British Standards Institution standards, because 'the British were further ahead than the Irish... At that point in time, British Standards were applicable in Ireland' (CEO of offsite company, US). A drastic change in behaviour followed with the adoption of wood framed homes. In the 1990s less than 2 per cent of housing in Ireland was built off site:

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By 2015...it had gone from two per cent to 30 per cent, which is a ferocious change in behaviour. (CEO of offsite company, US)

Today, Ireland' Built to Innovate programme (funded by Enterprise Ireland) shows how the Irish government support is instrumental to help de-risk innovation, encourage training and better building outcomes using modern methods of construction. In 2023 offsite manufacture represents 48 per cent⁴⁴ of all low-rise houses in Ireland⁴⁵.

⁴³ The report was produced by the Construction Industry Federation in support of Project Ireland 2040 and the work of the CSG Innovation and Digital Adoption Sub Group. Source: https://cifie/wp-content/ uploads/2022/01/1271-CIF-Modern-Methods-of-Construction-Report-v4.pdf

⁴⁴ Source: https://www.businesspost.ie/politics/construction-firms-must-use-off-site-modular-building-me-

⁴⁵ Scotland leads the way with British offsite construction, with 92% of Scottish housing production timber frame and 84% offsite in 2020, compared to only 10–15% in England. Source: <u>https://www.nweurope.eu/media/10913/</u> tg_construction_oxford_meeting_brochure.pdf

2.2 Supply chains and materials

Global supply chains challenges

The construction industry is currently experiencing major issues with supply chains and materials globally. In Europe, Covid-19 created a uniquely complex situation where, for instance, factories were closed and price increases spiked (Construction products lobbyist, Belgium). The energy crisis added more pressure while demand continued to increase (Construction products lobbyist, Belgium). In the UK, the impact of Brexit on supply chains has created major uncertainties in the industry ('no one could really tell what that impact was going to be on the supply chain... we were trying to figure out our reliance on the European market place for supply', Project director and senior executive, UK). North America is still experiencing material shortages and Australia has experienced mismatches between supply and demand, particularly for largelyimported products such as mass timber.





EXAMPLE:

In the US, there is a concern that impacts on the supply chain are already resulting in poor sustainability substitutions which will impact on building performance. For instance, a senior energy policymaker explained how substituting radiant barrier for insulation by less performant materials would cause an increase in energy consumption:

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That's a supply chain choice that was an expediency but you're not doing equivalent product...helping with making those choices given the supply chain substitution issues that you're probably having, at least trying to get an equivalent output. (Senior energy policymaker, US)

Material shortages have had further repercussions in the construction market:

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Both labour and materials availability issues pushed prices up and pushed affordability down. Builders at this point can't break even if they're building starter homes... of course we have options for that, one of them being manufactured housing. (Housing market expert, US)

Substantial supply chain issues (including months long delay periods between orders and delivery) led panelisation businesses to 'revert' back to on-site assembly in 2020: 'builders *en masse* reverted back to what they knew...basically built the parts in pieces and had them assembled at the job site' (Housing market expert, US). A similar phenomenen was observed with roof trusses, because of the lack of timely overseas steel imports:

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Roof truss manufacturers were delivering six months or more after their orders. So we saw the industry revert away from a factory built roof back to a site built roof, just because the industry couldn't handle the capacity. (Housing market expert, US)

Supply chain issues during the pandemic also affected the modular home industry as it faced a surge in housing demand:

With fixed production and a 30 per cent boost in demand, who is going to supply that capacity? Modular producers weren't really outfitted... and they just didn't have the capacity to grow with the market. (Housing market expert, US)

While moving to off-site construction is an aspiration among builders in the US, a market research division show that supply chains challenges and capacity in off-site housing does not currently match the rate of demand:

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A big problem with that is most off-site producers are small mom and pop shops...It's going to require a lot more capital before the housing industry adopts more off-site methods. (Housing market expert, US)

Better communication is required across the value chain

Poor communication across value chains is a commonly reported issue. In the US, for example, there are typically five to six steps between building materials manufacturers and end-users:

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they have a difficult time communicating benefits and technologies down the chain. The feedback coming from the market and from the users is slow and sometimes nonexistent... which inhibits innovation. (Housing market expert, US)

The Construction Innovation Hub in the UK is working at all levels of the supply chain (material providers, manufacturers, contractors etc.) in order to try to break some of the incumbent blockages in information flows across the industry:

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there is a reluctance to change at an appropriate pace, and there is a hierarchy that many people want to maintain. (Construction innovation expert 2, UK)

Tier 1 organisations are in favour of such changes to support growth in their supply chains, while smaller businesses show more reluctance to change the existing hierarchy. As explored in Section 1.1, the projected increase of the role played by manufacturing and manufactured product in the construction industry will reshape the structure of supply chains as 'it isn't just the traditional construction supply chain that we'll be delivering the built environment in in the future' (Construction innovation expert 2, UK). Additionally, manufacturers are developing their own approaches and systems (e.g., kits-of-parts, data and technology solutions) which indicates a shift towards 'thinking about wholelife performance of the asset rather than just that narrow, capital phase of the project' (Construction innovation expert 2, UK).

However, this vision of the industry should not be limited to Tier 1 organisations:

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we expect to see technology data companies and manufacturing companies bringing a bit of fresh air to the traditional construction supply chain as we move forward, but if we try and do it just by talking to big contractors, we'll get the big contractors' perspective, which isn't always 100 per cent correct. (Construction innovation expert 2, UK)

Another benefit of realising better collaboration across the supply or value chain is the achievement of net-zero goals, for which contractors must engage supply chains early in the development phase of a project alongside the client.

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high performing contracts have set up a physical or nonphysical co-located collaborative environment where everyone from client, designer, us as main contractors, architects etc. are all in that same discussion so it's much easier to make decisions to identify value and bring it in as early as possible (Senior project manager 1, UK)

Procurement and supply chains management

Good practice and innovation in the realm of procurement and supply chains management can help address these shared challenges. For instance, making construction processes more efficient requires decisions to be brought forward before the procurement or planning phase even start:

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the acceleration of decision making, early procurement or engagement is a key shift that the market needs to have. But the transactional facilities approach to construction has evolved over time for a very good reason, which is, it minimises the risk to the client. That's great because the client's exposure on the project is reduced over time in that early phase. But then it stores up problems down the line once they've got that commitment. Switching it around and having that contract involvement would reduce the longterm risk, but actually it increases the short-term cost. So, it requires a shift in how buildings are built. (Academic 1, UK)

Two examples are developed in what follows: UK's Platform Rulebook and Value Toolkit and Procurement systems in Glasgow 2014 and Birmingham 2022.

Case-study 9:

UK's Product Platform Rulebook (PPR), Construction Innovation Hub

The Product Platform Rulebook⁴⁶ was developed by the Construction Hub alongside industry partners to address the UK's Government's ambitions outlined in the *Construction Playbook and the Transforming Infrastructure Performance: Roadmap to 2030* towards solutions that will assist the delivery of housing and infrastructure. The Product Platform Rulebook consists of 'an open-access guide to support industry – clients, consultants, contractors, manufacturers and product suppliers – in building capability and capacity to develop and deploy product platforms to meet demand⁴⁷. It is intended as a tool which will cater to both demand and supply side of the market to support projects and programmes, help understand and follow requirements, and guide clients towards 'safety, performance and quality⁴⁸.

The Platform Rulebook was thought of as a part of how UK's government procure construction:

47 Source: https://constructioninnovationhub.org.uk/our-projects-and-impact/platform-programme/rulebook/ 48 idem

"

Any asset whatsoever that's built by government has to conform to the kind of rules that we shaped with them in this programme... There's that collaboration to say, why are we doing stuff that adds costs to us both, but doesn't add value to anyone downstream? (Construction innovation expert 1, UK)

This was based on the view that collaboration drives better building outcomes:

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A big theme within a lot of this is government saying, we recognise the value in starting to standardise some of the designs for our buildings... You gain all those efficiencies of working with our supply chain better because that's what will drive the schools programme in the UK to standardise. (Construction innovation expert 2, UK)



⁴⁶ https://construction-innovation-hub.euwest01.umbraco.io/media/nfdfyhoj/cih-product-platform-rulebook-edition-12.pdf



The approach developed by the Construction Innovation Hub was to 'collaborate on the rules and compete on the game':

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Collaborating on the rules is the right thing because that allows you to start thinking about if you've got standard approaches, standard interfaces, standard whatever.... Collaborate on the rules, compete on the product. (Construction innovation expert 2, UK)

The Construction Innovation Hub had a remit to look at developing an open-source platform that the construction sector could work together to use, and they've developed a platform rule book out of that, which is sort of saying how you develop the platform. They've developed a framework for procuring buildings called the value framework, so it encourages developers and builders to explore more than time and cost, basically, of the building and then describes how to get into that process. (Senior academic 1, UK)

Consideration was given to the effects of this collaborative approach to designing the rules on the supply chains, and on the overall cultural shift it will unfold:

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We have over 300 organisations working with us to develop [the Value Toolkit⁴⁹], giving their time and supporting it.

The idea about doing that is we probably get a more rounded product that's more acceptable, and people see the benefit of it. (Construction innovation expert 2, UK)

Aligning on overarching procurement rules and tools is intended to create a more consistent policy environment:

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when you look at it in public procurement historically... [every government department] all interpret it slightly differently... some of that purity gets lost and every single responsible office and every single procurement official just goes back to what they've done in the past. (Construction innovation expert 2, UK)

The success of this approach was demonstrated through growing adherence of contractors to the Platform Rulebook:

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We have found there's three or four very large contractors here in the UK, and at the start of the project, only one of them was actively engaging with our project because the others felt they could do it by themselves. We've now got all three of them working quite closely. They've seen the benefit of collaborating on the rules because the game is going to be different. If they haven't got the right rules, they're not playing in the game. (Construction innovation expert 2, UK) E

Case-study 10:

Glasgow 2014 and Birmingham 2022's procurement models, UK

The Glasgow Commonwealth Games offer an illustration of how to meet 'very challenging targets' for construction delivery (Government official 1, UK) in a timely way: 'every single venue was available one calendar year before we actually needed it to be' (idem):

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Our project was up seven years in advance. Not the full team obviously but the proper planning started... We delivered every single permanent venue – every permanent venue – in 2013 before 2014. (Government official 1, UK)

For the Birmingham 2022 Commonwealth Games, the delivery model was structured around 'scope books' which included all projects associated with the games, as well as scope, costs and risks. Good practice governance was emphasised:

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Get the governance in place, get the organisation in place, get change control in place, get reporting, get monitoring, get everything in place. If you don't know where you've started, you've got no idea where you're going to finish. (Project director and senior executive, UK)

A specific supply chains organisation was put in place ahead of the Birmingham Commonwealth Games to 'get the city ready':

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The supply chain, contractor supply chain, is so important... your contractor and your consultant of first and last resort... All of those supply chains go through their own different issues, and it's who has the most resilience... (Project director and senior executive, UK)

For the Glasgow Games in 2014, the delivery model was through a construction division company (City Building) owned by the municipal council which meant that all the contractors had previous experience working for the council, while allowing the division to 'serve as an arms-length external organisation to enable it to engage in construction activity in other areas of Scotland and other sectors of the construction industry to build houses for local housing associations. If they were part of Glasgow City Council, they couldn't do that' (Government official 1, UK). In this context, the procurement system established in Glasgow was a bespoke portal set up rather than existing frameworks, to fit the specific needs and requirements of the Games and offer contractors a 'fresh opportunity' to access the portal purely for the Games:

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it was a really fair and ethical thing to do, but it also drove best value in the process because it was still very competitive, and you got the value for money for that. (Government official 1, UK)

For the Birmingham Commonwealth Games preparation during Covid-19 and Brexit, the model for Lendlease to get sub-contractors was a 'deal or no deal', because of the uncertainty of the socio-economic situation at the time:

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we ended up running two horses, we ran a Brexit price and a sort of deal and no deal... The difference was quite stark... worst case forecasts were based on no deal, that's how we built our budgets, based on no deal. Then when we went into contract and we've started to get into contract, we just had to bite the bullet with some of the contractors because we didn't have time and just say right, price that in. You take the risk. (Project director and senior executive, UK)

Supply chain related issues and changes in trade agreements with China meant that material and products (including lighting columns) were stuck internationally and added pressure on the project:

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we were literally tracking on an hour by hour basis where our lighting columns were. In the China Sea, the Indian Sea, going through the Suez, coming through into the Med, lost in France... We could have had them procured and made in Sheffield, a hundred miles up the road. We thought we were going for the best in the marketplace, but that then had other problems. (Project director and senior executive, UK)
New Engineering Contracts (NEC)⁵⁰ were used by Lendlease in the Perry Barr Residential Scheme to help 'drive the right behavior' and 'bring the collaborative ethos to the fore' (Project director and senior executive, UK) so that potential risks are communicated and mitigated early. In this process, a cooperative leadership model through steering group meetings was key to 'always bringing forward key risks and issues across the programme' (Senior commercial manager, UK).

The management contractor of the Perry Barr Residential Scheme procured a number of Tier 1 contractors via NEC to deliver the plot through a lump sum design & build (D&B) contract:

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effectively, those tier ones were taking the bulk of the risk in terms of delivery. We've been principal contractor for the site and each plot, those tier one contractors were principal contractor in their own right. (Senior commercial manager, UK)

However due to Covid, the scope of the project changed radically after it started, from 11 plots to be delivered to four, with strict security protocols about materials and workers coming on site:

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we were concerned about how we could get resources here, what the build methodologies would be, how we could look to diversify the supply chain, make sure we had different pools of resources, make sure we didn't have an over reliance on traditional brickwork, that we perhaps had different alternatives... there was a lot of work done around strategy and procurement, and logistics. (Senior project manager 2, UK)

For the Perry Bar Residential Scheme, off-site was used by one sub-contractor and that had benefits: 'Willmott Dixon used the opportunity of off-site manufacture more than the other tier ones, and that paid dividends' (Senior project manager 2, UK). Two plots were awarded to Willmott Dixon, who throughout the whole Covid-19 pandemic were 'very forward-thinking in their approach' (Senior commercial manager, UK), finishing ahead of contract (their contract end-date was extended by virtue of Covid-19, but they still managed to beat that extended date). Willmott Dixon used MMC (modular pod bathrooms) and innovative materials (light-gauge steel, a composite concrete floor), facilitated by their experience and an 'up-and-ready supply chain' which meant that they could 'hit the button on, get it to contract stage, with the certainty of starting off-site' (Senior commercial manager, UK). This experience of offsite manufacture by Willmot-Dixon was a rewarding one:

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[The bathroom pods] have been snagged in the factory under factory conditions. They've come to site in an impeccable standard, really, and apart from a couple of on-site adjustments and they look really good. (Senior commercial manager, UK)

Willmott-Dixon also used Corium brick cladding⁵¹ (a system of mechanically fixed clickable bricks) as another form of innovation on the site of Perry Barr, which involve less manpower, no scaffold and are more sustainable.

Harsh winter weather conditions made the delivery of pods difficult and slow but once it was locked in, it was much faster than traditional methods of construction which was subject to traditional bricklaying. *Supply chains from Willmott Dixon were within the UK and local workforce was employed to support the installation:*

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whilst the pod manufacturer was outside of the SME KPI radius, what they were able to do is utilise the certainty of their supply chain in the manufacture and delivery, and then combine the local labour requirements, the opportunities of the social value KPIs to get the local labour in to support the install. (Senior commercial manager, UK)

The use of offsite processes was beneficial with regards to Covid safety requirements (see 1.3), with social distancing made easier by a smaller number of operatives on site (85 vs 350 on the traditional construction plots). However, the benefits of off-site construction were somehow counterbalanced by the local spend requirements. One of the project managers observed that traditional delivery (concrete frames, brickworks etc.) made it easier to obtain local spend and resources, while 'the more specialist or off-site processes, we've had to go further and wider to achieve that' (Senior project manager 2, UK).

^{50 &#}x27;The New Engineering Contract (NEC) is a series of contracts designed to manage any project from start to finish. The contracts are written in plain English with a straightforward structure and are designed to be easily understood. NEC contracts aim to prevent costly disputes. First developed in 1993, they were designed to replace typical construction contracts which until then had been largely 'adversarial' in approach. An adversarial contract is one where people who've signed up to it are likely to act in their own interests if something goes wrong. Adversarial contracts can mean companies going out of business when they're hit with severe contract penalties – for example when a project falls behind schedule. NEC contracts are endorsed by both governments and industry bodies. They have a strong track-record for helping to deliver large-scale projects successfully.' Source: "Design and Fabrication of a Reusable Kit of Parts for Diverse Structures."

Supply chains and MMC

Poor supply chain integration and resilience is one of the key barriers to the adoption of MMC. As MMC manufacturing products become more specialised and sophisticated, the challenge will be to ensure that operators' interests align and risk is minimised, especially in the context of SMEs, which characterise the housing industry in countries like Australia and the UK⁵². Two perceived risks were highlighted with MMC in terms of supply chain management:

 Overreliance on a unique supplier, which was advanced as one of the reasons that housebuilders are not making the transition to offsite in the US:

52 Dowsett et al., "Projecting at the Project Level."

when you go off-site you have to build your operations around the supplier of your structural components, so there's just a desire to remain flexible and nimble, and not to tie into a single supplier. (Housing market expert, US)

2. Logistical challenges associated with on-site assembly, including the craning and storage of pre-built modules and other components.

Solving these issues and generalising offsite will require transformation of the industry. The following two case-studies highlight supply chain management; Ontario's emerging local mass timber manufacturer, and a Laing' O'Rourke mixed-use development project in London, UK, The Whiteley.



Case-study 11:

Ontario's emerging local mass timber manufacture industry, Canada

Element 5 is the first mass timber manufacturer to be based in Ontario, Canada. Element5 started out as a small facility in Quebec, in 2015, with financial support from the federal and provincial government. It opened its 13,000 square metre factory St Thomas, Ontario in 2019 and was pressing its first panels in 2020. Local officials and governments have been very supportive of Element 5 as only local mass timber manufacturer in the province. It is ideally located two hours outside of Toronto and sell situated towards the US market too, through Detroit and Buffalo. They have two-fully automated production line, one for CLT and one for glulam. All their equipment comes from Slovenia, who produces turnkey automated lines to ship worldwide. Element 5 is able produce about 50,000 cubic metres of CLT per year and about 5000 cubic metres of glulam. Because of owning one of the widest presses in North America, the manufacturer is able to produce a range of sizes for its CLT products, up until 16 meters long.

They also produce added value products, one of them being an exterior wall envelope system called the CLIP (Cross Laminated Insulated Panel), by which air vapour barriers and insulation is prefabricated in the CLT panel in the factory and delivered to site. The long-term goal is to have 'a fully unitised envelope panel with cladding and windows, everything unitised...you would have CLT, air vapour barrier, rigid insulation, strapping, and then, on site, you would put your windows and your cladding attachment' (CLT manufacturer, Canada). Element 5 is not building volumetric volumes, only flatpack to site.

One of the drivers behind the creation of this local manufacturing facility was job creation and regional development. As a highly industrialised, service-based region, forestry has not traditionally been a priority area for Ontario (as opposed to other Canadian Provinces such as British Columbia or Quebec). Stumpage pricing is highly complex and politically heated in Ontario. With 90 per cent of the wood produced in Ontario being shipped and manufactured products being imported, the political impetus was to capitalise on this natural resource through enterprises such as Element 5.

In 2022, Element 5 delivered a women's emergency shelter development in Kitchener, Ontario (see also Part 4) amongst other projects. In terms of the costs benefits of mass timber, they found that (CLT manufacturer, Canada):

- using a repeatable typology to save on costs and adding value to mass timber;
- 2. using off-the-shelf proprietary connections (instead of custom connections) help keep costs down;
- design coordination with other trades (architects, engineers, mechanical, electrical, and plumbing consultants) tend to slow the projects down, and improving this coordination can drive these schedules;
- mass timber becomes cost-effective at 4-6 storeys (less than that it is cheaper to use light wood frame, because of the structural loading), depending on the footprint of the building.



Case-study 12:

Laing O'Rourke's model and The Whiteley, London, UK

The Whiteley is a privately led regeneration project of a former department store redeveloped into a mixed-used precinct (110-rooms hotel, 151 residential homes including 14 affordable housing units, retail, public spaces) in central London, UK. Laing O'Rourke is the main contractor project⁵³ defined as a 'super sized job' by a senior Project Lead, UK. The contract reached 400 million British pounds.

