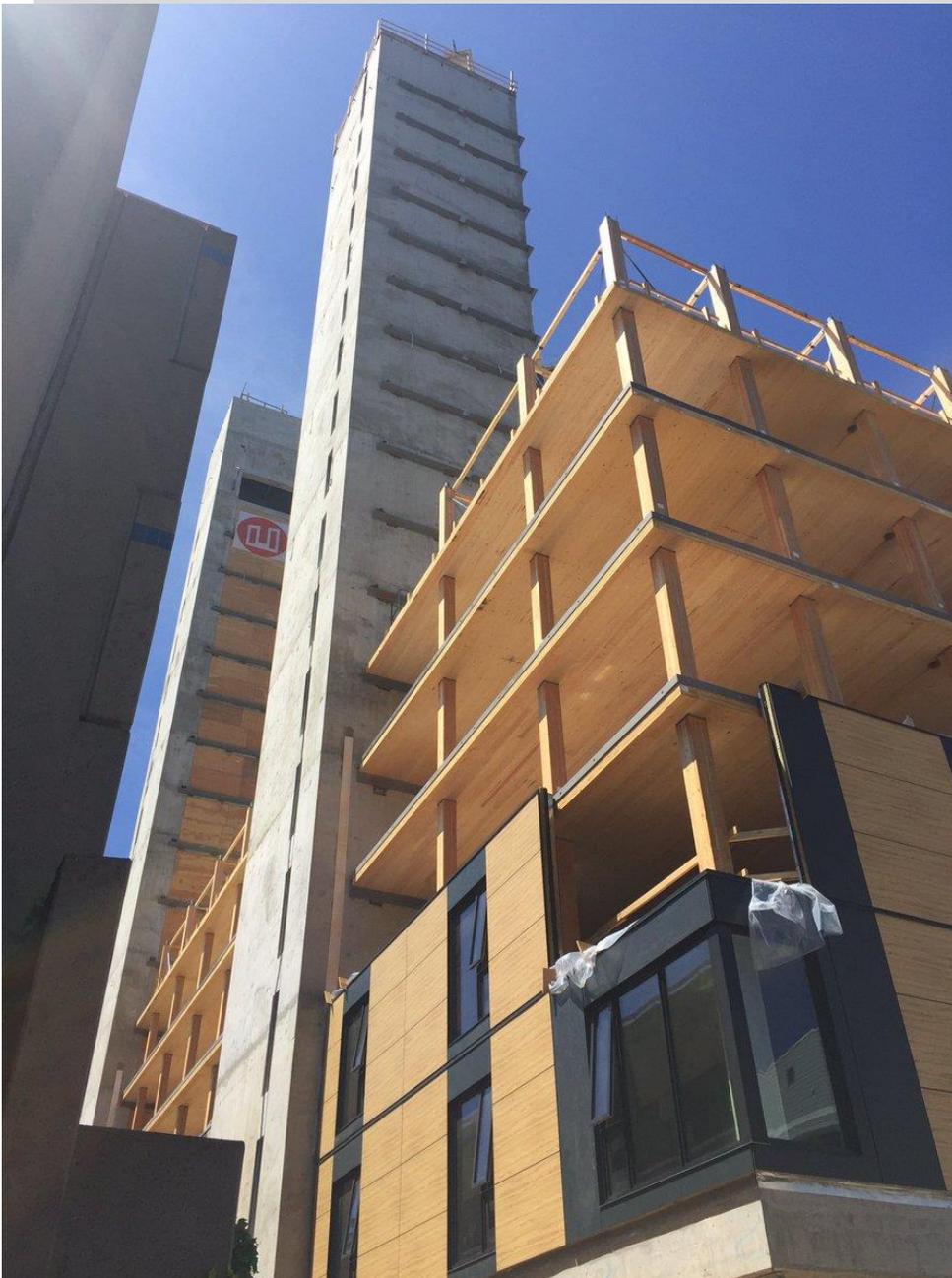


Procuring Innovation in Construction

a review of models, processes and practices



An initiative of the:

**CONSTRUCTION
INNOVATION
PROJECT**

Building BC's vision.

A note from the BC Construction Association

With the publication of this follow-up to the Construction Innovation Study (published in 2016), the BC Construction Association (BCCA) is pleased to continue its leadership role in the discussion of innovation in BC's construction industry.