The project is a 'top-down construction':

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This is where you pour a slab, dig down, pour a slab, dig down. Very expensive... but you save six months on the super structure. We got to the top of the building before we got to the bottom. We're 20 metres down, 32 metres above...they paid us 10 million more to do this approach. (Senior Project Lead, UK)

Laing O'Rourke's structure and operating model spans across the UK: one side of the operation handles concrete frames, groundworks, envelope; another manages the fit out. Crown House Technologies (CHt) is Laing O'Rourle in-house mechanical and electrical specialist based in Oldbury in the West Midlands. According to Laing O'Rourke website:

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Today CHt is the UK's foremost prefabricator of modular building services, providing nationwide capability from a 12,000m² facility near Birmingham. Its highly skilled workforce can meet increased demands and fast track programmes while maintaining high standards in quality, health and safety'54

54 https://www.laingorourke.com/company/our-businesses/crown-house-technologies/

53 https://www.laingorourke.com/projects/united-kingdom/the-whiteley/

Photo credit : Louise Dorignon





Laing O'Rourke also runs a data centre business, an offsite factory for concrete and building products, a raw material manufacture in Sussex and Explore transport, a transport network which support the integration and automation of the whole end-to-end value chain, 'critical when you build off site' (Senior engineer, UK). They also use an equipment and services operation, Select Plant Hire, and use Avetta, an asbestos contractor. Laing O'Rourke's operating model is based on the 70/60/30 model⁵⁵, also a 'vision', 'reality' and 'minimum standard' according to a Senior engineer, UK:

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70 per cent of whatever we build onsite comes offsite from our factories or our supply chain partner factories... That enables us to reduce the workforce we have on site by 60 per cent. It enables us to build 30 per cent faster. (Senior engineer, UK)

The challenge with this model revolves around the 30 per cent faster, as materials and products do not get delivered to site for a large workforce to assemble it. As a result, delivering building components as large as possible is key to the success metrics of the project: big piece construction is a language that we try to drive... that's where logistics comes in, because when you've got a site like this and you've to plan to get it here, it doesn't just come in a helicopter. (Senior engineer, UK)

For The Whiteley, the design to manufacture and assembly approach was supported by a diverse supply chain:

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Our direct delivery, the fact that we can stand up our supply chain businesses and cover the vast majority of the scope of work, we don't always do that, this job's got a far richer mix of partner contractors, but it gives us the ability to stand up to the plate if we need to. (Senior engineer, UK)

In order for DfMA to work, Laing O'Rourke needs to be involved from the beginning 'to try and influence the design and use our standard products' (Senior Project Lead, UK):

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You can't pick up something that is well baked, that's got planning permission, that a client's stuck with and some cost consultant has told them they can get it for the money. (Senior engineer, UK)

^{55 &#}x27;In the UK our DfMA 70:60:30 operating model is based on an unrivalled in-house capability in modern methods of construction (MMC). The jewel in our crown is the £200M Laing O'Rourke Centre of Excellence for Modern Construction (CEMC) in Nottinghamshire.' Source: <u>https://www.laingorourke.com/company/modern-me-</u> thads=of-construction/

For this reason, most of their contracts are design and build⁵⁶ (aside from a few projects where Laing O'Rourke works as a second tier) to be able to capitalise on their expertise, use their 'know-how about how to automate the whole end to end process' (Senior engineer, UK) and ensure the project can be delivered through keeping control over the entire process:

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When we bid a job, it's on the basis that it's going to be modular. We'll have a complete model of it, complete MEP [mechanical, electrical and plumbing engineering]. We'll have a schedule of every module. We'll know when it's going to be made in the factory, the lorry it's going to come on, the route it's going to come on, the day of time it's going to be arrived and how it's going to be put into the building and integrated into the works, the sequence of building the building so we can get it in to the place it needs to be. If you don't have that at the start, you come and try and then you'll lose. (Senior engineer, UK)

Laing O'Rourke is also striving to educate consultants and to make their drawings packages available to them via open source access so that consultants have what they need to design modular. Information sharing across the supply chain is key:

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We have a large digital engineering team in the Crown House business and they maintain standardised models, pump sets, pipes, electrical distribution solutions et cetera, and we make those available to our mechanical electrical services design supply chain... so we can start to really standardise some of the back of house, unseen stuff (Senior engineer, UK)

Laing O'Rourke factory took about 18 months to build and about another year to be running stable, with continuous upgrades of the manufacturing facility:

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We're going through our next planning phase now of upgrading a large chunk of that factory to semiautonomous and autonomous operation with AGVs [Automated Guided Vehicles] that that drive stuff around rather than fixed production lines that have a constraint, so far more flexible. (Senior engineer, UK) The UK government supported the development of this facility through proactive procurement policies, government research projects and investments in R&D involved with the construction sector:

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Some of our structural concepts and our decarbonisation programme was funded through a UK government innovation fund, so yes, indirectly, not directly. We have eight prisons, they're all going to be the same solution [modular]. We are therefore able to let a level of investment to put solutions on the table. (Senior engineer, UK)

An expansion of the facility into the infrastructure sector is also underway, with significant investments to automate the design engineering, construction and manufacture of bridges for instance:

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we broke out of doing DfMA on buildings and we've solved the puzzle on how you do DfMA on large scale infrastructure and nuclear projects in linear infrastructure (Senior engineer, UK)

A key challenge to this business model is to understand 'how to work with the factory... without having the system to track the design through the whole process' (Senior engineer, UK).

Laing O'Rourke is also developing a wide range of building products (e.g., steel beam, lattice planks, hollow core slabs, columns; as well as a range of architectural products, bathroom pods, kitchen pods, modularised service panels in hospitals etc.) offsite through kit of parts that provide both environmental and efficiency benefits:

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We're just finishing off a next generation walling product... how do you eliminate dry lining in projects? It is wasteful, it is expensive, it has a massive carbon impact, it is slow, it is heavy work to do, so we created a new automatically placed walling system that's similar in construction but is 60 per cent less carbon, and two people will do what a gang of 10 dry liners will do in half the time. (Senior engineer, UK)

The next phase is to automate manufacturing processes further:

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we'll get to the point of driving autonomous machinery into that space, so when you go to bed at night, machines will start work, you come in the morning your walls will be done. It's all practically possible, that's the direction of travel of offsite that we're driving as a business. (Senior engineer, UK)

⁵⁶ Design and Build Contract in the UK is designed for construction projects where the contractor carries out both the design and the construction work.



Part of this system relies on minimising risk before the factory parts come to site:

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we're actually putting the BMS [Building Management Systems] and the controls into our modules at the same time and we're actually commissioning offsite everything so that it works... all we have to do when we come site then, is to just double check nothing's happened in transit (Operations Director, UK)

Although transport to site sometimes present challenges, being able to produce large modules offsite has proven to improve efficiency:

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a 12 metre module which we're using for a riser, we'll build offsite... we then crane it in. Now, if we did that onsite, that would take us around about 20 weeks with about eight different trades, and we do that within two hours. You can see that there's massive advantages when we get to the larger modules. Now, each job is dictated by the design. The design will dictate what we can and can't do and repetition. (Operations Director, UK)

To achieve this transition from on-site to factory work, Laing O'Rourke supports ongoing career development and learning for their local workforce:

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they do a lot of training from the person pulling cables all the way up to senior leadership, going back at the age of 50 to university to do a masters, so we continue developing from all the different ages (Senior Project Lead, UK) In The Whiteley, having built most things offsite enabled a smaller workforce and a calmer ons-site environment:

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A hundred and forty-five guys, if we were looking at those onsite, we would be more like 500, 600... for this job, we would have needed a hundred class 1 welders. We've done it with six in our factory with the machines, so we have one welder on site. (Operations Director, UK)

Driving digital models was an essential part of The Whiteley project which capitalised on Laing O'Rourke strength in digital engineering:

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We're getting it right from digital. All my construction managers, all my steel fixer foremen... they all used iPads, nobody uses 3D drawings no more – and these are the Pros, because of the memory capabilities... A big investment, but it pays dividends, because it's real time information coming through (...) I know exactly where all the pre casts are and on-site is coming through to me in a real time. (Senior Project Lead, UK)

Bespoke, on-site specific QR codes to be scanned by the iPad supported this system by showing models that could be placed against the site using transparent layers.

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our capabilities in terms of managing a digital value channel to off site is something that is steps apart. It's taken us 10 years of know-how to work out, what we need to know, how you need to know it, but then create the graphical models and the solutions, with 3D scan data to come back and correlate the model. (Senior engineer, UK)

2.3 Digitalisation

Regulating with digitalisation

As emphasised in Case-study 9, digital tools are essential to the future of the construction industry. However, digitalisation should not be seen as a 'fix' to a broken system, but rather as a support mechanism to a healthy and sustainable industry:

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The message is, digital is a way forward as a tool, in support of... It is not the horse before the cart, because that never works. It can only come in support of something that doesn't collapse, that offers shelter, and that is long lasting. (Construction products lobbyist, Belgium)

Government-led innovation can be a powerful tool to drive a responsible digital transformation of the industry as demonstrated through the Construction 2025 Strategy⁵⁷ in the UK. Two major part of this investment was the Construction Innovation Hub and the Active Building Centre. The Construction 2025 Strategy also funded a relatively small academic based project called the Transforming Construction Network Plus. Investment towards digitalisation of the construction sector led to the development of guidelines based on the Gemini Principles⁵⁸ for developing Digital Twins through the Centre for Digital Built Britain⁵⁹. Another domain of action was the funding of demonstration projects covering digitalisation, DfMA and carbon reductions in materials. This activity has led the UK government to create the Construction Playbook to drive good practice in terms of procurement, offsite, carbon reduction, collaboration etc. One of the objectives of this programme is that it has increased R&D in the construction sector, 'to get the people in construction to think about R&D rather than just letting somebody else worry about it' (Senior academic 1, UK). Yet because of the sector's fragmented nature, varied processes and businesses, 'each of these sectors are approaching digital transformation in quite different ways' (Architect, UK).

When they started funding projects, Innovate UK found that one of the barriers in the construction industry was the lack of codified processes that the construction sector could digitise or standardise:

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Some of the projects we funded, that was the first real big leap, just to start to treat all parts of the process a bit more like

58 'The Gemini Principles report was published by the Centre for Digital Built Britain in December 2018 to begin enabling alignment on the approach to information management across the built environment, as establishing agreed definitions and principles from the outset will make it easier to share data in the future.' Source: <u>https://</u> www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples

59 https://www.cdbb.cam.ac.uk/research/digital-twins

a factory kind of thinking... The best projects had a range of different expertise in there and some very clear goals into what they could achieve. (Construction innovation expert 1, UK)

The UK government also played a significant role in developing policies that support better outcomes for businesses and consumers through digitalisation and manufacturing, and through shifting the focus away from 'project' towards value-based outcomes:

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If you're trying to fix construction when you start on a project, that's far too late... a lot of it is about setting out a clear vision of what you want the endgame to be... it's about to deliver better outcomes for society, for the economy, for the environment. The project is not the thing to focus on. What government has done quite well, is to have a supportive policy environment in terms of thinking about: how do we drive value? How do we make value-based decisions? We want to support better outcomes, not think about processes that try and create cheap solutions and transfer the risk to industry. (Construction innovation expert 2, UK)

Digitalisation can be leveraged to transform the industry in a positive way:

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It is not focusing on doing the wrong thing properly or the wrong thing better, but focusing on how do we do a better thing. How do we bring in expertise from other sectors? How do we use digitalisation? (Construction innovation expert 2, UK)

For instance, digital twins can be used to perform environmental performance and regulatory compliance tests and push this information down the supply chain:

BIM has dropped off the agenda, in terms of a driving force, but many practitioners use them for the proper graphical common environments now to generate buildings... You can ensure that the fire specification is up to scratch as well. Then, of course, you pass that information down the chain as you go forward. (Construction product executive, UK)

⁵⁷ See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/ file/210099/bis-13-955-construction-2025-industrial-strategy.pdf

Case-study 13:

Europe's building's logbooks and material passports

Digital systems represent a significant and untapped opportunity to inform continuous improvement and innovation. In Europe, the technology is moving towards data templates that can help support the tracking of energy efficiency of buildings if they are open sourced. Similarly, building materials could be associated with data sheet information (about provenance etc.) in a 'product passport', with the data readable in an open-source format. All this combined data could form a 'building logbook' that could give information about energy performance, materials, and allow comparative analysis between buildings. As described bluntly by a participant, a system of open-source data may be the most important lever to activate in the coming years:

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The concept is there that from the product itself, and its data, then we have a system... It's happening here, but we're not quite sure how fast, how big, and how long something is going to start. Forget all about these acronyms about BIM, the freedom of information lobby. The last time we counted there was 118 initiatives in the 27 member states. Don't listen to the mermaids of digitalisation. It's very simple. It's about data template, it's about open source, and it's about connecting all the levels, and then you have a system that's viable. (Construction products lobbyist, Belgium)

In this way, the material build-up of a building or its operational performance can be utilised at three scales: the product level, the building level, as well as the building stock level (Construction products lobbyist, Belgium). Building Performance Institute Europe (BPIE) has been looking into how such a system can be rolled out and linked with major policy objectives. It is not the lack of data which seems to be an issue, but the lack of sharing data for various reasons:

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Some of these are technical reasons, other are on purpose, holding back data because of proprietary systems, or very often because of liability issues. Simply no one wants to guarantee the quality of the data. (Construction products lobbyist, Belgium) The concept of 'building logbook' has been advanced by EU policymakers as follows:

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it's essentially better data collection and more systematic data management across the whole value chain. It's indeed about not having a central depository, not a physical database but more like having interpretability and having a gateway that connects all these different data sources which essentially means that it requires a common language (Construction product expert, Belgium)

While building logbooks are operated locally with various levels of data hierarchy and granularity, they require an overarching framework at the EU level:

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the way the European concept of a building logbook has been laid down was exactly as a repository that brings together all relevant data, essentially to record every major event throughout the history of the building, every single intervention carried out (Construction product expert, Belgium)

Underneath this European framework sit several modules and functionalities to assist with controls and verifications:

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it's very much like a big infrastructure, that is the logbook, to which you have individual Apps that one of these is maintenance app, or sending alerts or having a building renovation passport, and that's all documenting or reconciling as build versus in-use performance because you have the record, you have the design of the building with all the specifications, materials and everything, and that can use the logbook as a check to what went into the building, so then you have that moment of commission influence. (Construction product expert, Belgium)

The idea of building logbooks can be traced back to Scandinavian nations 15 years ago where lists of materials were mandated in

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building projects to identify and track in an application any harmful or hazardous substances used in buildings. In the context of ambitious national environmental legislation, this was then linked to indoor environmental quality.

In Belgium, the development of a building logbook is well progressed, with the information accessible via a national and digital ID:

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The public authorities have in different databases or data repositories in Belgium... it's tagging of data, and then with that national ID or unique identification key, I can pull together all the data which it spreads across. (Construction product expert, Belgium)

There are still some gaps, as the building logbook only contains the information held by public authorities, but this can be developed and opened up to private third parties so their data can be recorded and included. Resistance to the roll out of building logbooks seems to be linked to transparency and the implications for insurance and fiscal compliance:

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there was a bit of a pushback from building owners on linking the logbook to insurance as well as taxation... the key issue here is similar to probably how they do whole-life carbon assessments, using genetic data as well as product specific data. (Construction product expert, Belgium)

This could be resolved with incentives to have insurance premiums determined on the basis of the logbook's actual data. A building passport is underway in Europe which will combine building permits and certifications in one place like an 'identity kit' (Senior policy maker, Belgium) that can be shared with professionals or administrative bodies, to apply for an energy or renovation grant, for instance.

Integrating digital systems to design and planning

The implementation of digital systems and their integration was a recurrent issue. An example presented was the integration of BIM across architectural practices in the London Legacy Development Corporation redevelopment of 1,700 homes in Balfour Beatty, London, UK.

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whenever that digital model comes to us, we put it in the BIM, we design it, we do it from scratch. You have to develop from scratch because we've got our very specific standards. There isn't that universality across BIM standards... we always start again. We can't trust one line in that model or one element. (Architect, UK)

While there is a good level of sharing for BIM models, this does not mean that these models are readily usable between practices with a discrepancy in quality and coherency:

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Industry is very keen to give us all their BIM models for every component we can never use...Our issue on this project was, us giving them our big models and then it coming back to us when we've delivered the project and it's been adapted and changed...We have a BIM team... we're pretty much one of the best in the industry and certainly one of the most sophisticated in how we use it. (Architect, UK)

Digital models require shifts in practice, skills and expertise:

You've got a digital model that should be reflective of what's built. With all the components of that model intact with their maintenance information, how often you've got to inspect it etc. It proved to be very hard. (Architect, UK)

Similarly, when BIM requirements are not integrated to a project it becomes time consuming and expensive to retrofit the process to include BIM in the mechanical and eletrical (M&E) design. London Bridge and Paddington Stations in the Crossrail in London were offered as examples: an extent...we tend to have already started delivering value add construction works before we start actually finalising the M&E design. (Senior project manager 1, UK)

A lesson from this was that you have 'to have the end user in mind, work back from there. How is the M&E going to work that allows them to operate the station? Then, how do you develop a structure that fits around that?' (Senior project manager 1, UK). Otherwise, rectifications need to be made when structures are already in place to match to fit the M&E around it which can be time consuming and expensive.

Similarly, there are important challenges with the planning system and digitalisation of the construction industry, where different systems engage differently with digitalisation (or not):

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Planning is the hardest thing because they still to have want drawings and documents... But I think the building rates ones will eventually get automated. What that means, if they can automate it, I can use the same software to not have any building rates errors in the first place. (Senior digital innovation expert, UK)

In Ontario, Canada, observations were made about building code and the need to standardise planning approval processes and regulations to speed up building application processes. Digitalisation can assist in this, and there is a lot of interest currently in e-permits and the standardisation of definitions and data for various planning approvals and across municipalities and agencies, so that, for instance, a single-family house would be treated consistently in different jurisdictions:

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In planning you can have different goals and different priorities and different objectives, but the language and the data should be the same. With digitisation, that becomes necessary and possible. Standardisation is the next threshold, the next challenge. (Building regulations expert, Canada)

Government has an important to play to align standardisation and digitalisation and to create an environment that is supportive of industry. The point was made in the UK that it is very difficult for

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Resources dictates our BIM requirements and levels that they're all supposed to meet, and they are integrated to

businesses to develop an investment case when every project is different, because the investment can only be used on the one project:

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If you've got an approach that government and clients take on a supportive environment that says, over the next few years, we're trying to drive greater levels of manufacturing, we're looking to standardise our specifications and rationalise how we ask and make value-based decisions that really consider the support to local jobs or local productive growth, it becomes much easier as a business. They'd see the investment case to start developing the capability and capacity to respond. (Construction innovation expert 2, UK)

Increasing industry digital capabilities

For some companies, the response to the Covid-19 pandemic prompted acceleration of the digitalisation of their processes. For instance, a housing redevelopment director in the UK explained how they had to meet with homeowners online, and take them through the customer journey and expectations of a project.

However, an architect in the UK commented on the lack of digital uptake by the profession, despite young architects' appetite for it:

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you produce 2D drawings that will be a PDF and then they'll print out and they'll look at it with a scale ruler rather than click on all the different assets...That's pretty universal, and they don't use the BIM model, they'll use the drawing. (Architect, UK)

There is a perception from graduate students that digital capabilities are already in place in the construction industry like in the financial industry, which is not the case:

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from a contracting background, the biggest challenge with graduates is we are not in that space yet. We have pockets where we are digital...but we aren't across the board... We are very, very inconsistent in what we offer across the board. We have a lot of paper-based processes (Senior project manager 1, UK) One of the roundtables explored the challenges around how to best train graduate cohorts, including because what they used to do (checking activities, monitoring etc.) has now been automated and is being performed by a computer. An architect explained that the lack of university training in BIM is not necessarily an issue given that the in-house training programmes and systems they use to teach graduate recruits:

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That means that they just need the ability to understand. Some software is more intuitive and it's more about designing like we would do with a pen, but just in a different mode... we do find [graduates] more ready and easier to adapt to the software as well. (Architect, UK)

This of course relates to larger organisations with access to such training resources, rather than the many small businesses across the building industry, who rely on training being provided externally.

The issue of digital literacy was also brought up in relation to the industry's shift from heavily paper-based, onsite processes to digital-based, offsite manufacture processes.

There are several benefits to switching to digital systems. First, it relates to question of accessing the information in terms of the 'golden thread of information' (see 4.1), with different digital solutions being deployed depending on the level of accountability (one building vs several buildings):

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we ought to require for it to be digital because lots of people need to access it at the same time. (Building safety regulator 2, UK)

Second, digital systems such as virtual reality can offer significant feedback for reducing tolerances. Smart glasses can deploy a realtime understanding of the accuracy of what has been built on site. There is the potential for the industry to equip workers onsite with such headsets so they access an immediate digital feedback and identifies the difference between the virtual model and the built:

> There's a huge step in terms of confirming that what we've actually constructed is what was meant to be constructed... Then on from that, we'll be doing maintenance... (Construction product executive, UK)

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This could even be extended to other areas of compliance and safety:

> If you take it a bit further and can you say, why can't we have the fire service equipped with that so that, when they go into a fire and there's no visibility, they've got the BIM model on the visor in front of them so... (Construction product executive, UK)

While some organisations drove the digitalisation of their activities, it can be more difficult to achieve for others. The example of 122 Leadenhall in London, completed in 2014 by Laing O'Rourke⁶⁰, was evoked by a participant as 'a standout building from the outset' (Construction product executive, UK):

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Everything was designed in the computer. They had their full testing done and all the components were fully organised BIM components. 90 per cent of that building - maybe more - was built offsite. When they had huge components coming down from being constructed in Yorkshire into the City of London, they had radio detection devices on each component, so they knew, real time, where those components where.

60 https://www.constructionnews.co.uk/buildings/project-reports/cheesegrater-challenge-laing-orourke-

brings-leadenhall-to-life-15-05-2014/

At the start of every day, every team were given a threedimensional digital briefing, in terms of what they were expected to do that day. Obviously, that had things like GeoFencing⁶¹ for safety. They had sequencing programmes where they were shown what was going to go together that day. It was a great example of what you can really do if you push the envelope out at that time. We've moved on a bit even from there. Trouble is, guys like Ray O'Rourke only turn up every so often. (Construction product executive, UK)

There are also challenges with upskilling the workforce when technology is perceived as developing very fast, with a diversity of software and platforms (for design, procurement, commercial appearing on the market and requiring to be adopted in the early phase of a project):

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We are trying to upskill them, it's a slow process. We do train our managers, getting to the next level down, we haven't got there yet. (Senior Project Lead, UK)

61 GeoFencing is a virtual geographical boundary that triggers an action on a mobile device when a user enters or exits that perimeter



Case-study 14:

Digitalisation of UK's Considerate Constructor Scheme (CCS)

The Considerate Constructor Scheme, which helps constructors focus on the impact of their construction activity (see 4.1) provides a good example of how digitalisation can be beneficial. Initially, monitors of the scheme would visit sites with paper checklists before this process was moved to phone or tablet. 'Now for CCS, everything is digitised' as explained a Construction safety expert (UK). Similarly, registered companies can check all their sites on their phones, and what the monitor scores are, how many public complaints were lodged, what the complaints were and so on:

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We haven't had pushback on that. The industry is slow to digitise, there isn't any question of that, but the early conversation two years ago was, will we have broadband onsite? Those things are really solved. (Construction safety expert, UK)

Recording live data feed (of air pollution on site for instance) is the next undertaking for the industry, rather than digital literacy. The reality of the cost of a live data feed means that there are some obstacles to resolve before it can be generalised, although organisations like CCS drive good practices and advancement in the field:

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When an organisation like CCS makes that change, as it has done over the last three years, it drives a lot of behaviours quite commonly because it's so commonly used across sites. That has helped with some of the basic digitisation. (Construction safety expert, UK)

E-learning courses turned out to work particularly well to operationalise equality, diversity and inclusion initiatives, which benefit teams in the medium-term:

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we have E-learning courses that we just provide through mobile phones...we've had really amazing uptake on it...it's often younger operatives who know that they're going to get some benefit from having done that and being part of the team. So, they'll sit and do it at lunchtime and get it done. (Construction safety expert, UK)



Case-study 15:

Digitalisation of the International Code Council (ICC)

The International Code Council (ICC) has also embraced the digital to transform how they deliver content and solutions globally. The code has been digitalised and made available on various platforms. Digital solutions provide access to a wider audience while being more cost-efficient and sustainable (less paper):

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we feel by providing solutions digitally, we can offer more enriched experience in a more cost-effective way. (Senior building code regulator 2, US)

In terms of their digital solutions ICC provides online resources (digital codes premium with more than 1000 title; cloud-based solutions (community development solutions such as online permitting or inspection software) and online training:

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We do online exams. You can actually take an exam online that is proctored and has all the security that a classroom experience would have. This is one of our fastest growing areas, exam certification online. (Senior building code regulator 2, US)

Additionally, the ICC is working with companies within the BIM sector to create BIM software add-in for their digital content. Providing digital solutions means that their members and customers can work better:

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Digital Codes Premium is an on-the-go tool. If you're in the field and you're doing inspections, you have it right there on your iPad, or your mobile phone, you have it on your desktop, it syncs across devices. (Senior building code regulator 2, US)

All the codes that have been adopted into law by jurisdictions are available at no cost in a read-only, basic format. This had business advantages (demonstrating the value of the product) as well as public safety benefits: It was also in our interests from a public policy perspective, and our members who are in the building safety community, and many of whom are public officials to be making this information available. (Senior building regulations expert 1, US)

Making these available has increased traffic on the online version of the code, and the ICC believe it has improved behavioural compliance and audience reach:

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We're growing 50 per cent, year over year in unique visitors and in search. (Senior building code regulator 2, US)

The US codes and standards ecosystem differs from the EU or Australian one and means that the digital development costs are recovered in the process:

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there's no national building code in the US... we facilitate the development of these model codes... but it only becomes the law when a state through a regulatory action, or a legislative action adopts it. We're able to recoup our development costs, the money that goes into the IT infrastructure (Senior building regulations expert 1, US)

Through their digital platform, ICC is providing global content and has developed an approach similar to that of streaming services, whereby they are releasing on their platform global content for global customers. Partners include the Australian National Construction Code (NCC), the New Zealand Building Codes or the Research Council of Canada Codes and Standards:

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within our premium we have something called Premium Complete, like an all-access model. That's that 1300 titles. That's where those are going to sit (Senior building code regulator 2, US)



IMPLICATIONS FOR VICTORIA

Opportunities for the Victorian construction and building industry to grow include innovation in material and service supply chains, and in digitalisation, especially through the development and greater application of MMCs. Large-scale governmentled initiatives to 'back' the industry such as the Construction Innovation Hub in the UK have led to notable results and breakthrough projects and initiatives, such as the Product Platform Rulebook. A shift from traditional methods of construction to MMC in Victoria will necessitate financial, regulatory and training incentives as well as a protective policy environment that de-risks the adoption of innovation, such as DfMA and kit-of-parts methodologies. A live, digital twin of the Victorian built environment could assist implementing these processes.

While Victoria is not currently developing a coordinated, largescale system of off-site manufactured housing, such facilities could be developed if Victoria is to rely on MMC to accelerate the production of affordable housing and decarbonise construction processes, as, for example, Ireland. The adoption of MMC requires specific skills and training that are not yet widely available in the construction workforce. Overcoming regulatory barriers in Victoria will require a collaborative approach between government agencies, industry stakeholders, and research institutions. This could be helped by a broader, coordinated construction innovation consortium to help facilitate this transition. The development of manufactured construction to accompany the projected growth of Melbourne metropolitan area and regions in the coming years offers significant prospects to set up manufacturing hubs that will also create employment opportunities.

Governments in Europe lead the way in producing and renovating well-built housing with considerate designs. Pilot projects can help demonstrate the effectiveness, potential cost savings and safety of these methods, and build confidence among regulators and future residents. However innovative solutions and designs (such as clickable bricks or using rammed earth) must also be supported by appropriate changes to the National Construction Code (NCC). In all jurisdictions visited, the research found that supply chains are in dire need of integration, and that better communication across the value chain would assist all stakeholders involved.

An important aspiration for Victoria has been to move to a building passport approach. One of the challenges is to build as designed as opposed to build as built. This has created significant challenges in Victoria given the combustible cladding crisis that involved monitors to go on site with plans that were not accurate. Building passports are a key opportunity to increase compliance and transparency, while also presenting sustainability benefits and ease of maintenance. Furthermore, building passports with data open source and available offers an important solution to consumers in relation to insuring homes, commercial properties or areas in the current surge of environmental disasters.

3

PART 3: CLIMATE RESILIENCE AND INDUSTRY PREPAREDNESS

Introduction

- Across different jurisdictions, policies are being created to support a transition to a circular economy, promote carbon accounting and the adoption of low-carbon and recycled building products and there is a consensus building in the industry that circularity is becoming an essential driver.
 However, there is still concern over these impending changes, amplified by risk, uncertainty, and insufficient training, regulation and standards aligning and encouraging circular economy building practice.
- The mandatory Energy Performance Certificate (EPC) introduced by the Energy Performance of Building Directive (EPBD) in Europe has proved to be an effective tool to measure building performance and support the development of retrofit upgrades and national policymaking, when applied with rigorous monitoring systems.
- Achieving net zero emissions by 2050 is a common goal across jurisdictions and tackling carbon emissions within the built environment is a priority. Although the EU and the UK have established regulations, policies and initiatives to support this transition, there is still a significant challenge in implementation. New methods and practices require institutional leadership and clarity and consistency regarding new requirements take time to establish.
- Retrofitting the existing housing stock remains a huge challenge, due to the diversity of the building stock, different housing tenure models and a lack of consistency in programme drivers.
- The lack of financial incentives for consumers and support for builders to undertake retrofit training are constraints that will need to be addressed to support housing retrofit objectives. A centralised low carbon retrofit hub coordinating training, demand and information, may help address the matter, although more will be required to regularise low carbon retrofit across all renovation activity.

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This section of the report addresses the following key areas of industry transformation: circular economy; decarbonisation and energy efficiency and; disaster resilience. It responds to RQ2: What are the key innovations (including in the realm of circular economy and sustainability) pertaining to construction methodologies, supply chains and materials use and availability? and RQ3: What key innovations (including quality assurance, certification and compliance) exist to improve building standards and regulations towards climate-adaptative buildings?

Buildings are responsible for a third of global greenhouse gas emissions. Innovation in low carbon materials shows significant carbon savings from circularity principles being applied⁶². Accelerating climate change along with digital disruption necessitate accelerated efforts to help the construction and building industry prepare for climate resiliency and circular economy. This means, for instance, rethinking new construction and prioritising regeneration and retrofit, using low-impact materials that are made from recycled content and are reusable or otherwise do not end up in landfill, in building and maintenance systems that support large quantities of productive, high value green jobs. It also means ensuring that the buildings produced are physically able to withstand a changing climate, ensuring that our communities can be resilient, cohesive and cooperative in the face of extreme events and shocks.

Circular economy ideas have been implemented in China and Europe since the early 2000s⁶³. The concept of a circular economy has been described as 'a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling'64.

Climate resilience and circular economy industry preparedness is linked to other trends disrupting building industries globally, including: jobs and economic crisis, globalisation, energy supply, resource depletion, digital and broader technology change and demographic change⁶⁵. These trends represent key challenges and opportunities in Australia, together with policy drivers towards zero waste. The long lifespan of buildings necessitates a consideration of circular economy approaches to both new-built and retrofitting of existing building stock⁶⁶. While the construction industry needs to rapidly transition to circularity, current circular economy policies and efforts are unlikely to be enough and may

even exacerbate aspects of consumption⁶⁷ and inequalities⁶⁸ that together challenge efforts towards climate resilience.

Different governments around the world are developing strategies that can support a systemic shift to a circular economy. Several municipal urban governments, such as Groningen in the Netherlands⁶⁹, have launched such strategies. This work reaffirms that a transition to a circular economy will require comprehensive policy frameworks and institutional shifts at all levels of governments. Demand for circularity, sustainability and adaptive housing is an important component of the change agenda, and grassroots innovations may be as important as progressive policies⁷⁰.

As in other countries, the shift to circular construction in Australia necessitates new skills, training and can create new jobs. While there is some debate around the quality of these jobs, more optimistic assessments suggest the need for a heterogeneous skill-base offering rewarding and diverse employment opportunities⁷¹ through skilling-up and reskilling, and an inclusive labour market⁷². According to the International Labour Organisation (ILO)'s Skills for Green Jobs in Australia report⁷³, even without policy certainty and consistency, previously instituted policy in energy-efficient housing have created ongoing demands for embedding 'green' skills in many building trades. Some State and local governments in Australia have adopted their own emission reduction targets and consumer demand for rooftop solar panels for residential energy generation has increased significantly⁷⁴. Retrofit and more efficient new construction have also been presented as key paradigms for global recovery from the Covid pandemic, with estimates that 9-30 jobs can be created for every million dollars invested in energy efficiency measures in the building sector⁷⁵.

The Victorian Government's 10-year policy and action plan towards circular economy outlines the State's ambition to transition to a circular economy aimed at reducing waste and pollution, fostering recycling, reuse and recycled content products, while also enabling economic growth and the creation of new jobs.⁷⁶ This circular economy strategy is further supported by policies such as the 'Recycled First Policy', requiring that bids for large infrastructure projects in the State demonstrate the use of recycled and reused materials according to current standards and specifications77. Coupled with this, 'Regional Circular Economy Plans' establish the priorities for regions to support the delivery of Victoria's circular economy policy, as a result of a collaboration between local councils, businesses, industry and social enterprises.

72 Dufourmont and Brown, "Jobs & Skills in the Circular Economy. State of Play and Future Pathways"; Wijkman and

- 76 DELWP, "Recycling Victoria: A new economy".
 77 Victorian Government, "Recycled First Policy"

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⁶² Nußholz, Nygaard Rasmussen, and Milios, "Circular building materials: Carbon saving potential and the role of business model innovation and public policy".

⁶³ Prieto-Sandoval, Jaca, and Ormazabal, "Towards a consensus on the circular economy" 64 Geissdoerfer et al., "The Circular Economy – A new sustainability paradigm?

⁶⁵ De Groote and Lefever, "Driving transformational change in the construction value chain: reaching the untapped potential"

⁶⁶ Pomponi and Moncaster, "Circular economy for the built environment: A research framework".

⁶⁷ Camacho-Otero, Boks, and Pettersen, "Consumption in the circular economy: A literature review".

⁶⁸ Gregson et al., "Interrogating the circular economy: the moral economy of resource recovery in the EU".

⁶⁹ OECD, "The Circular Economy in Groningen, the Netherlands".

⁷⁰ Pomponi and Moncaster. "Circular economy for the built environment: A research framework."

⁷¹ Burger et al., "The heterogeneous skill-base of circular economy employment

Skånberg, "The circular economy and benefits for society" 73 ILO, "Skills for Green Jobs in Australia"

However, despite these intentions and support from sustainability practitioners, there is still limited knowledge and awareness across the building sector of what this transition actually involves⁷⁸.

Australia has made a commitment through the Paris Agreement to transition to net zero emissions by 2050⁷⁹. Nationally, the energy efficiency requirements for new buildings have been improving over the last two decades through increased building code stringency, adoption of building rating systems, programmes aimed at disclosing building energy performance, and initiatives supporting the adoption of energy efficient and/or renewable technologies in residential buildings. Most buildings are built to the minimum energy efficiency requirements of the NCC at the time they are built, hence increasing building code stringency in planned increments is a critically important activity. Other comparable countries are ahead of Australia on this. However, a focus on new buildings should not be at the expense of addressing retrofit of the existing stock⁸⁰. As in other countries, state and local governments aim at leading the way to carbon neutrality⁸¹. In line with this trend, the City of Melbourne launched its *Zero Carbon Buildings for Melbourne Discussion Paper*, stating that to achieve the council's commitment to be carbon neutral by 2040, the municipality would need to retrofit 77 building per year. The discussion paper argues that decarbonising through retrofit would create jobs and foster the economy, specifically \$2.7 billion to the state's economy and around 12,000 jobs, coupled with energy saving of \$184 million per year, over the next 18 years⁸².

This section of the report provides an overview of how international jurisdictions (namely the EU, UK, US and Canada) are working towards circular economy models and trying to achieve carbon neutrality and resilience. It identifies common challenges and barriers, and examples of what is being implemented and tested.

79 ASBEC, "Low Carbon, High Performance: How buildings can make a major contribution to Australia's emissions and productivity goals".



⁷⁸ GBCA, "A circular economy discussion paper

⁸⁰ COAG Energy Council, "Trajectory for low energy buildings"

⁸¹ ASBEC, "Low Carbon, High Performance: How buildings can make a major contribution to Australia's emissions and productivity goals".

⁸² City of Melbourne, "Zero Carbon Buildings for Melbourne - Discussion Paper".

3.1 Circular economy

Policy shifts

Industry and consumers are becoming increasingly aware of the through-life impact that buildings have on the environment. As the industry comes to grip with methods for embodied carbon accounting and circular products, there is a better understanding of fundamental impacts on the environment, such as the impact of construction products or of building's operations and end of life. As a sustainability consultant in the US noted, there is a change in the mindset of consumers and the market is evolving:

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We've historically just bought commodities with names, but now we tend to be focused heavily on buying commodities with prefixes, 'low-carbon' concrete, 'carbonnegative' furniture...because the markets are supporting, requiring, and asking for the prefixes... The buying-selling nexus is more important in a lot of ways, than what the consumer thinks...and certifications and policy is starting to mimic behaviour. (Sustainability consultant, US)

Data systems are central to a circular economy. They can enable measurement and monitoring of environmental impacts of products (see 2.3), and thus point towards prevention measures and areas for focus. Across jurisdictions, Environmental Product Declarations (EPDs) were referred to as the standard, internationally accepted procedure used to communicate the range of impacts, including carbon footprint across a product's lifecycle. Using life cycle assessment (LCA) to measure the impacts of a product, EPDs are documents disclosing this information, governed by International Organisation for Standardisation (ISO) standards that act as an independent verified third party. A participant recognised that data acts as a driver to advance circular economy but also allows to better understand product performance and strengthen policy development:

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if you have that data, you can drive procurement, you can drive labelling, you can drive embodied carbon accounting... Low carbon insulation is actually terrible... so, you have to figure...how performance data and longevity comes into play...there are some policies that have definition of just 'the bright green'... they don't care about the end of life and that's a miss. (Sustainability consultant, US) Recently, the US Federal Government and some States have introduced policies aimed at addressing the issue of carbon and product transparency. The US Federal Government, one of the largest buyers of road asphalt, started to specify the carbon intensity for concrete and asphalt for any infrastructure project, and it is expected that it will soon apply to steel, glass and other materials. Some States and municipalities have followed similar paths, implementing purchasing restrictions on products that exceed a carbon footprint threshold:

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over time, that threshold is shrinking. It was about 200 kilograms in 2025, by 2030 it would be 150 kilograms. The market, the manufacturers, producers, suppliers, are responding to this saying, 'geez, I've got to find ways to make products that fit within these sorts of purchasing confines'. (Sustainability consultant, US)

This was further enhanced by the Inflation Reduction Act:

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When the Federal Government passed the Inflation Reduction Act, they put in about \$350 million in terms of mobility, decarbonisation, product transparency, and environmental product declaration for support and development... people say \$350 million doesn't really sound like that much money, but you will recognise the LCA and EPD market in the US probably wasn't a \$50 million market prior to the Inflation Reduction Act, so it's changed the significance, and size, and importance of that. (Sustainability consultant, US)

Similar policies have been proposed the EU. The EU Ecodesign for sustainable products regulation legislation⁸³ published in 2022, that has a strong focus on carbon and circularity. In the UK, the importance of circular economy in construction has been rising. A participant noted that with two third of buildings' embodied carbon coming from the substructure and structure, there is a trend in London for planners to resist and refuse demolition. This indicate that in the long-term there will likely be an uptake of refurbishments, wherein new methods of construction play an important role:



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I do like the idea of future buildings being designed to be adaptive so that we can convert a building from a hospital into a hotel or hotel into residential...That will be the longterm trend... finding a contractor that can do DfMA for refurbishment, because that is the future – you take things off and you put them back on. (Senior digital innovation expert, UK)

Some clients are driving this trend:

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A lot of clients are saying to us: 'we want you to do the spelling up, but we don't want to demolish it', so we strip out everything except for the frame. (Senior digital innovation expert, UK)

In Brussels, there has been a regional-level commitment since 2016 to implement circular economy in the built environment, coordinated by the Renolution programme, in charge of the city's building retrofit strategy. A participant indicated that the region's strategy to transition to a circular economy relies on two key initiatives with less impact on the environment. Firstly, there is an effort to maintain buildings and their materials. Secondly, the reuse and repurposing of building materials is emphasised through newly created companies specialised in reusing these materials in different ways.