As a trusted representative of the industrial, commercial, and institutional construction sector in our province, the BCCA has a policy to equally support the use of all building materials. We recognize that there is innovation in many assemblies and products, including wood, steel and concrete.

Construction procurement is a major focus for public owners such as Ministries, school districts, and health authorities, as well as for private owners. As international competition for large projects intensifies, true innovation calls for a shift from a culture of "lowest bid" to a focus on quality and "whole life" value. "Procuring Innovation: a review of models, processes and practices" is a significant step forward in that shift.

We hope you will find this paper informative and inspiring.

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British
Columbia
Construction
Association



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Canadian Wood Council / WoodWORKS! BC

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Mountain Equipment Co-op (MEC) sees sustainability and the use of wood as consistent with its corporate philosophy, and something with which it can reinforce its brand identity: not just with its own members (customers) but with a broader public interested in demonstrations of corporate social responsibility.

How innovative projects are different

An innovative construction project is different from a conventional one in order in the following ways:

- Longer upfront design time
- A greater degree of involvement by regulatory bodies
- Collaborative involvement of the entire design team from an early stage (e.g. via an integrated design and/or integrated project delivery process)
- The involvement of technical specialists

1 About this report

The objective of this report is to help public and private owners become “innovation friendly” in their construction procurement – to enable them to access the potential environmental, economic and social benefits that innovative construction solutions can bring. It is also intended to assist architecture, engineering and construction (AEC) firms set up their competitive response processes so they can bring their best to projects that push technical and logistical boundaries.

The question this report hopes to answer is: using mass timber as a case study, how can the procurement process be best deployed to accommodate project specific R&D, allow for new technologies and processes and encourage project team creativity?

Public procurement, in particular, is a major source of investment in R&D. Evidence of this can be seen in Canada’s support for forestry sector, which is a global leader in state-of-the-art, sustainable forest management and wood product processing, the majority of which is destined to construction markets at home and abroad.

Innovation is a hot topic in Canada’s construction industry but its scope is vast. This report uses recent examples of innovation in wood design and construction as a means to illustrate broader themes that can be applied to a wide range of building products and materials. Wood is used as a case study because there have been significant recent advances in the area of new wood structural systems and because expertise in wood technologies is considered as a key strength in BC’s design and construction industry.¹ For example, the tallest, and the most energy efficient wood buildings in the world are currently in BC. The design and construction of these high performance wood structures is driving the adoption of modern methods of construction such as digital design and pre-fabrication. It is hoped that best practices highlighted in this report will encourage a wide range of new products and materials (not just wood) to be more readily adopted by the construction market.

Innovative design and construction in wood is stimulating the development of a host of other innovations in digital technology, pre-fabrication and lean construction. Brought to market through initial application to wood projects, tools that aid collaboration, increase productivity and improve project quality and environmental performance, are finding application in all types of construction projects.

Procurement procedures can be highly complex, and can vary substantially from project to project so there is a considerable degree of overlap and interaction between the different sections in this report.

UBC Brock Commons student residence under construction. The project comprises an 18 storey mass timber structure.



Image: www.naturallywood.com²

“Innovation is the successful introduction of new technologies and processes into industry.”

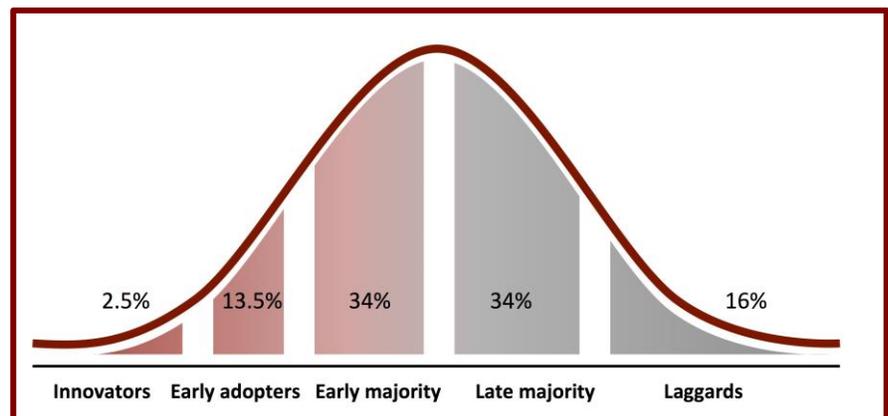
BCCA Construction Innovation Project, 2015

Using the adoption of mass timber as a case study for innovation, it attempts to explore how innovative solutions can best be encouraged within the many different stages and elements of construction procurement. Although wood construction is not appropriate for every project, mass timber has the potential to substantially improve the speed, cost and environmental performance of buildings. However, it radically changes the way buildings are designed and constructed and the lessons learnt may be applicable to other forms of construction. Further, BC is emerging as a leader in mass timber design and is currently home to the world’s tallest mass timber building.