Despite the development and implementation of what seems to be a new trend in policies and regulations around circular economy, a large part of the industry is struggling to adapt or resisting change:

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when it comes to more specific directives, like the European construction directive, the circular economy package and implementation in different sectors, things are lagging now. You can feel that the sector is pushing back and saying 'this is going too fast, you cannot do this, this is too hard on us'. (Circular economy practitioner, Belgium)



Materials innovation

Recycling construction materials faces many constraints. The impact of demolition, cross-contamination, sorting and distribution costs, and how these affect manufacturers' business models were some of the concerns raised in the discussions. Participants shared examples such as the use of mineral wool and the ability to recycle it into new mineral wool, notwithstanding the costs associated with energy, transport and reprocessing after the material has been applied on site due to its natural expansion and likelihood of contamination. Another example was gypsum waste and the potential to collect offcuts from new building sites, where the waste is clean and once it is back in the factory it can be reprocessed. However, participants also noted that the way in which buildings are commonly built represents a challenge for the reuse of materials:

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[in the context of a] renovation, I will glue that plasterboard with the insulation layer to the brick wall, that is 100 years old, how long will that be there: 10, 15, 50 years? At some point, somebody is going to want to open that space up, knock the wall down, and you've contaminated the bricks with the plasterboard, because you probably can't clean it off. (Construction products lobbyist, Belgium)

To be able to reuse materials you need to think about the way in which you put them into place. If you glue everything together you can't reuse. You have to screw it together... The [first] loop which is still better than just throwing it away is recycling. If you recycle, you're going to lessen the value of your materials, so it's less good. (Senior policy maker, Belgium)

Some organisations in Europe have stated they currently have the technology to sort and organise waste from building demolition sites and recycle it. Nonetheless, it was argued that recycling materials can reduce their performance, and within current legislative frameworks, it remains unclear who is responsible for sorting and recycling:

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The duality of this recycling-reuse thing is who owns it? Who has the cost? Who has the benefits? Then, you have to supply it back into the system. (Construction products lobbyist, Belgium) Coupled with this lack of structure of recycling building materials, there is currently insufficient supply of these types of materials to provide for a sustainable industry. This hinders the buy-in from recycled product manufacturers, as well as the industry willingness to use them:

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if you would want to build essentially, to have a new construction or a renovation project just by reuse materials, I would really struggle with that simply because of the lack of supply of secondary raw materials. (Construction products expert, Belgium)

from the recycling industry, the two issues are quality... and quantity. We have to rely on those two characteristics. If you can supply quality and quantity, as you would raw materials, then you can have us as clients. (Construction products lobbyist, Belgium)

The lack of regulations around the use of new materials, and the resistance in shifting practices to use recycled materials, does not apply only to recycled products but also to lower-carbon products, such as rammed earth, as a participant in Belgium explained:

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builders will usually build the way that they've built for 10 years because they're used to it and because they have a responsibility... The stars have to be in aligned in the sense that everybody has to give the green light, because otherwise new materials don't get integrated very fast. (Circular economy practitioner, Belgium)

Regardless of these challenges, there is consensus around the fact that a circular economy will increasingly become a driver in the building industry. Participants working in the sustainability sector in the US agreed that policies supporting circular economy and reducing the carbon footprint of materials are being implemented with increasing resolve and purpose. Before these policies, the government would simply try to demonstrate and encourage best practice by providing reward-like benefits to 'above-code' performance:

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The other way that the United States have done this is just voluntary above code programmes. Energy star, water sense, these are labels and so a federal agency will use their bully pulpit [US term; a conspicuous position that provides an opportunity to speak out and be listened to] to espouse the benefits of these beyond standards for water efficiency, or energy efficiency, and then they will advertise you, the products will be labelled, the builders that build to these standard, get to show that patch on their shoulder, and it's a differentiator. Sometimes they'll tie in tax credits to building to those levels, or they'll tie rebates, and all of that can reduce the cost of doing it. (Senior building regulations expert 1, US)

This recent shift indicates government interest in encouraging innovation in materials research, including promoting low-carbon materials that can be grown/made, produced and manufactured in the US. Across different jurisdictions, there is a belief that policies and government are influencing the shift to a circular economy in the industry: "

Adapting the cores in the future will be something we need to start doing... They'll start learning that they're not pushing hard enough. That's back to the point, the bar will just get higher, planners will keep just ratcheting things up and making it tougher. (Senior digital innovation expert, UK)

Things are changing in and around circularity, and carbon, and embodied carbon primarily because governments have gotten involved. The government behaviour is empowering private market behaviour as well. (Sustainability consultant, US)

The potential to achieve a circular economy in the building industry would also be enhanced by a transition to MMC (see 2.1), which can help improve efficiency and process optimisation, and reduce waste. In the US a participant estimated that some 15 to 20 per cent of all timber delivered to a building site is wasted, while in a factory environment, this accounts for less than five per cent.



Case-study 16:

BC Materials' reuse of excavated earth, Belgium

BC Materials is a workers' cooperative committed to transform what is often considered 'waste' by the industry – excavated earth – into circular building materials. A spin-out of BC architects, the company received subsidies from a programme of the Brussels government, called Be Circular, targeted at young start-ups and spinoffs of existing companies who committed to an exemplary circular approach. BC Materials is based in Brussels harbour, a central location which allows for trucks to deliver earth. This is also close to where a lot of earth is regularly excavated from many construction sites according to the principle that 'you need the right material in the right spot' (Circular economy practitioner, Belgium):

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We wanted to be at the source of the market because Brussels is... the biggest city. There's a lot of construction going on, a lot of renovation. We thought this is the shortest supply chain that you can actually have. You're at the city, you have the sources and you have also the market that you can immediately deliver. (Circular economy practitioner, Belgium) According to BC Materials, about two million tonnes of earth are excavated in Brussels per year (37 millions tonnes in Belgium). About 30 per cent of this earth is used for roads and asphalt, but the majority is disposed in mines or quarries:

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Our whole idea was that if there's so much earth that is not being used right now, we should really delve into it and use it as a valuable material. (Circular economy practitioner, Belgium)

BC Materials makes use of the earth layers underneath the biological compostable layer. In Brussels, the first layer is called resilient sand and can be used to make clay plaster and in compressed earth blocks. Underneath, there is a deeper layer of clay, also used by BC Materials, called Yperian. BC Materials also use hempcrete – hemp mixed with lime – which offers good insulation, and is practically carbon negative. A wall sample was exhibited and described in these terms:





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This is probably one of the closest things that you can get to having a CO2 neutral wall, because the rammed earth, you can make it without baking anything, the clay, the sand or the gravel in it. Most of it is waste... it's excavated earth that is mixed and then rammed. Then you attach a layer of hempcrete, which is a biobased insulation that's probably CO2 negative and that you can apply without having to bake again. Obviously, the lime that you use is something that you have to bake, but it's compensated by the uptake of CO2 emissions by the hemp.

We make the rammed earth wall first, then we use beams of wood to attach the hempcrete to it. To say what could be the ideal wall in a very clean building approach, a very sustainable building approach. That is also much healthier because these walls are vapour permeable, all the humidity is passed through. It's not like a concrete wall where you have to use vapour screens. (Circular economy practitioner, Belgium)

They recognise the decarbonisation imperative facing the industry and the significant greenhouse gas load and waste generated by standard concrete. Therefore, BC Materials prefer to use secondhand concrete. The environmental challenge that the Belgian industry faces is further influenced by supply shortages and rising energy costs:

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you have to dimension which kinds of materials you use and which you stop using. This is a very big assignment for construction and architecture in general, because from the 1990s when we binged on steel, concrete and glass. All of it was possible and energy and commodities were supercheap. Now we've gone to an economic system, especially with the crisis in Ukraine, where fossil fuel is very expensive.

There is also a lack of certain materials like classic sand and at the same time we see giant amounts of waste of concrete which we don't know really what to do with. Instead, we're just dumping it in an artificial quarry. To retract that building culture will take a lot of time and we don't actually have that much time, if you see what climate change is already wreaking upon us. (Circular economy practitioner, Belgium)

BC Materials make clay plasters, compressed earth blocks and rammed earth. They see rammed earth as a promising material for circularity that does not chemically bind, offering the possibility to be broken, re-humidified and applied somewhere else. Although there are still limitations to its use, particularly in exterior settings, it can be an alternative to concrete in certain situations:

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rammed earth can replace certain amounts of concrete, not all, because sometimes concrete is really loadbearing. In a very high development, you cannot do that because the walls would have to be so massive. But we made walls of rammed earth that are 15 metres high, they are considered to be the highest in Benelux and probably in Europe. (Circular economy practitioner, Belgium)

There is a lack of regulatory framework in Belgium regarding the use of rammed earth and alternative materials. For that reason, BC Materials refers to German building laws and certifications for the use of their materials: "

the Germans are quite gründlich [thorough in German] on building laws, they have a whole register of norms and certifications and tests that have to be done. All of our materials that we have are norm approved by the University of Brussels here, the ULB. They did all the tests, all our materials are approved, but they are only approved to German laws. In that sense it is a bit illogical. Ideally we have a European market, at some point there will be European regulations for it. But it will always depend on the bravery or the willingness of a client to say I like this material, I know what it does, I know what it doesn't do. (Circular economy practitioner, Belgium)

However, barriers to the use of rammed earth are not limited to the lack of regulations; its use in the construction sector in Belgium is still quite expensive. A rammed earth wall is technically complicated and contractors typically price it above 500 euros per square meter. BC Materials is exploring the possibility of reducing costs in their production process by automating it, using robots to ram layers and machinery in baked brick factories to produce compressed earth blocks:

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We are in a transitional era, where the advantages of new materials cannot be fully implemented because they are not scaled yet. (Circular economy practitioner, Belgium)

The firm has also developed a training department through which they provide workshops and training to contractors that are diversifying their activities, people who are actively seeking a new job, but also architecture students, architects, and self-builders, sometimes partnering with universities.



3.2 Decarbonisation and energy retrofit

Energy performance regulation in Europe

In the EU, directives are legally binding instruments emanating from the European Parliament. Ratified in 2002 and revised in 2018, the Energy Performance of Buildings Directive⁸⁴ (EPBD) introduced mandatory reporting of property energy performance, and is widely regarded by experts around the world as world-leading energy and environmental ambitions. A participant in the US (CEO of offsite company, US) considered EPBD as the 'biggest driver' from an environmental perspective and 'one of the most successful pieces of legislation' in terms of results achieved:

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ings-directive_en

What's very interesting about this for the building industry is, rather than prescribing to the industry that you have to hit this standard of energy efficiency in the building, what it did was it said to the public buying the building, here is the energy efficiency standard of your building. They made it a legally binding document. It's submitted with your title documents when it goes into the Land Registry, for example, in Ireland. (CEO of offsite company, US)

84 https://eneray.ec.europa.eu/topics/eneray-efficiency/eneray-efficient-buildinas/eneray-performance-build-

The EPBD requires an Energy Performance Certificate (EPC) using a consistent format EU-wide, to be displayed at point of sale or lease of a property. The document contains the energy rating, in Kwh/msq energy demand. This is then given a score between A and H which relates to the climate zone and the energy rating of the property. The CO_2 emissions related to the energy consumption of the property are also specified, having the energy source (fossil fuels, renewables, etc.) in consideration. The document also includes recommendations on how to retrofit the property to achieve a higher energy efficiency standard.

Concerns have been raised about uneven implementation across the EU, and the cost of implementation. Data collection varies across the member states, with some jurisdictions allowing remote data collection via photographs, and few internal consistency checks between ratings. Others, such as Portugal, have more rigorous systems of on-site survey and checking, a risk-based assessment, and mechanisms to automatically check consistency and pick out outliers.





For the cases where there is a large and good quality building performance dataset, it can be confidently used for national policy making, for example, in Portugal it is linked to a turnkey renovation portal, like a renovation one-stop-shop. The market can consult the data, and then propose tailored renovation measures. The portal also acts as an intermediary. Thus, other benefits include confidence in the data, from the industry, which can then commit to the medium term. Builders routinely compete with each other to have a higher standard in their projects.

The 20 years of operation of the EPBD has provided both experience and confidence in retrofit, and also a wealth of large-scale datasets on building performance and data about energy performance over time. Together, these have provided the preconditions for current efforts towards accelerating energy efficiency retrofit and whole-of-life carbon reduction. For example, a reliable certificate can also form the basis of a mandatory retrofit upgrade to a minimum standard. It also allows for such standards to be regularly raised, in a phased programme. In Brussels, for example, to support their retrofit strategy, the government intends to use an EPC to instruct retrofits:

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From 2026 every owner will be – will have to have a certificate, an energy certificate which is made by a professional, by a software of the government. So, the

calculation method, it will say, in your house it's economically feasible to obtain that [emission level], you'll have to do that and that measure. So, already now there is a certificate which is pointing out the major measures to do, but at the moment it's not mandatory. (Senior policy maker, Belgium)

This said, the EU is a diverse region and ambitious Directives often experience member states' push back, and/or uneven application of legislation. As one expert participant in the EU says about the EPBD and EPCs;

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There is a disconnect between EU level policy making and what is actually happening on the ground, (...) it's really difficult to have a consistent approach because of the diversity of the building stock of Europe.

...some other countries are at the opposite end, and there is very little consistency, and comparability between the different ratings or the different steps or scales, within the EPC, so that's one of the key issues why it's really difficult to calibrate policy ambitions against it. Construction products expert, Belgium

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Case-study 17:

Using Energy Performance Certificates (EPCs) as a tool to support retrofit, Belgium

The European Commission, through its Fit for 55⁸⁵ programme, established that the EU would have to reduce its greenhouse gas emission by 55 per cent by 2030 and aim to achieve climate neutrality by 2050. Within this regulatory framework, the Renolution programme⁸⁶ was established in 2019 as Brussels-Capital Region' strategy to retrofit its building stock.

Brussels is a densely populated city region of 1.2 million people, where 75 per cent of the city's energy consumption comes from buildings. For this reason, local government established that reducing carbon requires a focus on Brussels' building stock:

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Unfortunately, the building stock is very old. Nearly half of the buildings date before the Second World War. One third of our buildings are not roof insulated, for instance. That's a huge challenge. In a densely built environment we have not much potential for renewable energy. The plus is as a city region we have a lot of regional portfolios. We have leverages on environment, energy, housing, urbanism, all those aspects that need to be attacked to do something about the building stock. (Senior policy maker, Belgium)

Brussels-Capital Region's government has created initiatives to provide information and support for building and homeowners to renovate in an efficient way. Since the 2000s it has provided financial support, under the form of energy grants, and in 2005 it started 'houses of energy', a place where individuals can go to get advice on how to better renovate their homes. Brussels-Capital Region also support a similar service for professionals:

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The objectives of Renolution are to renovate quicker, and to renovate better, and to renovate more buildings. Now we turnaround one per cent of our building stock that is renovated each year. To get to the European obligations, we would have to raise that percentage to three per cent a year. That's just enormous. (Senior policy maker, Belgium)

The government sees this as an opportunity to deliver benefits for the environment, but also for the health of the population as these retrofit projects contribute to the quality and comfort of buildings. Local policymakers also see this strategy as a boost to the economy, with the possibility of creating more and better local employment, responding to the jobs and training demand of the region's population.

Following the EPBD, one of the objectives of Renolution for the residential sector was to get to an average performance level of 100 kilowatt hours per square metre per year by 2050. The rationale behind the choice of this threshold was explained by a Senior policy-maker

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Why 100? It's a nice number, but it also goes with a level of C+ on our Energy Performance Certificates...an A level is great, an F level is not so great. So, a C level, that's already nice, knowing that passive is 15 kilowatt hours per square metre per year. 100 on average for new building stock, it's quite ambitious.

That's why we are saying an average of 100 because we know that some buildings will be able to do a better renovation than others. We're not going to say insulate the whole Brussels with white façades, but keep the cultural and heritage and characteristics of Brussels. For some buildings 100 will not be feasible. (Senior policy maker, Belgium)

For public housing, this will have to be achieved by 2040, as policymakers at Brussels-Capital Region believe that public authorities should be setting the example. Tertiary buildings should be nearly net zero by 2050 if privately owned, and by 2040 if owned by the government. From 2026 onwards every owner will have to have an energy certificate delivered by a professional, stating the emission level that is economically feasible to obtain.

These renovations can be done incrementally over time, as it is not financially feasible for every household to do it in one attempt. However, the focus will be in prioritising dwellings rated at the lower levels:

we are not going to say to them if you renovate you have to be C+ right away, but if you renovate, you'll have to make sure that you improve your home gradually. By 2035, there can't be any more buildings with an F and G level. We're trying to phase out, firstly, the worst buildings and then for

⁸⁵ The European climate law makes reaching the EU's climate goal of reducing EU emissions by at least 55% by 2030 a legal obligation. EU countries are working on new legislation to achieve this goal and make the EU climate-neutral by 2050'. Source: <u>https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/</u>

⁸⁶ https://renolution.brussels/fr



10 years later, it would be D and E levels that have to be upgraded to C. (Senior policy maker, Belgium)

Renolution's strategy focuses on reducing energy use, increasing the rate of renovation, and also the quality of the renovation. The Renolution programme also aims to support the professional development of construction workers by developing sustainable building training and guides, and by stimulating, technically and financially, projects that go beyond the traditional retrofit schemes:

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if people only put 10 centimetres of insulation and they have to redo it, it's just not efficient. Improve the quantity of companies and the quality of their work so that every building owner that needs to renovate will find a good company that can do the job in a reasonable time. (Senior policy maker, Belgium)

Currently Renolution is focused on defining the legislation that will become mandatory and the tools needed to apply it, including a more robust energy certificate. They are supporting companies, building owners, and construction companies to have the quality and quantity of tools, materials and knowledge to retrofit, while also addressing the innovation requirements needed to make the initiative work. They are also exploring financial solutions to achieve their retrofit strategy while avoiding additional financial burdens to households:

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You make it mandatory for everybody to renovate, but not everybody has the means for it. We need an innovative approach... We'll have to find ways to help people who cannot afford it, but in a context where we don't have endless money in the region. (Senior policy maker, Belgium)

In Brussels, Renolution have also attempted to incentivise the market through providing financial rebates and the use of competitive grants for new projects aimed at achieving high energy efficiency levels, such as a passive social housing development:

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That was really remarkable because municipalities with social housing don't have much money, from the beginning we said, let's do it because we believe in it. We think it will be great for our social tenants if they have a great house and they have to pay less for their rent... there were four criteria: energy, sustainability, but also profitability and reproducibility... and architectural quality. A lot of people thought that if you wanted to do a sustainable building that it will not be a nice one. We wanted to prove that you can combine all those aspects. (Senior policy maker, Belgium)

Path to net zero in Europe and the UK

The Whole Life Carbon Roadmap⁸⁷ of the European building sector is currently being developed by WorldGBC, in collaboration with BPIE and other partners. It is based on an assessment of the current baseline of greenhouse gas emissions both on the operation side, but also in terms of upfront and end of life emissions. The proportion of overall building GHG footprint that lies in embodied emissions of materials and building processes, compared to through-life emissions, are not well understood and vary from place to place. As energy efficiency standards and information drive operational energy efficiency, embodied GHG becomes a larger overall proportion of the carbon footprint of the dwelling, and therefore a higher priority for action.

BPIE are currently working on a number of building archetypes within different geographical regions to produce information about where the carbon hotspots will be and what their related mitigation potential is. Many low carbon solutions which could play a role in the decarbonisation of the building sector rely upon material substitution but also improvements in manufacturing. They also include shifting cultural and social norms, for example, discouraging new construction, or prioritising renovation, repurchasing, retrofit, and/or reuse. Diffusion rates assumed for low carbon solutions or for recycling or use of secondary materials are quite difficult to predict.

In Europe, the diversity and the state of the building stock as well as the number of individual dwellings is likely to make retrofitting a significant challenge:

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you fairly quickly get to that sort of magic figure of one building per 15 minutes in Europe... We have something like 220 million buildings that will need to be renovated even before 2050 and hopefully in one stage, and not in multiple sequences. (Construction products expert, Belgium)

Renovation activity in the housing stock also varies according to the tenure and typology structure of the housing sector. For example, in Romania, where most of what was state housing was privatised and most of the population received a flat, over 95 per cent of housing is owner-occupied. Here, renovation presents a major challenge because these splintered property arrangements, with many owners on low incomes, mean putting together renovation schemes is highly complex. In other European countries, housing tenure models are entirely different: There are countries... like the Netherlands, whereby private social housing providers co-exist with public providers, and they compete on these grounds of quality... it's enshrined into the fabric of the Dutch and regulatory landscape that the renting of social housing is not stigmatized. Something like 50 per cent of the Dutch population is actually living in social housing, and these houses are really of good quality⁸⁸.

... the great thing about the Dutch case is also the fact that they support the public as well as the private sector providers, they have big portfolios, and they have quite a good overview of what they have in terms of the performance of the stock. They are actually obliged to have for each of their assets a have a climate neutrality roadmap, so renovation plan that would assure that there would be no excessive costs, energy costs, for vulnerable categories of people. (Construction products expert, Belgium)

The UK, like Europe, has legislation obliging a shift to net zero by 2050, including across the 28 million existing homes that are responsible for about 20 per cent of CO₂ emissions. This is combined with an on-going energy crisis. The building industry in the UK, through the Construction Leadership Council (CLC), is working on a national retrofit strategy. A 20-year long-term plan was developed to make existing homes greener and more energy efficient:

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We've asked the government to start that funding, and then that would lead to private sector funding coming in... not only would there be benefits in terms of improving people's quality of life, making cheaper energy bills, but it would also create a lot of new jobs in our industry... that could be really important as part of the government's leveling up agenda. (Construction association senior executive, UK)

A key problem raised regarding the UK experience was that initiatives have been shortlived, introducing short termism and uncertainty into the retrofit industry which has increased risk and dampened investment and commitment:

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Unfortunately, this government doesn't really favour too much intervention, so we've had some piecemeal initiatives.

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87 https://globalabc.org/resources/publications/eu-policy-whole-life-carbon-roadmap-buildings
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^{88 &#}x27;The Netherlands is the country with the largest share of social housing in the EU, accounting for about 32% of the total housing stock and some 75% of the rental stock in the country.' Source: <u>https://www.housingeurope</u>, eu/resource-111/social-housing-in-europe

A few years ago, we had the Green Deal, that came and was taken away. We had the Green Homes Grant scheme, which was a short-term measure. Again, it was introduced and then taken away. We want to move away from that and create certainty, so that small companies will invest in the retrofit. (Construction association senior executive)

Innovate UK, UK's innovation agency, is committed to net zero and have supported the Active Building Centre, to understand how different technologies can be combined in buildings to understand the ideal mix between energy efficiency and renewable technologies to deliver net zero at the lowest cost:

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the Active Building Centre, a very simple idea that the market failure is that buildings are a load on our energy networks, rather than an active component of them, and there's no reason why they can't be an active component of them if you put the right kind of technology in so that they're relatively energy efficient in the first place, have renewable technologies on them that allow them to generate, store and manage energy in a dynamic way, whether that's on a building level or a district group of buildings level with the wider grid. (Construction innovation expert 1, UK)

The Active Building Centre is working with clients, supporting them to adapt their designs for developments to meet these criteria, and with manufactures who are then interested in producing products compatible with this new aim. Through this collaboration between developers and building and product innovation technicians, there is an understanding that the uplifting capital cost that comes from installing these new measures would be offset by some of the avoided costs:

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Those avoided costs start to offset the extra capital costs, which are relatively low if you design things right. It's simple stuff like orient the buildings properly, insulate them properly, maybe not to extreme lengths. You can put in some very simple technologies to make them run to net zero. We think for new buildings, the argument's almost there now. There's no reason why we can't do it. We think the costs generally are going to be fairly equivalent if you design it right. (Construction innovation expert 1, UK)

हि EXAMPLE:

In the UK, Laing O'Rourke is developing a programme to move towards decarbonising their facility and take it to low-carbon concrete. Their programme uses basal fibre reinforcement to eliminate the use of steel, allowing them to manufacture products over the last year, with 60 per cent less carbon:

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That combination, with some advanced structural solutions that we've now got, we could build a structural frame equivalent to what we've built out here [The Whiteley], not done like this, but we've now got the technology to do that with about an 80 per cent reduction in the embodied carbon.

We've got a route map of that over the life... The materials work is co-sponsored with an Australian R&D business in here, and that materials work leads us on a journey part to actually net absorptive buildings using aggregates and things that are generated by carbon capture techniques as that industry evolves with calcium carbonates and other things. Our view in 2050, we'll still be doing this sort of stuff, we'll end up with net carbon, zero carbon buildings. (Senior engineer, UK)

The other key concept for Laing O'Rourke is using concrete as a material, as opposed to steel, creates a bigger thermal mass and enables very low efficient buildings:

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we embed the cooling into those planks, as in under floor type pipes, to do either radiant cooling or heating of the frame as the means of controlling a building environment rather than pumping air around and that has a huge impact on building operation performance. (Senior engineer, UK) Innovate UK recognises the complexity of mass scale zero-carbon retrofit. The organisation is focusing on what it calls 'the heat challenge', which includes how to stop using gas to heat water and space in buildings. It sees an urgency in addressing this issue, with less than 30 years now to decarbonise almost 30 million buildings in the UK:

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It's how we industrialise our approach to retrofit. Transforming Construction was how we industrialised our approach to new builds. It's still an artisan sector that's building a prototype every time with craftspeople onsite, but it doesn't need to be that. How we do that for existing buildings is obviously a larger challenge. (Construction innovation expert 1, UK)

The scaling up challenge is prompting innovation at various scales:

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We need to do more than a million buildings a year, and we're doing a few thousands at the moment...we are looking at how all those things integrate and fit together, and particularly deliver probably at a local level, which is quite applicable to you thinking about a regional government level. Subregional is probably the right answer because the mix of things that come together are different, depending on the geography, even in a country as small as the UK. (Construction innovation expert 1, UK)

A UK participant also noted that CLC's two key programmes are promoting building safety and climate change (see 4.1), pointing to the fact that building safety regulations and addressing the climate emergency can be seen as complementary issues in the way that they require new overall awareness, social engagement, and rigorous processes:

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The change of culture through building safety, the change of rigour, in terms of regulations and all that comes with it - so in other words, we will design something that actually is a properly tested design, procure correctly and build something that is properly performing. You can use the same narrative for taking carbon out of the system, for producing a building that is properly sustainable. The two work hand in hand. (Construction product executive, UK) Aligning with strategies and actions towards net zero, there is currently a growing interest in green assets in Europe by ESG minded investors, boosted by several incentive measures by the EU in the aftermath of the financial crisis. However, the market has not been able to fulfil this demand:

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the more environmentally conscious investors and asset owners, they actually failed to find the green assets. There is a shortage of supply currently in the market, so there is more money chasing green objectives, or green credentials, which cannot be fulfilled by the markets. (Construction products expert, Belgium)

The disconnection between policies and the reality on the ground, the lack of consistency in mechanisms to measure and monitor real performance, and the shortage of skilled labour in the industry are some of the contributing factors as well as the bar being set 'too high':

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when the EU Commission's green finance proposal came out, that taxonomy, the sort of technical criteria whereby not just the financial sector, but generally, the stakeholders could recognise and certify a building as being green or not... less than two per cent of the building stock would have qualified for this. Initially they set the threshold so high that... there was a shortage of assets to issue green finance against it. (Construction products expert, Belgium)

Retrofit consistency and learning rates remain a challenge

In the EU, there are ready-made solutions to support retrofit for energy efficiency in the market, but regulations vary according to location. For example, when insulating using façade technologies with polyurethane and sealing with a render, there are fire safety challenges, and many jurisdictions have moved to avoid this practice following the Grenfell Tower tragedy. When insulating from the inside there are other limitations caused by bridging and zoning.

Efforts towards decarbonising exist but more remains to be done to align these initiatives with regulations, including pertaining to fire safety:

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A few years ago, we had an analysis done on quite a few buildings in the UK. Most of them did not comply with the environmental criteria that was set out in the first place. It was quite poor.... there is a desire to have sustainable buildings, a desire to have buildings that are very energy efficient... Where these two meet is where we look at a drive to be sustainable. Let's have more timber buildings. ... Concrete is bad. It's a high carbon material, so we don't want to do them in concrete. So, here we have a clash directly between a safety issue, particularly fire, and a sustainability issue, in terms of what materials you use. (Construction product executive, UK)

Even where scaling up is achieved in the context of increasing building renovation for improving performance and energy efficiency, there are ongoing questions about the efficacy of the process of accounting and practice:

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[There is] another big disconnect between real performance and calculated asset ratings, because regulations in Europe could cross various members, it is mostly a calculated rating, and this is what the law requires as well. There is no effective feedback group about the real performance, so you don't have a way of properly following up, and then also to have a meaningful incremental improvement for the performance of the buildings. (Construction products expert, Belgium) In the UK, although new housing is pushing for longevity and following energy efficiency measures, according to the 'Future Homes Standard', the argument has been made that some new homes will have to be retrofitted in a few years. A participant in the UK noted how the requirements to address the carbon challenges keep changing and how hybrid buildings solutions often deemed as innovative options, might not perform to more recent and ambitious standards:

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We think the steel CLT as a hybrid is a good solution because it gets that balance from a carbon perspective... We're doing a scheme at Liverpool Street just now that's got lots of cantilevers and really sensitive to the grid size...We've got something like 50 projects in London. We ran a study recently of the embodied carbon on all of these projects. Not one of them will pass the new LETI [London Energy Transformation Initiative] standards... The carbon challenge is just going to get harder and harder because the dial is just going to go up all the time, and that's why we're having to look at other new materials, the recycling, the reuse. (Construction product executive, UK)

When discussing retrofit schemes, many participants across jurisdictions said that formal programmes to train and upskill the workforce need to be created, with a structured body overseeing the education programmes. Construction association representatives suggested a retrofit hub as a mechanism that could coordinate the training capacity in the building industry and give consumers information. Incentives for consumers, through tax breaks, were also raised as solutions that could be coordinated through this retrofit hub model, which could be a centralised think tank, working with local government and private sector to deliver solutions regionally.

There is a need to kickstart demand, training and capacity in a coherent and coordinated manner that the current market arrangements cannot achieve:

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Consumers are not asking yet, because there aren't grants available. Colleges aren't setting up courses, because they haven't got the demand from the consumers, and builders are saying, we're going to start training, but we haven't got demand. We need to break that cycle, and if government could introduce a 20-year grant that would be available over that period of time, then consumers would start asking for it, so then the builders would get the colleges doing some courses that they could then train. (Construction director, UK)

The need for coordinating training was also linked to the role that building associations could play to support builders to address these challenges. For example, the Green Homes Grant Scheme, a retrofit scheme in the UK, introduced the requirement for building companies to be PAS 2035⁸⁹ accredited, which turned out to be a complicated process for some members of the Federation of Master Builders:

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That accreditation doesn't work well for a lot of our members... There is another organisation called TrustMark... They set the standards, like an accreditation body for organisations. We are one of the scheme operators for TrustMark, and they're talking about doing a licence plus scheme, so that could be the benchmark for companies wanting to do retrofit work. It's just coordinating those three parts of the triangle. (Construction association senior executive 1, UK)

Aligning objectives is key to the success of these standards, so they do not end up competing against each other.



⁸⁹ Introduced in 2019, PAS 2035 is a British standard that creates a recognisable quality standard for the retrofit and energy efficiency sector for housing. Source: <u>https://socialhousingretrofit.org.uk/articles/understanding-pas2035</u>

Case-study 18:

Built Environment and Smarter Transformation (BE-ST), Scotland, UK

The Built Environment and Smarter Transformation (BE-ST)⁹⁰, formerly known as Construction Scotland Innovation Centre, rebranded to reinforce its objective to focus on the transition to net zero throughout the whole built environment ecosystem, rather than just construction. Although BE-ST's themes of work remain the same, the centre has broadened its scope, particularly focusing on MMCs and related advanced manufacturing approaches:

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We had always supported projects that were developing systems or products, or processes that were relevant to existing buildings, but we didn't have an explicit kind of retrofit theme, which we then introduced as part of the rebrand. We had a sustainable materials focus previously, that we've broadened into a wider sustainability focus. It then now has sustainable materials within that, but also includes a lot of work we're doing around circularity, a lot of work we're doing around sustainable processes and operational and embodied carbon. (Senior built environment expert, UK)

Since 2014, the work of the centre has focused on supporting industry to deliver value along the triple bottom line – economic, social and environmental. Since becoming BE-ST, the centre is also committed to help customers of the building industry understand what the industry can and should do for them.

90 https://www.be-st.build/

They have found that for home-owners or business-owners wanting to retrofit it is quite difficult to access or navigate the right information regarding energy efficiency and decarbonisation;

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There's nowhere where those that are interested in the solutions to heat decarbonisation and those that are interested in solutions to energy efficiency for buildings come together. Often they are put in separate camps and you think that's odd, because both of them are intrinsically linked... It's probably more in that zero carbon solutions space where we're likely to engage more... we are planning for doing more of it. (Senior built environment expert, UK)

BE-ST intends to provide opportunities for the general public interested in retrofitting their properties or simply understanding how heat pumps work, to be able to access advice, information and guidance through sessions at the centre. This consumer education is seen as an add-on to the training they already provide to professionals. Through their Low Carbon Learning programme, they provide a range of online training programmes and practical sessions, covering Passivhaus and Retrofit, among other themes. Immersive learning programmes like *CONVERT* offer the opportunity to build a house virtually and to receive sustainability advice for all materials options selected in a gamification environment. *Offiste Ready* provided training around MMC and offsite construction:




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it was every key stage of offsite construction and modern methods construction. To develop that, we did a whole range of immersive... interactive questions throughout, and all that contents available for use. It has editable PowerPoints, technical books. It's invaluable teaching content... then we disseminated that through colleges and universities. (Senior retrofit expert, UK)

BE-ST *Passivhaus in Practice* training is about Passivhaus standards and low carbon construction techniques, for which the centre created four different timber Passivhaus rigs. The learning modules included immersive and virtual reality, but also online modules and in-person practical sessions:

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contractors really found the in-person practical sessions really valuable. This was funded through National Transition Training Fund. It was really out of the fallout of the pandemic to support people back into employment who were maybe at risk of redundancy or were unemployed... It was predominantly contractors that undertook this course... then you can go on to become a Passivhaus trades person. That is online learning followed up by the practical session. (Senior retrofit expert, UK) Coupled with the training they provide through their Innovation Factory, BE-ST enables access to industry equipment that is not available anywhere else in the UK. Even offsite manufacturing factories that have their own advanced manufacturing lines use their facilities for their R&D projects, so that they do not delay their own production.

As with the other six innovation centres in Scotland, BE-ST is hosted by the Edinburgh Napier University, which sits on their board. Practitioners at BE-ST have found that being hosted by a university has enabled them to identify industry problems and encourage collaboration across universities, bringing academic expertise together to solve those without the usual funding constraints:

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The smart bit in all of that was actually placing us within the universities, because otherwise, if we had been set up as a standalone company, constituted in whatever way and then came back to the university and said, would you like to work with us on various stuff in industry challenges, history has taught us that that hasn't always been a particularly successful process. [Funding] is really simple, because we are a university. (Senior built environment expert) BE-ST receives government funding, but has also competitively been awarded funding through grants and projects awarded by Innovate UK, UK Research and Innovation, and other sources. They also receive funding from commercial arrangements they have with companies that use the equipment they have in their Innovation Factory, although they do not run a membership model and any company may work with them. They believe that not being a lobbying group has allowed them to become an important and trusted entity for different stakeholder, while also providing them with the legitimacy to challenge government:

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we've managed to develop a role that sits in the middle of industry, academia and government, public sector....if our role is to be the linchpin in the middle of that... the more collaborative the project, the more impactful the outcome. (Senior built environment expert, UK)

During the pandemic, BE-ST was invited by the Scottish Government and industry stakeholders to join the Construction Leadership Forum, a partnership between government and industry to discuss how procurement could be made better. They ended up working intensely on how to support industry to go back to work safely, updating guidance and developing interactive and virtual training modules for furloughed industry workers, before the construction reopened. The collaboration and innovation fostered during that period has continued and BE-ST now constitutes the innovation team behind how the Construction Leadership Forum influences how the industry in Scotland can change the way it operates.



Case-study 19:

Birmingham 2022 sustainability approach, UK

For organisers of the Birmingham Commonwealth Games, the event presented an opportunity to implement several innovative sustainable measures within their supply chains. To reduce their carbon footprint, they started by maximising the use of venue grid power and by using battery storage:

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[this] really helped to scale back and reduce on prime running generator use, but also standby generator use... We also procured upfront innovative technology through use of battery storage - what we call stage five generators and use of biofuel and also a key planning requirement where we used a fully integrated power system for all of our venue requirements across all of our different key client groups. Effectively, you've got one integrated power solution. (Commonwealth development executive, UK)

In their tender information the organisers of the Games had five pillars of social values and required suppliers to ensure the delivery of social value outcomes, while also providing a degree of autonomy to their supply chain to deliver initiatives across these. The actions were varied and included sustainable procurement, waste-reduction strategies, contract commitment on reuse, recyclable material, UK-based solutions and so on. Various supplier and partners also engaged in broader actions, like tree-planting initiatives to support the development of a Commonwealth forest across the Midlands region, supporting the Games' ambition to create a carbon-neutral legacy.

The Games developed sustainable practices such as an inventory and product from the rental market wherein the inventory returned to local markets. Organisers also opted for a supply chain with a strong foothold in the UK and UK-based inventory, with very little import from overseas. This strategy also helped to de-risk the programme in terms of logistics and proved quite valuable during the pandemic.

Another initiative from the organising committee of Birmingham Commonwealth Games was to establish a carbon-offsetting programme and a carbon-neutral games strategy. Related actions included incentivising the use of local supply chains and the development of a proactive carbon offsetting programme to estimate the use of carbon by the Games' supply chains and its carbon footprint: [Consultants] helped the organising committee to develop a methodology for reduction and offsetting opportunities and establish a total estimated carbon footprint and offsetting strategy with that, including an estimation of carbon offsetting costs. Suppliers and sponsors were encouraged to contribute to carbon offsetting or reduction initiatives. (Commonwealth development executive, UK)

The infrastructure created for the Commonwealth Games also focused on sustainability. In Sandwell Aquatic Centre, Wates installed photovoltaic cells on the roofs and the walls had additional insulation installed to address the heat loss. A focus was placed on the viability of the building's future, ensuring that maintenance costs could be kept low. However, due to the pandemic, Wates experienced time constrained and some opportunities were missed:

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We did look at combined heating and power but unfortunately our local power generation people said you can't back-feed onto the grid, so that got scrapped... In order to keep the maintenance costs down... we don't want a building too much heavy maintenance costs and we're finding a lot of rainwater harvesting is quite heavy in maintenance. (On-site project manager, UK)

Government efforts towards decarbonisation in the US

In the US, at a federal level, environmental regulations are developed, implemented and enforced by the Environmental Protection Agency (EPA). The EPA also works closely with their co-regulators at the state and local levels, providing education to the public but mainly engaging with businesses and communities subjected to their regulations. The relationships between the agency and industries are often challenging and tense around the regulatory framework. To address this, the EPA created the Smart Sectors programme to collaborate more closely with the business community, analysing some of the most current challenging issues that require long-term generational, systemic change, like climate change, sustainable construction and environmental justice:

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Industry, really, as much as they want less stringent rules that are less costly for them to implement, they also want certainty. They want regulatory certainty, they want to have a stable planning environment, they want to know what's required and have some degree of stability. (Environmental programme manager, US)

However, differences in environmental regulations across US States create discrepancies for industry. For the building industry, wherein businesses might operate across different jurisdictions, it can be difficult to navigate different local zoning and sets of regulation requirements. This is particularly challenging for product manufacturers that do not want to have to have different versions of the same product to comply with different requirements based on localities. Similar challenges arise when it comes to competition:

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industry often wants a level playing field and where the federal role is less pronounced, more discretion is left to the States... you have competitive dynamics where companies operating out of parts of the country where they're subject to more stringent regulation want to raise the bar for everyone so other companies and other areas don't have a competitive advantage due to weaker environmental regulation. (Environmental programme manager, US)

The Smart Sector Programme aims to provide a stronger platform to engage with industry and advance collaborative efforts to improve environmental protection. They hope that through this new type of programme, they can take a broader view of the regulatory apparatus to connect different parts of both regulatory and nonregulatory programmatic infrastructure in order to deliver systemic change required to create better environmental outcomes:

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We're talking about changing the built environment, we're talking about capital stock turnover, we're talking about revisioning transportation and energy systems, and even the way industry manufactures things. EPA's regulatory authorities are usually focused narrowly and shorter term. What can be required today through a rule-making that this industry can implement within the next - usually within the next three to five years, for this pollutant or this process. It is important to be able to take the three steps back and to look more broadly and with a longer-term time horizon at many of today's challenging issues. (Environmental programme manager, US)

The pressure placed on the EPA to focus on individual short-term measures, as opposed to a long-term plan of work, is compounded by the political system in the US that often makes it harder for government to deliver a particular agenda:

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sometimes the legal authorities press us to focus a lot of our energies on individual rules under shorter-term schedules, and where we don't do that we get sued by the environmental community to be doing our job. In the meantime, we don't have the direct mandate to do some of the longer-term visioning and work... In terms of the White House and Congress, they are trying to achieve long-term goals for carbon, for example, out to 2050 but they're working within their authority. So, if in a split Congress they can do something with a budget authority that only needs 50 votes in the Senate, well, the budget doesn't extend out to 2050, so they're trying to do things to fund, to jumpstart for longer-term progress. (Environmental programme manager, US)

In parallel, US industry is coming up with various initiatives that are often unregulated, which raises concern about greenwashing, as consistent and transparent mechanisms to measure and record initiatives and plans are not in place. A participant in the US made some comparisons between current regulations in the US and in Europe, noting that: "

California, which would be deemed to be the environmental leading State inside the United States, their energy efficiency standards for housing are pretty much Ireland of 35 years ago...They have these prescriptive codes, so in other words if you do this that's deemed to qualify. But in reality it doesn't really have any impact, or beneficial impact, on the environment or on the building. You'll hear little bits of noise around decarbonisation, but there's really nothing going on. (CEO of offsite company, US)

Nevertheless, the US government is making investments towards green buildings and materials and support a better involvement of its agencies in the decarbonisation space, particularly through the enactment of the Inflation Reduction Act, which includes US\$40 billion to the EPA. These include provisions focusing on energy-efficient buildings, strategies to recycle and recover, but also mechanisms to understand the energy footprint of materials like cement, steel, wood-based materials, glass, and so on (see 3.1).