This report draws on activities in BC and other jurisdictions to assemble emerging best practices supported by case studies and examples as a means to promote ongoing discussion about how best to procure innovative construction projects. It is not a panacea for all that is challenging in construction procurement today.³ It is intended for industry professionals who have some familiarity with the basic procurement process and it builds upon a wealth of information about construction procurement best practices available from BCCA.⁴

Not every project is an innovative project and every owner and construction company will have a different level of interest in exploring innovative solutions. This report has been shaped by the BC Construction Association’s “Construction Innovation Project – a strategy for BC”, released in 2015.⁵ It is directed to **innovators** and **early adopters** seeking to improve their business performance and competitiveness through the acceptance of new technologies and processes (see the market adoption curve above). The very premise of innovation implies that this report is not for everyone.

Roger’s market adoption curve. Source: Wikipedia⁶



Resources

The **ISO 10845 series of standards for construction procurement**, which consists of eight parts, will help organizations establish a procurement system that is fair, equitable, transparent, competitive and cost-effective. These International Standards are designed to help public, private and international organizations and their main contractors to align their procurement systems with international best practice.

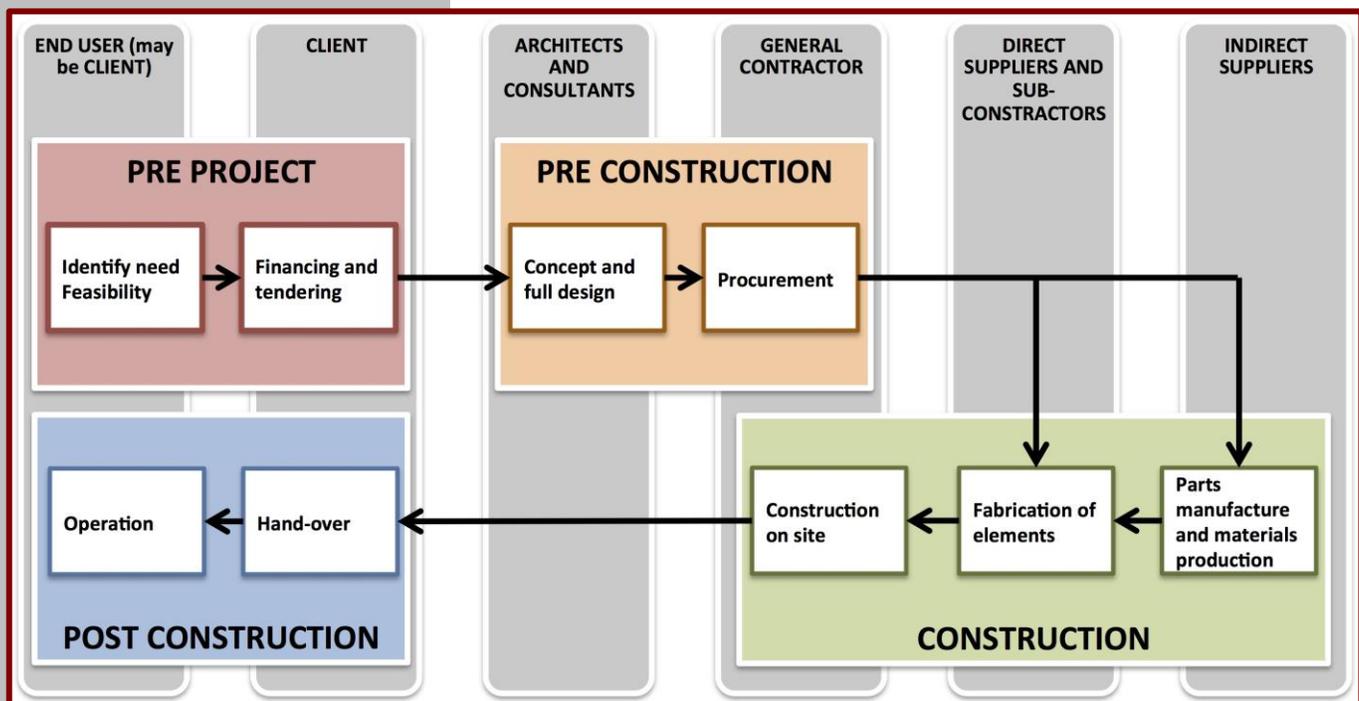
The Association of Consulting Engineering Companies of British Columbia (ACEC-BC) offers a comprehensive guide on how to successfully implement qualifications based selection (QBS), the best practice for selecting and engaging design professionals.