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Those provisions point to EPA as identifying and labelling low-embodied carbon construction materials and products. EPA was given \$100 million to develop a programme to identify lower-embodied carbon construction materials and products... it gives EPA a role and part of that role is how do you do the measurement, how do you do carbon accounting? Potentially EPA has the ability and the resources now to become much more directly involved in that, which has been a little bit of the Wild West here, with so many different entities, companies and consultants and proprietary databases and different procedures. (Environmental programme manager, US)





EXAMPLE:

Other US government bodies have also developed programmes aimed at driving sustainability with the building industry. The 'Zero Energy Ready Homes'⁹¹ is a flagship programme of the DoE, with the new version to be launched at the beginning of 2023. It is an above-code standard, voluntary programme, setting the standard and the recommendations to get to zero energy homes. Builders can also become Zero Energy Ready Home builders. Due to code differences between States, how far above code the programme is, depends on which state the building is located. Unfortunately, as it is a voluntary system few have adhered to it:

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They have just done 11,000 zero energy homes and then some other weatherisation programmes that DoE has. We are on their 1 millionth home in the US which is great. But 1 million out of a housing stock of 120 is not. We can't take another 30 years to get another 2 million homes. We have to go a lot faster. (Senior energy policy maker, US)

For the DoE there is a key role for government to support R&D for sustainability. Although they have mainly been a science agency, its role has shifted toward the deployment of R&D:

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the DoE, famously has been behind energy efficiency things, like triple pane windows, energy star appliances, which has become a big thing in the US. These are things that came out of the labs and the DoE as a principal funder of those labs... With the passage of the Infrastructure Bill, that came through earlier this year, the DoE just alone got US\$62 billion to work on infrastructure deployment and large-scale clean energy demonstrations. (Senior energy policy maker, US)

3.3 Disaster resilience

In the US, some organisations are working towards linking energy efficiency with resilience. A participant in Washington discussed the case of a community in Florida that had been built to a higher standard and how that influenced their ability to withstand a recent hurricane:

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a lot of solar power, green homes came out pretty much unscathed... it was more expensive, but people who all bought those are very happy with that. We had power and everyone else is out... Linking the energy efficiency with the resilience. (Senior energy policymaker, US)

The Insurance Institute for Business and Home Safety (IBHS) is a not-for-profit research organisation funded by the insurance industry in the US, providing science-based information to policy and lobby organisations. In their full-scale lab facility based in South Carolina, they can recreate a Category 3 hurricane⁹², a hailstorm or a wildfire ember storm, which allows them to research hail, wildfire, wind, and rain at full scale. This allows them to evaluate practices and construction details on real-scale buildings, and inform the building industry, regulators and the insurance industry, on cost-effective solutions to enable mitigation strategies for these particular weather events: we were very specific in looking at where could we provide something that was filling a knowledge gap that wasn't being addressed in other places. That's why we've concentrated on the wind, and wind driven rain, and the hail, and wildfire because for example, in the United States, earthquake has been receiving funding from the National Science Foundation. (Senior engineer, US)

Currently, IBHS is working collaboratively with James Cook University in Australia, looking at wind-driven rain penetration in typical openings of building façades, causing damages and losses, impacting the durability and sustainability of buildings. They have also developed 'Fortified', an above code-building method based on years of research studying wind events, for which they also provide training:

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this is how we are recommending that people build resiliently... this is a programme that any builder could take... very prescriptive, has plenty of drawings and examples of how to achieve it. (Senior engineer, US)

⁹² A Category 3 hurricane is considered a 'major hurricane' that can cause devastating to catastrophic wind damage and significant loss of life simply due to the strength of their winds. Source: <u>https://www.nhc.noaa.gov/aboutsshws.php</u>



Recently IBHS developed a programme aimed at preparing homes for wildfires. The result of a decade worth of research into how embers are moving and landing, accumulating and lighting buildings on fire, and what are the recommendations for households to significantly reduce their wildfire risk. IBHS is working closely with the State of California to deliver this programme and enable homeowners to access insurance:

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California has a map of where the risk is higher, and where the risk is lower, based on proximity of the forested area, the density of structures et cetera. Our programme is designed to say, homeowner, you live in this area where right now there is a difficulty with the affordability and the availability of insurance... if I'm looking at house A and house B, and house A has a wildfire prepared home certificate, which means it's got this roof, it's got these gutters, they've taken all the vegetation out from the first five feet... they have the six inches of clearance... Then, I know that the risk of an ember lighting that structure is much lower than the risk of an ember lighting house B, but that alone is the scope right now of wildfire prepared home. (Senior engineer, US)

IBHS' hope is for the programme to evolve into a neighbourhood rating, but currently, it enables builders to take the standards and build accordingly and homeowners to demonstrate that they have lowered their risk and discuss insurance affordability and availability.

However, initiatives like IBHS remain small in a country like the US and have limited impact in terms of coupling disaster reliance with environmental targets and energy efficiency. As a participant argued:

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There was a missed opportunity in the Inflation Reduction Act to pair resilience investments with energy efficiency, and it's not a lot of good to build a really efficient building that gets blown over and has to be built again, or gets burnt up and has to be built again. (Senior building regulations expert 1, US)

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IMPLICATIONS FOR VICTORIA

In Victoria, the government's 10-year policy and action plan towards circular economy outlines the State's ambition to transition to a circular economy, aimed at reducing waste and pollution, fostering recycling, while enabling economic growth and the creation of new jobs. The building industry has a key part to play in this by demonstrating leadership in creating and sustaining growing markets in recycled and reused materials, and by markedly reducing its consumption of virgin building materials. This is a major challenge, requiring change in all parts of the industry at all levels, from design to standards specifications to on-site work practices.

The shift to a circular economy requires new data systems, second hand material trading mechanisms, trust, risk and legal frameworks, training, institution building, together with reference studies and product declarations to establish transparent, independent building product information.

New systems of responsibility and organisational arrangements will be needed to enhance sorting of usable or re-processable offcuts and other 'clean' site material discards. Efficiency and process optimisation need for higher environmental performance of buildings are often associated with MMC such as off-site fabrication.

As Victoria also builds focus on whole-of-life carbon, it will need to build more durable, adaptable buildings, and turn to low carbon renovation as a growth activity instead of new build. This requires significant structural change in the industry. As some local governments take the lead in this space, pushing for retrofit of the existing building stock to try and achieve the net zero targets agreed upon, there are several hurdles that still need to be surpassed. Changes in policy alone will not be enough if the industry does not have the appropriate resources and knowledge in place to respond to these new requirements. Consistent regulations, educational programmes for practitioners and incentives for consumers delivered through a consolidated platform, all offer potential benefits for Victoria.

The EU has developed a track record of independently verified performance certificates generated by building assessments; Victoria should consider investing in this area more and roll out such systems to support the transition. The largest challenge is the low carbon retrofit task. It is more complex to retrofit than to change new building practice, and there are many more existing dwellings than those we build each year, hence a far greater task. This will create many jobs and take a concerted effort across Victoria.



PART 4: BUILDING OUTCOMES AND CONSUMERS

Introduction

- Regulations are important for ensuring building standards and performance. Compliance checks are required alongside these regulations to ensure they are working effectively to deliver the outcomes intended for society.
- The planning system is also important in shaping more sustainable outcomes beyond those which are regulated in building codes. It must strike a balance that recognises industry need for consistency and predictability, and the need to recognise the uniqueness of place and to incorporate diverse community needs and preferences.
- Covid-19 has exacerbated supply chain shortages and increasing construction costs. As a result, fixed price contracts are creating significant financial challenges for many stakeholders. Industry planning and information sharing on supply chain and cost issues may help address this issue.
- Australian society is increasingly committed to climate action whilst also facing cost-of-living pressures. There is renewed pressure to address construction costs whilst improving energy efficiency and greenhouse gas performance across the industry and the building stock.
- Banks and insurance companies have a key role to play to help drive quality and performance outcomes. In concert with consistent and increasingly stringent building codes, the risk profile of low carbon and affordable building must be reduced in order to reduce costs and attract entrants into the low carbon construction market.

This section addresses the following key areas of industry transformation: building quality and performance; demand and market performance and; housing outcomes and affordability. It responds to RQ3: *What key innovations (including quality assurance, certification and compliance) exist to improve building standards and regulations towards climate-adaptative buildings*? and RQ4: *What innovative and emerging financial tools and contracting practices exist that help manage business risk for the building and construction industry, and can these serve to incentivise the production of affordable housing*?

The housing sector contributes around 17 per cent of total greenhouse gas emissions⁹³, and consumes up to 50 per cent of raw and recycled materials for construction and retrofit⁹⁴. The way we design and construct each dwelling has significant implications for numerous future households that will inhabit it, as well as for our national commitments on climate, and for the health of the planet.

Quality and performance are increasingly not just an environmental consideration, but also have wider economic and social outcomes⁹⁵. Improved dwelling quality and performance has been found to improve financial and social outcomes, while poor quality and performance has been found to produce the opposite.

While data on dwelling quality in Australia is patchy, evidence from elsewhere shows the extent of the issues we are facing. For example, in New Zealand⁹⁶ around half of all dwellings lack adequate insulation in the roof space, have no mechanical extractors to ventilation bathrooms, and have no heating in bedrooms. In Victoria, data from 2016-2018 found that only around 3 per cent of dwellings were built to a 7 star+ standard⁹⁷. The vast majority of dwellings have much higher than necessary energy bills to maintain comfort, creating an energy poverty problem.

In addition to exacerbating climate change and energy poverty, the impacts of poor quality and performance of housing affects human health and therefore brings health budget and population health burdens too. In the UK it has been estimate that the cost of people living in the bottom 15 per cent of dwellings has a direct financial cost for the National Health Service of £1.4 billion per year⁹⁸. Health benefits from improved design, quality, and performance include a reduction in respiratory disease, improved sleep, and a reduction of the severity of issues like arthritis, colds, coughs, and other milder ailments⁹⁹.

Broadly similar issues are faced across developed owner-occupier societies where there are significant housing affordability and cost of living challenges. A key cost of living issue has been the rapid rise of energy costs, placing more households in or near energy poverty¹⁰⁰. Research has found that renters and low-income households, who typically live in the poorest quality and performing housing stock, are at greater risk of experiencing fuel poverty¹⁰¹. For owner-occupiers, additional capital costs for retrofitting to improve housing quality and performance are offset through lower energy bills, and if savings are reinvested into home loans this can help repay home loans more quickly¹⁰². Research from the UK found that households in energy-efficient housing were less likely to be in mortgage payment arrears than those in energy-inefficient housing¹⁰³.

Australia, like many developed countries, has sought to improve quality and performance for new housing through the setting and revision of regulations¹⁰⁴. This is the most cost-efficient way to 'raise all boats' and set sector wide performance expectations. As recent events around the world with defects, flammable cladding and poor performance outcomes have shown, the risks of self-regulation - or of lax regulation - can be devastating¹⁰⁵.

IEA, "Net Zero by 2050. A Roadmap for the Global Energy Sector."; IEA, World Energy Outlook 2020.
Marinova et al., "Global Construction Materials Database and Stock Analysis of Residential Buildings between 1970-2050."

⁹⁵ Bower et al., "Trapped", 'Anxious' and 'Traumatised': COVID-19 Intensified the Impact of Housing Inequality on Australians' Mental Health'; CABE, "The Value of Good Design. How Buildings and Spaces Create Economic and Social Value"; Clair and Baker, "Cold Homes and Mental Health Harm: Evidence from the UK Household Longitudinal Study"; Daniel, Baker, and Williamson, "Cold Housing in Mild-Climate Countries: A Study of Indoor Environmental Quality and Comfort Preferences in Homes, Adeloide, Australia", Pevalin et al., "The Impact of Persistent Poor Housing Conditions on Mental Health: A Longitudinal Population-Based Study." 96 Stats NZ, "The State of Housing in Aotearca New Zealand."

⁹⁷ Moore, Berry, and Ambrose, "Aiming for Mediocrity: The Case of Australian Housing Thermal Performance"; UK Government, "NB2 Energy Performance of Building Certificates."

⁹⁸ Garrett et al., "The Cost of Poor Housing in England. 2021 Briefing Paper."

⁹⁹ Baker et al., "New Evidence on Mental Health and Housing Affordability in Cities: A Quantile Regression Approach"; CABE, "The Value of Good Design. How Buildings and Spaces Create Economic and Social Value"; Chapman et al., "Retrofitting Houses with Insulation: A Cost-Benefit Analysis of a Randomised Community Trial"; Pevalin et al., "The Impact of Persistent Poor Housing Conditions on Mental Health: A Longitudinal Population-Based Study"; Willand, Maller, and Ridley, "Addressing Health and Equity in Residential Low Carbon Transitions – Insights from a Pragmatic Retrofit Evaluation in Australia." 100 Boardman, "Fuel Poverty"; Lawler et al., "Homes and Health in the Outer Hebrides: A Social Prescribing

¹⁰⁰ Boardman, "Fuel Poverty", Lawler et al., "Homes and Health in the Outer Hebrides: A Social Prescribing Framework for Addressing Fuel Poverty and the Social Determinants of Health", Middlemiss, "Who Is Vulnerable to Energy Poverty in the Global North, and What Is Their Experience?", Sovacool, Lipson, and Chard, "Temporality, Vulnerability, and Energy Justice in Household Low Carbon Innovations", Sovacool et al., "Dispossessed by Decarbonisation: Reducing Vulnerability, Injustice, and Inequality in the Lived Experience of Low-Carbon Pathways."

¹⁰¹ Middlemiss, "Who Is Vulnerable to Energy Poverty in the Global North, and What Is Their Experience?", Porto Valente, Morris, and Wilkinson, "Energy Poverty, Housing and Health: The Lived Experience of Older Low-Income Australians", Sovacool et al., "Dispossessed by Decarbonisation: Reducing Vulnerability, Injustice, and Inequality in the Lived Experience of Low-Carbon Pathways."

¹⁰² Moore, "Facilitating a Transition to Zero Emission New Housing in Australia: Costs, Benefits and Direction for Policy."

¹⁰³ Guin and Korhonen, "Staff Working Paper No. 852 Does Energy Efficiency Predict Mortgage Performance?" 104 IEA, "Building Envelopes,"

¹⁰⁴ IEA, "Building Envelopes." 105 Oswald and Moore, Constructing a Consumer-Focused Industry: Cracks, Cladding and Crisis in the Residential Construction Sector.

4.1 Building quality and performance

Across the jurisdictions covered, regulations were universally reported to be the cheapest and most effective way to improve performance and lift affordability and innovation. The design of this regulation is important and aspects of the latest changes are resisted by some in the Australian building industry. Linked to this, the emphasis on self-regulation and general lack of certification and oversight is problematic for quality – an issue that is also found in the UK:

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There's nothing wrong with the regulations. If you build to the regulations, we wouldn't be where we are. It's because you have gamed the system and no one has enforced against you gaming that system, that we are where we are. (Senior construction safety expert, UK)

We would like it [more regulation]. So, it's particularly in the domestic RMI sector, anyone can call themselves a builder. So, there's no registration. There's no licence. I'm not a builder, I could go out with [their colleague] this afternoon, and we could go out and say, we can do home maintenance work, and just be up on a ladder and I could be ripping out a kitchen. I have no experience. No, it's perfectly legal. (Construction association senior executive 1, UK)

We do have some pockets where bad behaviours have existed. Testing, gaming the system, trying to get that market edge. (Construction product executive, UK)

While there was broad support for improved, consistent and wellimplemented regulation, there was also emphasis on the need for more quality and pride in workmanship:

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Not everything has to be regulated to make it work. We just have to get that sense of, you've got to do this better. (Construction products expert, UK)

With this idea of quality and pride in workmanship in mind, EU policy-makers in Brussels are trying to reduce some of the regulatory burden to streamline the process and make it easier for households:

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Yes, you need building permits. Now we tried to lessen the constraints... the code has been adapted so that minor works now can more easily be done without a building permit. For instance, if people change their façade windows, before you needed a building permit. Now if you're doing it with the same aspect, with the same sizes... you don't need the permit anymore. ...the new code tries to simplify those things, but you need permits for quite a lot of things. (Senior policy maker, Belgium)

In the UK it was noted that several seminal reports have shaped policy and industry change over 25 years, since the 1998 report *Rethinking Construction: the report of the construction taskforce*¹⁰⁶ which explored opportunities for improving quality and efficiency of the construction industry and providing greater benefits to the customer. Another key report was the *Construction Strategy 2025 Report*¹⁰⁷ published in 2013 which was about scanning forward to 2025 in terms of what type of industry the UK should be developing. The more recent report by Dame Judith Hackitt (*Independent Review of Building Regulations and Fire Safety: Hackitt review* in 2018¹⁰⁸) has also driven more recent policy developments and changes in the industry. Its purpose was to make recommendations that will ensure a sufficiently robust regulatory system for the future and that residents feel that the buildings they live in are safe and remain so.

The consistency and foreseeability of regulatory requirements is perceived to be a significant barrier to raising efficiency and standards and reducing risk and costs. Various governments preside over regulations of different types and scope, and successive administrations often seek to reshape those of the previous administration. This adds cost and uncertainty, and entrenches delays and confusion across the industry.

Even where regulation is widely seen as useful, in can take time to implement. For example, a participant (Building safety regulator 1, UK) spoke about developing a new national regulator for construction products and it taking about three years from inception (2021) to having full powers (2024). This new regulator oversees a more effective construction products regulatory regime

¹⁰⁶ https://constructingexcellence.org.uk/rethinking-construction-the-egan-report/ 107 https://www.gov.uk/government/publications/construction-2025-strategy

https://www.govuk/governmen/publicuturis/construction-ZUZs=strategy
https://www.govuk/government/collections/independent-review-of-building-regulations-and-fire-safe ty-hackitt-review

and co-ordinates market surveillance and enforcement¹⁰⁹. This is predicted to help address a significant governance gap:

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We haven't had a national level of scrutiny of construction products regulation prior to that. That's been done by local authorities previously. There's a mismatch there because they would have to go after and prosecute in that area. But actually, the problem is most likely to be a national one. So that will be a step change. (Building safety regulator 2, UK)

The UK has also recently implemented a new Building Safety Regulator programme, created under the Building Safety Act 2022. This programme is responsible for overseeing the competence of everyone working on all buildings:

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We will be the regulator for high-risk buildings, and that is a building over 18 metres, or seven or more storeys which contains at least two residential units...So, we are setting up our own programme to, effectively, regulate the regulator, which is never been done before, so it's challenging. (Health and safety regulator, UK)

Another recent development in the UK is the Code for Construction Product Information and assessment process. This is an independent, voluntary, not-for-profit scheme. It is specifically 'about making sure that misleading claims on product information are a thing of the past' (Senior construction safety expert, UK) by addressing leadership, culture and behaviour of the industry. Key to this scheme is the development of robust and transparent data.

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EXAMPLE:

In addition to these schemes, the following initiatives have, or are being, developed in the UK:

- 'BSI Identify'¹¹⁰, developed by the Construction Product Association, and which aims to increase the identification and transparency around construction products by providing a unique digital identifier for a particular product.
- 'LEXiCON'¹¹¹, developed by the Construction Product Association, and which aims to establish a common language across the sector so that everyone is working from the same set of definitions and understandings to provide a 'golden thread of information'.
- Construction Leadership Council (CLC) which aims to bring together all the trade and professional bodies from the construction sector.
- Part of the CLC, the **Product Availability Group** represents key sectors of the construction industry products in the UK. It provides monthly updates to the industry regarding supply shortages and implications over the coming months and helps the industry to better adjust to changes in the supply chain and with cost changes.