2 Construction procurement state of play

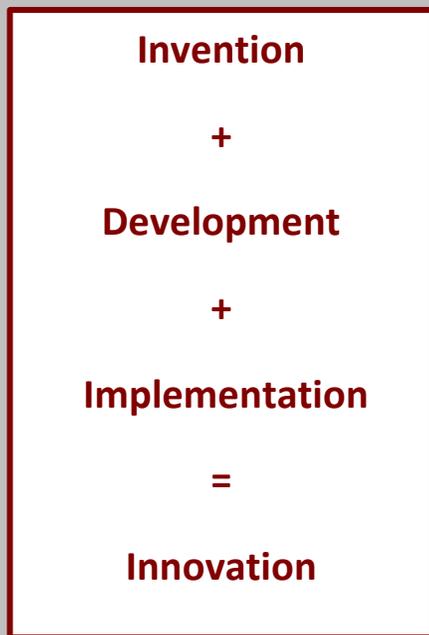
Procurement is an integral part of a construction project. It includes sourcing, purchasing, and all activities related to providing knowledge, manpower, construction equipment, materials, supplies, supervision, and management services necessary to accomplish the project objectives. Increasingly, it includes the ongoing management of the asset, to the extent that building operation and maintenance procedures are affected by the original work.

Effective procurement identifies a project's target market and packages up the opportunity to appeal to that market. It also focuses on securing a deliverable and affordable solution that best meets the owner's needs, and providing a firm contractual basis against which delivery and performance can be assessed. However, construction procurement can be a highly complex procedure, and present some significant challenges for procurers – not least due to the scale of the works being procured, and the variety of professional services typically required for project delivery.

Overview of construction procurement. Source: Adapted from Sci-Network⁷



There is no clear definition of the concept of innovation. However, it generally means that something new is created - a product or a process - and put to use.



“Construction innovation is being driven forward by shifts in owners’ requirements for building projects success factors to include non-economic factors such as environmental and/or social concerns (emergence of “social procurement”) and economic constraints facing the construction industry in the form of rising labour and materials prices and lack of improving productivity rates.”

Architect

3 Innovation in construction

Broadly, innovation can be applied to a product, a process, an organization or a market. It involves successfully incorporating new ideas, which generate changes that help to solve the needs of a company and so increase its competitiveness.

The patterns of innovation in construction are different in many ways from those of other industries, and effective management of innovation is essential to create value for construction companies as well as their customers and owners.

The application of innovation to the construction industry is not straight forward, despite the importance of this sector in the development and growth of the wider economy. Every project is different, which means that construction companies have to be constantly adapting their processes and resources to suit. Every site is a singular prototype whose configuration changes over time. Construction works are located in different places, and involve the constant movement of personnel and machinery. In addition, the weather and other factors can prevent consultants from applying previous experience effectively.

This means that although innovative solutions to specific problems add to the overall experience and practices of a company, as innovation is undertaken on a one-off basis, it does not necessarily benefit the company as much as might be expected unless it is possible to incorporate it into the organization's standard management processes. Formatting the procurement process to enable construction companies to manage, measure and control the development and application of new ideas systematically is an important first step towards the standardization of innovation. A construction company that has a standardized management of innovation could see significant improvements in the following areas:

- Organization of activities.
- Competitiveness in the medium and long- term.
- Integration of corporate management processes within the company's overall strategy.
- Efficient exploitation of the organization's knowledge.
- Systematization of new process and product knowledge.

These improvements will have direct and positive impacts for building owners and clients.

Innovation by modularity: modular construction is traditionally considered to comprise volumetric building units such as site trailers and simple housing units. However, it can include the pre-assembly of a wide range of components from washroom pods to “plug-and-play” mechanical rooms.



Image: Skanska

How does innovation happen in construction? For the purpose of this report, innovation can occur at any stage in the design and construction process and involves the following mechanisms⁸:

Innovation by production technology: Competition to be faster, cheaper or greener drives companies to optimize their production processes to keep costs down. Ideally, the saved money is invested for research, development, increasing technology and also to continuously improve the production process. While continuous improvement will inevitably run up against limits in labour based production systems (such as traditional construction) highly technological and automation based production systems such as modular construction have virtually no limitation.

Innovation by modularity: Open and changeable modular designs allow designers to improve or adapt a product continuously. New features can be added right away without making it necessary to abandon or re-engineer the whole product. Using a kit of interchangeable components, designers can offer the market a wide choice through “mass customization”, which combines the flexibility and personalization of one-off products with the low unit costs associated with mass production. A modular structure can be set up in a way that makes it possible for individual modules (e.g. HVAC, windows, partitions) to be exchanged by new or upgraded designs at any time, thereby future-proofing the entire building.

Innovation by technology transfer: Production systems that are commonly used in one industry can be applied to another or be used in a new context. For example, under-slung cranes (roof) and rail systems (on ground) are used in shipbuilding and aircraft construction and several modular construction companies adapted such systems for moving large assemblies through the production process.

Innovation by performance: The complexity of buildings continues to rise rapidly due to new paradigms such as the “internet of things” and the demand for energy efficiency. Buildings are increasingly equipped with a multitude of new sub-systems and extend their performance to areas, which have formerly not been accounted as being part of the construction industry. Buildings are not only becoming more intelligent, but they can be much more personalized to the inhabitants’ needs and could further serve as platforms for a multitude of continuous and commercial services. These changes could have a tremendous impact on the whole value chain and are likely to transform building structures, construction technologies and business models.

Innovation by overlay: when the 100 year old Ōsanbashi Pier at the Port of Yokohama was upgraded in 2002, the complex steel roof structure was built by the Kawasaki shipyard not a regular structural steel contractor.



Images: ArchDaily⁹

Innovation by transformation: Incremental adaptation and improvement is probably the most common way for innovation to occur. Here, an established technique will be transformed and adapted to improve efficiency and/or performance. In this way, the BC Construction Association has taken the principles of bidding and tendering and created BidCentral, an online marketplace for construction projects. By doing so, the processes have been tightened up and improved.¹⁰

Innovation by overlay: New innovations can arise from using a novel production process or unfamiliar company to make a familiar product. For example, a highly advanced and automated (compared to construction) shipbuilding company might take on the prefabrication of a building thereby injecting new knowledge, design approaches and technology into the resulting “new” product.

Innovation through customer collaboration: The requirements of a building increase constantly and project team members can learn a lot about what their customers need and how their designs are being used through regular periodic post occupancy evaluations, user surveys and other tests. Feedback from after-sale customer service offers tremendous opportunity for product and service improvement. Companies try to gather as much information from customers and production in order to directly inform to improvements in management and product design. In construction, the desire to know more about how buildings work has spawned a host of new data management, sensing and controls technologies.

It is important to note that this report advises innovation only when it is necessary. However, in a time of rapid change, escalating social and environmental problems and when public finances are under pressure there is a greater role for innovation. Yesterday’s solutions are not equipped to meet tomorrow’s challenges.

Wood is the “material of the future” on account of its malleability, affordability sustainability, availability and ability potential to support local economies in British Columbia.

“Wood projects really lend themselves to digital design and construction technologies. From concept design, through to construction detailing, fabrication, scheduling, etc.”

University researcher

UBC Earth Sciences Building

This five-storey, academic facility includes a conventional reinforced concrete laboratory wing, and an office / lecture hall wing and connecting atrium space built of innovative glulam post and beam and solid wood panel construction.

LSL floor panels span 21 feet between wood-concrete composite post and beam frames, which are fully transferred across the 63 foot wide lecture theatres located on the ground and second floors. The roof and exterior canopy structure surrounding the building consist of 5-ply CLT panels. The atrium features a fully cantilevered stair composed of a seamless folding “ribbon” of glulam plates, a first of its kind in the world.