109 https://www.gov.uk/governmen struction-products-factsheet There are still significant gaps in policy and regulation in the UK. Concerns around product substitution were raised emphatically as follows:

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Has regulation kept pace with construction? No. But I think it's wider than that. I've seen a gradual erosion of quality standards, of responsibility, of delivering what we're supposed to deliver... I take this back to the widespread use of design and build contracts in the UK... Contractors take control of a whole project... That led us to the fact that we will build it as fast as can and we'll build it as cheaply as we can. That led us to issues around substitution of products. A lot of those substitutions are not talked about, not known, not discovered. We then have a situation where we have – with greatest respect to colleagues in the regulatory side of the discussion – very little oversight, very little focus on what's actually happening... We're just interested in tick box and filling the paperwork. (Construction product executive, UK)

Others noted the issue of compliance:

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For a lot of things where it's falling down is the policing and the monitoring of these things... if the process is followed as a process should, I would say it's right. Sometimes where it falls down is where we aren't doing the checks. (Housing redevelopment director, UK)

Compliance issues extend to other areas of the industry as well. For example, there are ongoing challenges across the industry to ensure that products are certified and labelled correctly and that what is specified is what is delivered. There are mixed opinions on how to achieve this, with some stakeholders suggesting that government needed to improve processes and compliance checks, while others felt that industry could improve outcomes through culture change. However, clearly, improved regulation and oversight is needed whichever route is taken, given that the industry has not accomplished significant progress on uptake of properly certified and sustainable building inputs in place of standard ones. There has been reports looking at this issue such as *Setting the Bar*¹¹², from the UK's Construction Industry Council: "

When we were thinking about who is best placed to lead which bits of change and so on and so forth - obviously, government has to lead the legislative change and the regulation change. But in terms of the competence and culture change, well, culture change, maybe, that's a push in both sides. But competence I think we really felt that needed to be industry led. (Building safety regulator 2, UK)

These issues of compliance are not limited to just the UK but was also raised as an issue across Europe:

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We've already had wood pellets sold on the EU market... and they couldn't work out why there was radiation in the house. This wood was cut out of the Chernobyl forest, illegally, because there was so much money to be made out of wood pellets. That's the reality of the market... about regulation, there is no market surveillance. We need more surveillance, and that can be done through digital tools. (Construction products lobbyist, Belgium)

An important initiative regarding the safe conduct of workers on site is the Considerate Constructors Scheme (CCS; see 1.3), which covers around 60 per cent of construction across the UK each year. CCS covers three key areas: community, the workforce and the environment. The scheme is about complying with minimum regulations (e.g., Health and Safety Executive standards), and also exceeding them. The scheme aims to address a range of issues which may emerge during construction, such as work occurring outside of specified hours, or parking in the area being difficult. In the past year the scheme has introduced 'stretch standards' designed around achieving a carbon net zero future. The scheme also seeks stronger accountability outcomes:

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It inspects and monitors behaviours on sites to help construction be liveable, effectively, for local residents.... they're not trivial things, they're super important...We've brought in stretch standards which were all about things like biodiversity, [net gain] and measuring for carbon net zero. Really built it up that way. But absolutely core to the scheme is there's a very big telephone number on the side. If you're a member of the public, you can phone up and tell us what you're concerned about. (Senior construction safety expert, UK)

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It was also noted that there has been limited focus on consumer protection as a lever to drive change across the industry:

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As a regulator, we often think about a triangle with the business in one corner, the consumer in another corner and the regulator in the third corner...In this market, there is no consumer lever because consumers are far removed from the construction products. There's been no active regulation or very little active regulation in the product space for some time... So, it's that lack of regulation and consumer, two sides of the triangle – two corners of the triangle are entirely missing. That's what we need to address on the product side. (Building safety regulator 1, UK)

What many of the points above talk to is the importance of transparent information or the 'golden thread' of information which could help unlock other issues across the industry such as compliance:

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All the engineers just talk about the golden thread. They absolutely just think it is the most important thing because it's tracking the original plans, the design, the sign off as it was built. Handing it over to the accountable person, who then needs to keep it updated. If there's any refurbishment work, if there's been a hazard, if you've had a Mandatory Occurrence Reporting incident et cetera. That information needs to be maintained in a way that people can access it, so that you've got that golden thread of information. (Building safety regulator 2, UK) The idea of a 'golden thread' of information was central to the recommendations of *Building a Safer Future*, Dame Judith Hackitt's review of the Building Regulations and fire safety. In response to broad concerns about the ineffective creation, maintenance and handover of building and fire safety information, which create significant safety challenges, a golden thread of information for all higher-risk buildings was proposed 'so that their original design intent and the detail of what was built would be preserved, and changes managed through a formal review process'¹¹³. Furthermore, continued access to up-to-date information is key to maintain building safety throughout the life cycle of these buildings.

Regulation of building control bodies, in the context of the Building Safety Regulator (BSR) becoming the regulator for high-rise buildings, is limited by resources and it still requires industry to be proactive in compliance:

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The thought has been raised already that prescribing something isn't really going to do much. So, our oversight of building controls are going to be about the delivery and the effectiveness of them. Are they performing in practice? Can they show that they're planning their work effectively? Can they show that they're taking a risk-based approach to planning their work? Are they making best use of whatever resources they have? Obviously, different authorities have different levels of resource. (Health and safety regulator, UK)

Consistency is key. As introduced above, it was noted that there are challenges with ensuring consistency across jurisdictions, and one participant pointed out the challenge where powers are devolved, such as in UK and Australia:

113 Sharma, "How Will the Golden Thread Work in Practice?"

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Of course, in the UK, we also have the devolved regions as well. So, slightly different in Wales, slightly different in Scotland, slightly different in Northern Ireland. Actually, that's kind of one of the points as well, from my perspective, working with cross state and Australia, it's quite a different approach that's been taken in Australia, and what surprises me at times is the lack of reciprocal thinking. How is an industry going to work across state?... it's very different regimes across states, and that's going to add some confusion to issues like competence and how you professionalise the industry. (Construction association senior executive 2, UK)

This raises another aforementioned issue in this report that kept being raised, namely; the push to further upskill and train the professions and ensure minimum levels of competency and certification are sufficient to provide a reliably high-quality result:

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There is a big focus on the professions and the trade associations to make sure their members are competent, trained, CPD'd properly, and that regime is being worked on through the [secondary] legislation at the moment, through the UK parliament, and there will be a slightly different approach taken in Scotland, but it will be the same apart from the building control aspects. So, the regulator will have teeth. (Construction association senior executive 2, UK) There is a change underway in the UK to improve the ethical and sustainability skillsets of people entering the industry. For example, there are discussions occurring in the engineering community about how to teach ethics to students at university so they have that grounding before entering the industry. There is also increasing requirements to maintain competencies through regular continuing professional development (CPD), although this was not required for all professions which created some challenges around quality:

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There are some areas which I'd pick out where we don't have enough of that. But certainly for professionals, for architects, for engineers, for building surveyors, all of the duty hold roles have a very specific CPD programme and some very specific education. I have to say, though, when you hold a mirror up and you say to all of them, can you today prove to me that all of your members are currently competent? The answer is no... I think from next year, if you're a member of the IRBA and you have not done the requisite health and safety training, you will be marked done and eventually excluded from the institution. So, there's a growing number of organisations that are pushing this. (Construction product executive, UK)

Do not underestimate the importance of this whole issue of less than satisfactory CPD, which is what we've had for a very long time. I've been to a number of conferences where I've been handed bits of paper that says, you want this for your CPD certificate. So, just attending conference gives



you points and, clearly, that's a nonsense...The whole system has got to be tightened up. We've got to be very clear what knowledge is required and how you keep that up to date. But again, do not underestimate how difficult that is. Because what you're actually dealing with here is people who believe they are competent and they have 20 plus years' experience. We are encountering, right now, people in the system who are saying, what do you mean I need to retrain? I need to get requalified? I know what I'm doing. Well, actually, you don't. That's really quite tough. (Senior building regulation expert, UK)

It was also noted that CPD was also a barrier for faster regulatory change:

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When a new building reg has been introduced in the UK, it takes at least two years for it actually to be deployed properly and understood. That, to me, is quite tragic. People should be getting ahead of the topic, not following it. (Construction product executive, UK)

Minimum levels of compliance, competency and liability was seen as critical and there was a view that these would have to be regularly reviewed and further improved moving forward. Related to this, in cases of accidents on sites, the UK's new building sector regime is designed to ensure consumer protections:

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This is where the new building sector regime will track that situation better. Even though in headline, our health and safety regime is very much focused on tall buildings, and everything around that, the detail within the Act [Building Safety Act 2022], also will create a regime where, in that scenario, ultimately, even if the original company had folded, the liability will be traced through to an individual, and if that individual isn't even in that company anymore, is with a different company. It's going to have quite a correct, but significant impact on the smallest part of the market. But then another problem with this is that this Act is still - the details are still being worked out...and then need to be tested ultimately probably in the courts to really demonstrate the efficacy of them before it's widely known that that protection then does exist. (Industry association representative, UK)

Increased focus on building a strong, fair and accountable industry culture and leadership across the construction industry in the UK has been a focal point since the Grenfell disaster which highlighted various shortcomings in the industry. There was recognition from a range of stakeholders that regulation on its own was not the answer to solving these issues but that wider systemic issues across the industry needed to change from within the industry itself. The focus has been on moving away from 'cheap and quick' transactions to quality outcomes. For this, regulators need actual mechanisms and resources to pull up those in the industry who fall short of expectations:

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We had to put a huge amount of effort into getting industry to see its role and its purpose very differently, and to move away from do it cheaply and get out. Get into a place where this is about delivering safe homes for people. That culture change thing is very important. (Senior building regulation expert, UK)

Changing that culture from one of everyone else can tell us what to do, to self-assurance and making sure that we deliver compliance... The internal audits are turned from quality audits into just quantity audits. We're now trying to reverse that and take on that responsibility, so that we can face the regulator that is going to be tougher and is going to say, prove to me that you have complied. (Construction products expert, UK)

You can have all the regulation, you can have all the systems and process, you can have whatever you like. But at the end of the day, people's behaviours – although will be partially driven by regulatory demand, it won't completely be. They're driven by all the truths that they have understood themselves, all the stories that they tell themselves, all their own behaviours that are well entrenched. That's where the culture piece starts to be very important in this conversation... (Senior construction safety expert, UK)

In the UK effort was put into learning from how other industries are doing this better:

The construction sector does not accept that major hazard is part of its responsibilities. Never has done. Until it understands that and fundamentally changes its thinking, we won't get a change of behaviours... There are lessons from other sectors [e.g. the water sector] that we can really pick up here when we put together the Building a Safer Future Charter. (Senior construction safety expert, UK) This change has been guided by several reports which have been developed in recent years including the *Built Environment* - *Proposed construction product competence standard* - *white paper* ¹¹⁴. There is support for the calls for development of a system of compliance identified in these reports. However, there are also concerns that the industry is not prepared for the changes and is in a state of denial as to the extent of the issues:

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you can't just sort of faction off one part of the industry and say, all the problems are there...there's a sea change that's coming. I'm still not 100 per cent sure that the industry in the UK is fully aware of what's about to [come]...and that

114 Construction Products Association, "Built Environment – Proposed Construction Product Competence Standard – White Paper." includes the professional bodies, as well... We're quite good at preaching what's right, but we've actually now got to think about how we actually deliver that in the right way. (Construction association senior executive 2, UK)

But the brutal reality is... we're still in a bit of a phase of denial... It's almost, yes, we accept there needs to be leadership and culture change... Now, even though there are frameworks, like Building a Safer Future Charter framework, we have - we're not seeing fast enough engagement with it. It's just while the sector slows down the conversation, while it's seeking to absorb what's happening with regulation. For a long time it's been,'we'll wait until the regulation comes'. (Senior construction safety expert, UK)



Case-study 20:

Changes and challenges of the building regulatory system in Ontario, Canada

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A range of national and local building and planning regulatory changes have been occurring in Canada in recent decades. The National Building Code of Canada is a model code developed by the National Research Council of Canada. However, constitutionally, provinces and territories are responsible for housing and building regulation. Ontario only updates its building code every five years, with interim amendments in-between and has been working to improving links between building codes and planning system.

Transformational change to the building regulatory industry was with the introduction of Bill 124 (*Regulatory Statute Amendment Law Act*) around the years 2005-2006:

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That standardised the way building departments operated, so that's when they brought qualifications out for building officials. They standardised the application form. There are other standardisation processes that came about. It was a great endeavour, because that assisted us, in regards to the departments that accept building permits, to assist applicants through standardisation. Again the code was always there from a standard technical perspective, but what that did was set the stage in regards to us working with the ministry and developers across the province. (Senior building regulator, Canada)

However, Bill 124 had limitations:

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One of the failures of Bill 124 back in the day was that we had builders initially involved in the system, but then the government at the time said no, no, no, we've got to take builders out of the system, because we really want to focus on building officials. We don't really have any kind of, at least as a ministry, oversight in terms of builders. (Senior housing policy maker 2, Canada)

While Bill 124 has improved some aspects in Ontario, it was reported that there are ongoing challenges with interpretations of the Ontario Building Code, which makes it difficult to implement and process planning applications and causing delays for projects. There has been an effort towards standardisation: The reality is that when you look at such a document, the Ontario Building Code - and it's two four-inch binders it comes down to interpretation, so you still get a variation of interpretation across municipal building departments. That's what we try to streamline through these conversations with the ministry and our working groups...If there is an anomaly in regards to how we are reinterpreting a certain section or article in the code, we have these direct conversations with ministry staff and then we disseminate that through our working groups across the province to ensure standardisation. Over the last few years, we've seen an abundance of changes through the code. (Senior building regulator, Canada)

It seems crazy. We wrote the building code, but we're not allowed to tell people how we think that should be interpreted or what it meant. (Senior housing policy maker 1, Canada)

There are also challenges in getting planning applications approved, because there are many different authorities involved in the process. The example of designing and building a coffee shop. While the building code is consistent across the 444 local municipalities, each require to learn a new zoning bylaw, site plan process, ministries or conservation authorities, or paths of approval, which is extremely time-consuming:

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You have to constantly relearn and rethink these processes that affect the design of your building... It would be great to have one zoning bylaw across Ontario.... (Senior building regulator, Canada)

In this process, digitalisation and standardising drawings is key to ensure time is not wasted duplicating drawings:

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we're looking at how do we standardise the actual drawings that get submitted...We're trying to do that to see if we can create some type of system so designers don't always have to retool their drawings based on municipalities' needs. That got complicated with the digital world, because we were forced



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into that through the pandemic. We jumped from paper to digital very, very quickly. (Senior building regulator, Canada)

Digitalisation was perceived as being more advanced in the realm of building compared to planning:

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The building departments have been really good at getting the building code digital and doing the reviews digitally... The planning world has not really gone that far digital... (Senior housing policy maker 2, Canada)

A number of benefits around digitalisation were mentioned including speed, efficiency, transparency, collaboration and standardisation. It was also noted that artificial intelligence (AI) may have a role to play in digitalisation moving forward:

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That's another beast we all have to figure out in regards to are we going to go down that way or do we use AI. They're integrations where you almost have a mothership where that's your portal and it learns how to interact with the 444 different platforms. But that would have to be governed potentially by the ministry to say, here's the Ontario portal. You want to apply to Burlington? Here you go. It pushes the data down. (Senior building regulator, Canada)

Additional development for the building code and planning system is around modular construction and accessibility:

We just recently signed a memorandum of understanding between our ministry and the Accessibility Standards Canada. Basically, one of the things that we're hoping to come out of that is going to be a modular component of how, if you wanted to build higher accessibility standards, then you could opt into that... The technology's there, so if we're going to have a quicker way to build housing that makes it hopefully cheaper, then allow it to be used in a stackable form in multiunit residential. Again there's another example where regulators, do your best to be nimble. Get out of the way. Don't be there as a barrier for industry. (Senior housing policy maker 2, Canada)

4.2 Demand and market performance

Ontario is an example of where the market drove changes ahead of regulation. This was largely led by private industry looking for market advantage. It meant that when regulations did improve, over 20 per cent of the industry was already building to that level. This is different to Victoria where data from 2016-2018 found that 86 per cent of new Class 1 housing was built to only meet the minimum standard, and around 3 per cent were being built to the soon to be mandated 7-star standard ¹¹⁵, demonstrating a difference in how the markets are operating:

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The reason Ontario got so far ahead in terms of energy efficiency is because there was a private marketing drive to do that on behalf of private industry themselves. They pushed high-performance houses...innovation happens once there's pull-up in the market. (Senior housing policy maker 1, Canada)

The improved energy efficiency of housing in Ontario was perceived to add additional costs to construction. However, there was also the perception amongst builders that they were accounting for this additional cost in how much they would pay for land, therefore paying less for land than they had previously, resulting in no positive increase in costs from improved performance requirements (e.g., the land value decreasing to absorb additional cost).

In the US, effort has gone into providing support for the construction industry to go beyond regulatory minimum standards. For example, the DoE has provided education and tools for net zero energy ready homes to builders with opportunities for them to market this type of housing:

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Here's the standard we think it should be, this is based on our best interpretation of the science and what we think is reasonably achievable today. With commonly available materials and approaches...the zero energy ready home designation is meant to be the seal that says, this is meeting this standard and we've certified that standard. So it allows someone to market it that way. (Senior energy policymaker, US)

Also, significant Federal investment through the Inflation Reduction Act of 2022 has spiked demand in the building and construction industry to the extent that there are concerns about whether there is sufficient labour to meet demand:

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You might have seen the Inflation Reduction Act just put \$370 billion worth of investments in the construction of clean energy facilities like electric vehicles and carbon sequestration and, you know, solar and wind and hydro and all these things. That's going to have another demand on our labour supply. (Construction association senior executive, US)

There are a range of issues emerging in the US which are going to impact on the housing market for the foreseeable future. This includes the challenges around urban migration and a poorly maintained housing stock which needs to be significantly updated or replaced:

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We're seeing a lot of that [urban migration] driving demand. Interest rates were really, really low too. Everything was cheap and affordable and people were upsizing and buying second properties and they're, Airbnbing it out. It's just all kinds of new disruptive stuff happening here as globally... All this stuff is aging out. We're 70 years into a lot of this stuff, so we need to replace our bridges and big infrastructure projects that have been poorly maintained frankly, for a long time. Also, a lot of our homes are ready to be turned over. (Construction association senior executive, US)

An additional challenge is that, like Australia, the low-rise residential construction industry is dominated by subcontracting arrangements with small businesses who do not have the resources or capacity to invest in strategic innovation. More than 85 per cent of companies

¹¹⁵ Moore, Berry, and Ambrose, "Aiming for Mediocrity: The Case of Australian Housing Thermal Performance."energy security and energy productivity are driving countries to improve energy and thermal efficiency of their housing. Australia established a Nationwide House Energy Rating Scheme (NatHERS)



in the construction industry in the US have less than 100 employees (Construction association senior executive, US). Even the larger companies in the industry operate more like a coalition of smaller companies, where their innovation model is based on optimising existing practices, and where as a result, they lack resources, processes or capacities to undertake strategic innovation:

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Probably the biggest hindrance to innovation is the fact that this industry is dominated by small companies. Small companies don't have a culture of investment... Innovation requires that you co-operate, and but at this - in our current time there is so much work ... that if a builder or contractor tries to innovate [it] makes things more difficult.... Say, no, thanks, I don't want that job, I'm going to go to other jobs who are willing to pay me money so that I can do things the old way, because they're making money at that. (Housing market expert, US)

This illustrates the fact that this subcontractor-based industry can only strategically innovate if they are prompted to do this in concert, together, in other words, through regulation-led innovation. Regulation-led innovation, such as that occurring in order to meet increasing building code stringency, is a successful innovation model for subcontractor-based industries that cannot innovate in the same way as those industries where there are major vertically integrated corporations with access to global capital for innovation purposes.

In the EU, effort has gone into peer-to-peer learning and exchange:

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We feel as an administration that it's far more impactful if you have a peer saying, I had a doubt to renovate to a passive building because of those reasons, but I did it, and now that's my feedback. I'm very happy. I would do it again. That's really what you want. (Senior policy maker, Belgium)

On the demand side, there is an increasing understanding that households are not generally in a position to be able to initiate and self-guide their way through procuring innovative buildings or building renovations. They have limited knowledge of emerging technologies and in a market-based system they are faced with conflicting messages from sales staff of different technologies. In order to help address this, Homegrade¹¹⁶ was introduced in 2017 in the Brussels region as a 'one-stop-shop' model and 'accompaniment from beginning to the end of the renovation process' (Senior policy maker, Belgium) that enables owner-occupier households (and to a lesser extent landlords and renters) to seek advice on how to improve their dwellings:

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that is a place where households can go to have advice for improving their building. So, not only for energy but also for Europeanism for the healthiness and the comfort, the security of their building... the first steps will be typically,

what's an action plan, what are the major things I have to do, in what order. Then where do I find a good company and what should I look for when I'm trying to find a good company? How do I finance my work? How do I check if the quality of the work is well done? So [the whole of that chain], people will be able to find their answers in that one-stopshop. (Senior policy maker, Belgium)

Recent work that seeks to create new understandings across builders and consumers has emerged from the price spikes in materials post-Covid, and the difficulties builders have in honouring contracts where materials costs quoted were much lower than at the actual point of commencement of construction. This was identified as a significant problem in all jurisdictions. Some stakeholders in the UK and across Europe have been working with their members or wider construction community to introduce flexibility into contracts. However, while some in the industry (including customers) are responding well to these proposed changes, not everyone is accepting it and there is a feeling that it will take several years to rebound from financially difficult few years. This is challenging for an industry which historically has operated with low-cost margins and in the context of other market changes such as the Value Added Tax in the UK:

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We've been providing a lot of comms to our members to support them in having those conversations with their clients and managing the client relationship around, you may have quoted something at some point, but then six months later when you turn up to do the job the reality is very different. We've been working to build flexibilities into our own contracts to try and manage the impact of changes in input prices, which has been positive for those members who use them. (Industry association representative, UK)

Some clients will say, no, it's a fixed contract, I'm not prepared to budge on it...Some clients are, okay, we understand, we're hearing in the media that prices are going up, we don't really want to pay more. If you can prove that prices really have gone up, yes, we will contribute a bit to that. Some clients, even if you put in a flexibility clause, want that taken out. (Construction Director, UK)

In comparison to two years ago, that is a lot of problem, because, projects we do, civil works, are normally for the government, so we have price revisions, with formulas that are in the contracts, so, we are paid more. We also have to pay more to suppliers, but there is always a gap, because the formulas don't cover the complete cost. Okay, there's a risk, but for our department that does buildings, those are fixed prices, and that's a bigger problem now, but we start to see that the projects that were ongoing, we're finishing them, but there aren't new projects coming, because nobody is investing for the moment, because you have to pay twice the amount as two years ago, to put up the same building, but no one will rent it or buy it from you, so, that market is very quiet, for the moment. (Project manager, Belgium)

In Australia, the head contractor or builder takes all of the risk, whereas it is different in Belgium where the risk is shared with subcontractors and suppliers.



4.3 Housing outcomes and affordability

A number of rebates are on offer in the US and across the EU to help make energy efficiency more affordable for households upfront and to help incentivise people to go beyond minimum requirements.

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We try to give some money back and offset the cost of the home by meeting standards. The section 45L of the new act we just did is a 5,000-tax credit per home or dwelling unit that is zero energy ready certified. So, the government right now is in the process of trying to figure out how to incentivise the adoption of energy efficiency [unclear]. So, that's a fairly significant piece in this new inflation reduction act. The IRA [Inflation Reduction Act] bill just got passed. There's some question, there's others also benefits in there, not only for zero energy ready homes, but there's solar benefits and we're trying to figure out if they are stackable or not. (Senior energy policymaker, US)

We are analysing a possibility to do a kind of loan without reimbursement. So, the region would give the money to people so that they can retrofit and then people could live in it without having to repay, but the moment that they resell their house the loan would be repaid...Some other regions in Belgium and France, they're already experimenting with that. (Senior policy maker, Belgium)

There is also engagement with financial and insurance institutions to get them to recognise the benefits of sustainable buildings and the reduced costs and risks associated with them:

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The basic conversation is that if the home is a better quality, it's less risky basically and also lower cost to operate so that risk element of the interest rate that the bank has, they can adjust that based on the fact that it's a less risky building... if we can reduce the risk, maybe the insurance company can adjust that....That takes some enlightenment, but I think the larger banks and larger insurance companies have the people to start to appreciate what that means and for them to quantify that for themselves. You can reduce risk, that means it's a lower cost to us so that's actually good right? That's also a competitive market too. It's Zurich, Willis and insurance companies and a whole bunch of banks in the US. So, if they can reduce their loss portfolio, it's helpful to them. Everybody benefits. (Senior energy policymaker, US)

In the EU, other mechanisms are also being implemented to drive change. In Brussels, the local government has introduced a requirement that rent rises must be tied to quality and performance requirements. The intent is to incentivise landlords of poorer quality housing to make improvements:

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So, in the Brussels population we have kind of one third of people who are under or just at poverty level. So, that's really a tricky one. Everyone deserves a good quality house, but there is an economic aspect as well. Now in the energy crisis moment the Brussels government just decided that's an [indexation] of the rent will only be possible if the owner has a good certificate. So, people with a F or a G certificate of their house, for the moment they cannot make an indexation of the rent. So, just to mention, it's really an important issue. (Senior policy maker, Belgium)

It is also about enabling scale:

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One great project for the moment is a neighbourhood where people got together themselves, made a group, and said let's try to renovate our group of homes. It's really complicated. So, they have a grant for RENOLAB to help them figure out because they have Europeanistic constraints, they have all kinds of constraints. It's just difficult, but we feel that there is a huge future in collective renovations because people are stimulating themselves. You can have a scale advantage. So, that's a constraint that we would really like to attack. (Senior policy maker, Belgium)

Protections for renters are particularly important in Belgium where, like Australia, there is a housing affordability crisis that bifurcates the population into 'haves' and 'have-nots'. Homeowners enjoy tax breaks and rewards for their status, and this pushes up prices in the competitive housing market beyond the retail price index. The result is that renters fall further and further behind over time: "

Almost everybody in Belgium wants to own a house. If you go to Germany or the Netherlands, or France, it's not like that. The government made a law that if you buy a house, and you have a mortgage, you can deduct it from your taxes, partially...what happened over the decades, houses became more expensive, because people had more money, because they get back from taxes, but what you get back, you also have to put in, otherwise you cannot buy a house. What you see now is that houses are getting, each year, five per cent to 10 per cent more expensive, but people don't earn that much more. So, we're beginning to get a problem that not everybody can afford a house, especially young people. (Project manager, Belgium)

In the UK, the Grenfell Tower tragedy understandably casts a long shadow, and safety is another priority consideration alongside cost and sustainability considerations. Attempts to link safety and sustainability hold promise but, according to one participant, they also risk overwhelming the sector with change agendas: We talk about greener, safer buildings - they naturally come together. In thinking about culture and leadership, command and control, leadership in culture is not going to help us deliver putting building safety first, any more than it will help us with climate change and sustainability issues. So, there's a sort of culture change levers there that we're looking for when we're looking through Building a Safer Future. Or the Code for Construction Product Information. Either of those, they relate absolutely to the sustainability and climate change challenge just as much as building safety. But, in looking at how to bring those two stories together, it's a bit about timing... The building safety conversation is complicated enough. When you then start to say, by the way, we can bring this together with carbon net zero and climate change, there are lots of individuals who are excited by that, see the vision and the opportunity with that. But actually, if you're talking about getting into those sub-sectors in the industry, there is the question of when to do it? So it doesn't end up watering down and almost overwhelming organisations with change. (Senior construction safety expert, UK)



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A contrary view was also put forward, that the sector cannot afford to prioritise one agenda over another as this risks repeating the mistakes of history:

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Some of the mistakes that have been made previously have been because we've allowed one thing to take precedence over another. I'm absolutely sure that many of the buildings we've got that have been clad after they've been built here in the UK, it was done for reasons of energy efficiency. That was front and centre in people's minds and they forgot to think about fire safety. So, it's absolutely essential that all of these conversations, going forward, have to avoid any suggestion that one's more important than the other. (Senior building regulation expert, UK)

Another UK participant concurred and emphasised the scale and seriousness of the retrofit and sustainable building challenge:

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We need to keep the two in balance. If you look at some of the statistics, notwithstanding the horrific [nature] of Grenfell, actually over the year more people die from heat or cold in buildings than they do in fires. ... So, we do need to think about it in that way. (Building safety regulator 2, UK)

Another perspective on the links between sustainability and safety centred on confidence, in particular, challenges in building public confidence in sustainability in an industry where there have been catastrophic safety failures:

I think there's absolute parallels. If there's a lack of confidence in the safety performance of products, what confidence can we have in any other parameters? Especially for net zero. As a regulator, we've been dealing with the question of trade-offs in all the other products we regulate. (Building safety regulator 1, UK)

Case-study 21:

Creating legacy, Birmingham 2022, UK

As introduced in the preceding sections, this project was part of Birmingham City Council's bid to host the 2022 Commonwealth Games. The ambition was to host 6500 athletes in the villages with all associated logistics, and then for it to become mainly affordable housing for local residents. The project was 'a government backed project to start with... pump-primed by the government. So, the government, through its agency, Homes England, made a significant investment into this project to make sure it was very much seen as being that future legacy project.' (Project director and senior executive, UK):

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The fact that Birmingham could effectively guarantee a major residential scheme as being at the heart of its offer, being the athletes' village, that it was connected to the city, that it was part of a very big, wider regeneration programme, it ticked a lot of boxes. Birmingham could effectively provide an offer where 75 per cent of the assets that were required for hosting the games were already built or in the process of being built. It was basically the stadium... and then the aquatic centre which would be the two primary new builds. (Project director and senior executive, UK)

Comparisons can be drawn between the London Olympics, where large scale regeneration was undertaken, in public-private partnerships, in order to host the Games and then utilise the assets for housing and various employment related purposes. A participant referred to the decentralisation process from London to Birmingham, an impetus brought by the Games such as other infrastructure development with the intention to raise the profile of the city:

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I think where UK policy has been going of recent, over the last sort of 20 years... they've used the term levelling up. It's been about the shift away from London and trying to push things back into the regions and also to go back up north. There's a very big project called HS2 which you're probably familiar with, which is a high-speed rail link running from London to Birmingham...[people] were promoting Birmingham as going into what is called its golden decade of future events and building. (Project director and senior executive, UK)



Photo credit : Louise Dorignon



There was community opposition to the redevelopment of the Sandwell Aquatic Centre at a time where there was a lack of information around the delivery of the games. However, this was offset against the benefits they would get in terms of legacy:

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Unanimously, they came on board once we got planning and once we'd taken possession of the site... We were meeting the local community every four months, roughly... In terms of legacy, they can all see they're going to get a fantastic swimming facility or they're going to get a brand new football pitch out of it, or whatever it might be that their children want to use, so that was an easy win. (Project director, UK)

The Glasgow Commonwealth Games sought to ensure a positive legacy for the city beyond the event itself. Regeneration of parts of Glasgow were undertaken, raising questions and challenges to ensure the benefits would be disbursed appropriately to help Glaswegian workers and residents. Strategic thinking about infrastructure that could be used beyond the Commonwealth Games also resulted in Glasgow bidding for, and hosting, other major events such as the 2018 European Championships, and the cycling championships in 2023:

It's our default position. If we're going to do this, what do we get out of it after that's finished?...we've got an area of the city that could be really done with a regeneration project. All right, okay, all of a sudden Commonwealth Games presents itself. All right, let's link the two together, housing, infrastructure, the whole lot. Because along with housing came better transport links. One of our local train stations got a massive refurbishment... there was a huge amount of infrastructure that went into the Olympic Games down in London, that then got dismantled and taken away. Proportionately, a really low proportion of stuff was set up for temporary purposes in Glasgow...which meant that we made really, really good use of the assets and our legacy. (Government official 1, UK)

Housing outcomes from Glasgow Commonwealth legacy included affordable rental and an aged care facility which were able to be delivered from the athletes' accommodation with a small retrofit. It was noted that they could have pushed this even further as a school was built post event which could have been utilised for part of the athlete's village:

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The housing village that we constructed for the athletes to stay in is now 2000 homes for people to live in, in areas of the city that were needing regeneration. We could have put the athletes in all of the hotels... there isn't a legacy in that. We built houses, we put athletes in them, as soon as they moved out, a wee bit of retrofit and all of those houses are now available for affordable rent, social rented accommodation, and for market sale. So, a mixed tenure.... (Government official 1, UK)

WELCOME TO THE GAMES FOR EVERYONE

Case-study 22:

YW Kitchener-Waterloo Supportive Housing, Canada

Housing affordability is often pitted against environmental performance as a trade-off. However, new breakthrough materials and designs offer the promise of providing better built, lower cost and lower impact housing. At the University of Toronto, Canada, the privately funded Mass Timber Institute (MTI) is promoting affordable low-rise housing to the Ministry of Housing. Costs, environmental life cycle performance and energy efficiency are all factors in finding the right balance of wood-based products and other products in these designs:

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new woody products, for example, different CLTs with isolation, and also other properties ... we try to balance it with the concrete and the steel, to see that where it is still not a bad idea to use maybe 20 per cent, 20 per cent other materials, because they will be more durable. That is about the mitigation effect of this affordable housing. (Senior academic, Canada)

Manufactured by Element 5 (see Case-study 11) and developed with a local architect, the YW Kitchener-Waterloo Supportive Housing shelter in Kitchener, Ontario, was developed with speed and affordability as main considerations. The project was a four storey, 41 units women's shelter responding to a government initiative, the Rapid Housing Initiative, to implement affordable design solutions. Off-site CLT was chosen above standard on-site concrete and steel-based construction:

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We designed one specifically for mass timber, because when designing a building, you really have to design in mass timber from the onset, in order to make it affordable and cost effective. We went up against concrete and steel, and other building typologies, and were able to secure the first building. Since then, we've implemented that same building footprint on another site, north of Toronto, and we have two more. (CLT manufacturer, Canada)

The YW Kitchener-Waterloo Supportive Housing project delivered a complete mass timber solution, including mass timber stairwells, elevator pre-cores, unit demising walls, floor slab and mass timber envelop panel. One of the two buildings on the site was erected in less than 20 days from when the concrete foundations were ready:





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from the time of our contract, which was in schematic design, until the time the building was actually occupied, was less than a year. (CLT manufacturer, Canada)

There were other benefits from construction process in terms of neighbourhood amenities:

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five workers and a crane put this whole building up in 20 days... This envelope went up in four-storey lifts. All of the windows are pre punched out. All of that is coordinated with the window supplier. There's very minimal site traffic, very minimal bracing, very minimal hazards on site. So, not only does the building go up fast, but your actually able to start fitting it out with the mechanical, electrical, plumbing and the finishes extremely fast, as well. That's what enabled the whole building to be occupied so quickly. So, the whole process was expedited. (CLT manufacturer, Canada)

However, the costs benefits of CLT can only be upscaled if repeated in other housing developments:

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Being able to take a typology and make it repeatable is a huge value add for mass timber, where you're going to find a lot of the cost savings, is when you're able to take those buildings and repeat them. (CLT manufacturer, Canada)

IMPLICATIONS FOR VICTORIA

Currently Victoria does not allow cost escalation in fixed price contracts where prices can be adjusted based upon external factors such as the price of materials increasing during a project, except on contracts above AU\$500k. Given the significant increases in costs relating to some material and building products in recent years this has contributed to financial challenges for builders, suppliers and sub-contractors in Victoria. Specifically, it means Victorian businesses have been building houses at a loss, and are forced to do so contractually. Moreover, there are limitations on data available on forward price and availabilities of materials.

In this context, the UK's Product Availability Group is a model that Victoria could look to for ideas on how to ensure contracts are fair to builders and consumers. By tracking actual supply and demand and creating and improving the accuracy of live data, as well as enabling price increase simulations depending on different inflation scenarios, is a means for evidence-based variations in costs can be ascertained. This would also help identify earlier where additional government support could be beneficial to help address supply or cost chokepoints. Another relevant initiative was observed in Belgium where the financial risk is shared between head contractor, subcontractors and suppliers and could be an approach considered in Victoria.

Across the case study locations, the role of policy in driving improved quality and performance outcomes was noted as critical. However, policy on its own was not enough to guarantee that what is specified is being delivered so it is important that there is a clear and transparent compliance checking across the industry to ensure accountability and protection for consumers. The compliance checks should not happen just at the end of the construction process, but at different points throughout to ensure 'hidden' elements of construction are checked. The level of compliance checks needs to be high enough that there is incentive for the industry to ensure it delivers higher quality outcomes due to the risk of failing compliance checks.

The housing market is largely driven by costs and the least-cost means to meet carbon reduction targets is through phased improvements in minimum energy performance standards, together with enabling measures to support fuel switching, training, stimulation of consumer demand and associated system change. Again, compliance checking is important across the industry to ensure accountability and protection for consumers.



Clarity and consistency of policy development, implementation and checking is critical for long term reputation of the industry and protection of consumers and the commitment to net-zero by 2050.

In Victoria there is limited transparent and verifiable information available on the design, materials and technologies of individual buildings. This lack of detailed and transparent information has created significant challenges in recent years, such as with the flammable cladding crisis where there are ongoing challenges in identifying problematic buildings and materials without the benefit of accurate verified public records, and material testing. The move to the provision of a golden thread of information is occurring in several of the case study locations visited. The intent is that all stakeholders (including consumers) will have access to current, accurate and transparent information about a building. This will help with ongoing management of buildings, especially in relation to quality and safety, but also help provide a database to help with broader policy development and planning (e.g., retrofit). While a buildings database of this nature is costly to create and maintain, it is cost-effective when considering the benefits in terms of efficient targeting of upgrade programmes, fixing market failures in information asymmetry, and providing a solid foundation for planning and predicting the impacts of investments in net-zero initiatives.

Given the urgency required around upscaling retrofit of housing globally, there were several examples in different case study locations which are working to reduce the regulatory barriers to assist the greater uptake of deep retrofit. These include streamlining of the building and planning process applications for low-carbon retrofit activities in Belgium. Given the challenges around households understanding and valuing deep retrofit, any opportunity to make the process easier was seen to help drive retrofit. On this basis, opportunities to shift Victorian policy settings whereby proposed construction which goes significantly beyond minimum standards could be fast tracked or follow a more streamlined process could be investigated, as this might also incentivise the uptake of best practice.

Banks and insurance companies can play a key role to help drive change and promote the greater uptake of sustainability, health and safety in housing construction. This can have benefits for these institutions as well through a reduction of risk, as has been found in the US. The Victorian government could work with the financial sector, including superannuation funds, banks and insurance companies, to understand how they can change their practices to better account for wider value and help to provide support and/or evidence to foster more sustainable buildings.



CONCLUSIONS & RECOMMENDATIONS FOR POLICY

This report documents a research project that collected secondary and primary data from an international study tour to Europe, the UK, Canada and the US. The data collected formed a considerable evidence base of international best practice in building and construction. The report is organised into four main sections; workforce; construction process and methodologies; climate resilience and industry preparedness, and; building outcomes and consumers. Collectively, these add up to significant challenges and opportunities for the building and construction sector in Victoria, working in partnership with government and consumer stakeholders, to lead through the coming transition to a safer and more sustainable future. The opportunity now is to build on Victoria's position and ensure the industry is sustainable, resilient and affordable, where a built environment is produced, upgraded and maintained efficiently and effectively by a highly skilled and innovative workforce.

Facing significant pressures exacerbated from Covid-19 related economic and labour shifts, the building and construction industry needs to modernise practices and build its capacity to meet ongoing sustainability and climate change challenges as well as addressing the shortage of supply. The most efficient and effective way to achieve this will be a tailor-made, Victorian solution involving a wide range of stakeholders – the industry itself, governments, peak bodies, training and research organisations, civil society organisations, and more. This report sets out to inform this solution. It sets out best-practice skills, practices and innovation being developed and applied in leading international jurisdictions. It also identifies opportunities and best practice initiatives, tools, projects and instruments that have the potential to inform Victoria's post-Covid building and construction industry. Among the many examples contained in this report, the potential benefits of a more concerted move to manufacturing and off-site fabrication, was identified as a key short and longer term opportunity for Victoria. This type of construction could attract a much-needed more diverse and differently skilled workforce and make use of emerging digital technologies. It could help address safety, mental health and challenging work cultures characterised by a male-dominated, physically demanding industry as well as reducing construction times and addressing affordability. Building on the current training reforms, it is evident that significant changes are required to best prepare the Victorian industry for tomorrow's challenges. Fostering greater flexibility and inclusivity to accommodate a diverse workforce, and strategically incorporating cultural and sustainability training at the core of these programmes would help reach new audiences and, ultimately, employees.

The industry needs to be able to compete effectively to attract the brightest and best of our future workforce to be able to support Victorians in mass retrofit and providing sustainable housing for a post-carbon world. This will only be possible with government and peak bodies providing consistent and accessible support and incentivesto both consumers and practitioners, as well as a protective policy environment that de-risks the adoption of innovation. Similarly, overcoming regulatory barriers to modern methods of construction in Victoria will require a collaborative approach between government agencies, industry stakeholders, and research institutions. This could be helped by a broader, government-led construction innovation consortium to help facilitate this transition.





Short term challenges from price spikes in materials have placed severe pressures on the industry. This report documents initiatives from around the world to help the industry through this period. Mechanisms to track actual supply and demand and create and improve the accuracy of live data (e.g., of material supply and costs), as well as enabling price increase simulations depending on different inflation scenarios, allows evidence-based variations in costs to be ascertained. This would also help identify earlier where additional government support could help address supply or cost chokepoints.

The lack of detailed and transparent information about buildings has created significant challenges in recent years, such as with the flammable cladding crisis. Access to current, accurate and transparent information about a building is essential to address challenges in relation to quality and safety, but can also inform broader policy development and planning.

The Victorian government's commitment to net-zero emissions and its 10-year policy and action plan towards circular economy demonstrate the State's ambition to eliminate carbon emissions from its economy, and reduce waste and pollution. The building industry has a key part to play, by scaling up energy efficiency retrofit of existing buildings and improving the performance of new buildings, while markedly reducing its consumption of virgin building materials. This is a major challenge, requiring change for the industry at all levels, from design specifications to on-site work practices. The EU has significant experience of independently verified environmental performance certificates generated by building assessments; Victoria should consider investing in this area more and roll out such systems to support the transition.

In addition, the shift to a circular economy in the built environment requires new data systems, second hand material trading mechanisms, trust, risk and legal frameworks, training, institution building, together with research and product declarations to establish transparent, independent building product information. Changes in policy alone will not be enough if the industry does not have the appropriate resources and knowledge in place.

The building and construction industry in Victoria currently faces an unprecedented opportunity, to expand, draw in and develop new skills, technology and expertise, and lead the transition of the Victorian built environment. As the case studies in this report demonstrate, this opportunity will be made easier through new partnerships with government, finance, peak bodies, training and research organisations and civil society in addition to innovation in building practices, materials, technologies and regulation.

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APPENDIX

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