Image: Equilibrium Engineering

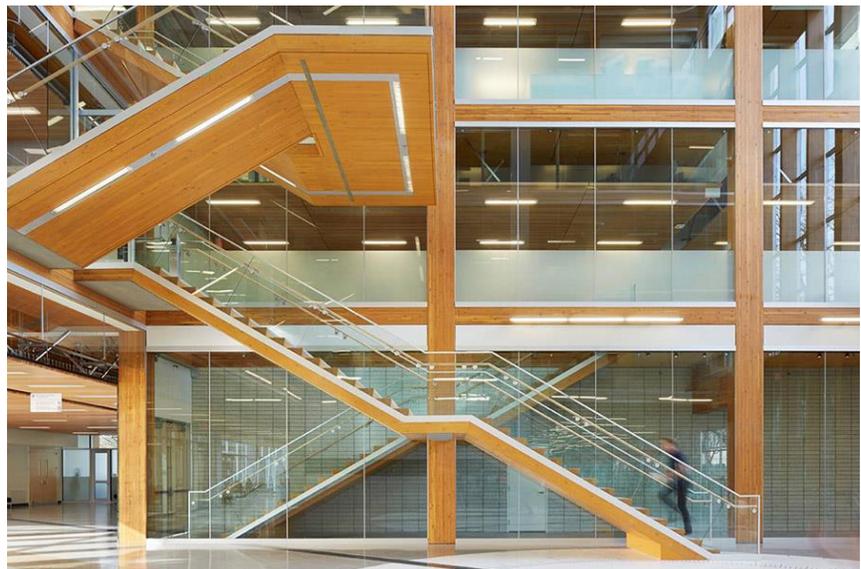
3.1 Innovative wood technologies

Canada’s wood industry has been investing heavily in advancing a range of novel building products and structural systems the success of which rely on processes such as off-site construction and digital fabrication. The following examples illustrate the range of innovations that are starting to emerge in projects across the country and around the world.

3.1.1 Products and materials

Engineered wood products (EWPs) have been with us for more than 100 years, with both glulam and plywood having been patented around 1900. Much more recently, these have been joined by other EWPs including; oriented strand board (OSB); parallel strand lumber (PSL); laminated veneer lumber (LVL); laminated strand lumber (LSL); glue laminated timber panels (GLT) and wood I-joists.

All these products represent improvements in the economy, efficiency and performance of wood, while capitalizing on its properties as a renewable and sustainable resource. All use strands, veneers or small sections of wood glued together to form larger panel, column or beam products with greater strength, consistency and predictability of performance than solid sawn products. EWPs use wood fibre more efficiently, and either distribute natural defects evenly throughout the product or eliminate them altogether.



Pres-Lam

Developed at the University of Canterbury in Christchurch, New Zealand, Pres-Lam is a pre-stressed laminated post and beam system that has revolutionized seismic design for mid and (potentially) high-rise construction.¹¹

The system is based on self-centring connection systems that had been previously developed for use in concrete frame construction. It consists of solid posts and hollow box beams through which steel 'tendons' are run. These tendons are secured to plates attached to the posts and post-tensioned to provide a ductile moment connection that can resist moderate earthquakes without incurring structural damage. Under seismic loads, the post and beam frames rock back and forth, but return to their original position when the force is removed. The system is licensed for use in North America.

Pres-Lam installed in the College of Creative Arts in Wellington, New Zealand

Image: Architecture Now¹²



CLT has reinvented load bearing structural systems for residential buildings, and reinvigorated conventional post, beam and panel systems for commercial buildings.

3.1.2 Innovative wood structural systems

Cross-Laminated Timber panels (CLT) are large engineered wood panels manufactured by cross laminating sawn lumber with adhesives or fasteners. CLT is produced with three to seven layers of lumber or planks stacked on one another at right angles and are either glued together in a hydraulic or vacuum press over their entire surface area or nailed together. Each layer is composed of softwood lumber typically with a 38mm cross section. Panel thickness is usually in the range of 50 mm to 300 mm but panels as thick as 500 mm can be produced. Standard widths range from 1.2 - 3.0 metres and lengths are limited only by the constraints of road transportation.

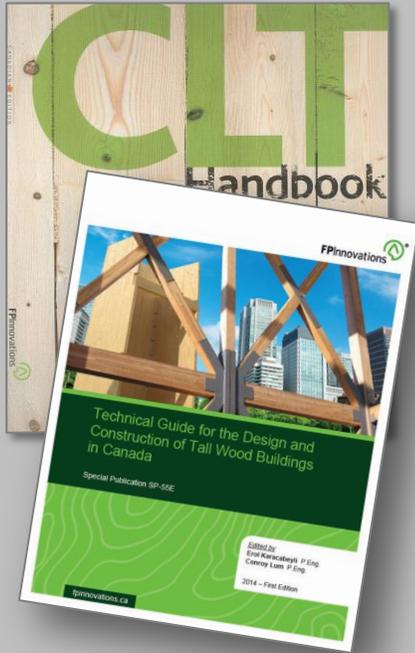
CLT panels enable wood to be used in a load bearing system similar to precast concrete or masonry, but the material has advantages over both because of its light weight, versatility and easy workability. Some solutions combine CLT panels with glulam post and beam construction, a system that lends itself to the longer spans and flexible plan configurations required by office buildings.

3.1.3 Connection systems

Connections are an integral part of the structural system that transfers the dead and live loads imposed on a building to the ground by way of horizontal, vertical or diagonal structural members.

Connection systems for wood buildings have been revolutionized by the introduction of proprietary epoxy-based systems developed in Europe. These systems, including HBV and HSK, consist of strips of steel mesh inserted into saw kerfs in the wood elements and glued into place with high strength epoxy glue. These systems create a ductile, high strength connection between wood elements or between wood and concrete. In the latter case, composite wood/concrete slabs can be created that reduce the overall weight and carbon footprint of floor systems compared with conventional all concrete equivalents.

Resources



Together, FP Innovations' "CLT Handbook"¹³ and "Technical Guide for the Design and Construction of Tall Wood Buildings in Canada"¹⁴ offer an excellent primer to designers and builders on the various issues that need to be addressed when working with mass timber components.

A growing body of technical knowledge on wood technologies is accumulating within research centres across Canada. The leaders include:

- The National Research Council
- FP Innovations
- University of Northern BC
- University of New Brunswick
- University of BC

3.1.4 Wood construction considerations

There are many unique technical and logistical considerations that owners need to be aware of when they contemplate wood projects.

When working with mass timber, contract documents need to make special provision for the following:

- Weather protection
- Constructability (e.g. lifting, storage, etc.)
- Fire protection during construction

Even though EWP's are more resistant to moisture damage than solid sawn wood, they need to be protected during manufacture, transportation and installation in order to ensure dimensional stability and the maintenance of the desired moisture content.

Time and costs must be included in the construction process to deal with weather issues. To prevent expansion / shrinkage (in smaller members), staining and other damage from moisture and bleaching from sunlight, wood products must be constantly protected from the weather during transportation, storage and erection which means wrapping, tenting and other solutions may need to be deployed until the building is enclosed. Where the face of the wood product will be exposed in the final building, the wood must also be protected from other trades during construction. Sealed plastic wrapping may come with its own challenges as the wood can "sweat" over time, so other protection materials (such as plywood for floors) should be considered.

Storage and set-down of products on site can also cause problems if not properly protected. Storage of wood products must be off the ground with spacer blocks placed between members.

Weather damage from storage can be minimized through the sequencing of arrival of products on a "Just In Time" basis so that they can be lifted off the trailer straight into their final position.

Even with best efforts, it is likely that wood will get wet and therefore the schedule needs to allow time for it to dry out before it is closed up. Designers need to proactively address weather protection in design specifications and contractors need to accommodate the cost and logistics in their tenders.

Resources

reTHINK WOOD®

The Rethink Wood Research Library hosts the latest research related to fire safety during the construction of wood buildings along with a wealth of other topics.¹⁵

Results of a fire test on a CLT panel conducted as part of a 2014 NRC research study. Image: NRC¹⁶



Projects that seek to use unproven products and technologies need to accommodate the time and cost for research, evaluation and testing into the project budget and schedule

Extra care is required when it comes to the application of technologies that are new (in terms of the location, configuration or application). Testing is required to ascertain the performance of a material, product or assembly for many characteristics, such as:

- Structural
- Moisture resistance
- Fire
- Durability
- Toxicity

Testing takes time and can be expensive so it needs to be identified early and factored into the design and construction process and budget.

Research funding may be available to defray some of the additional costs. Application to funders takes time and while Canadian universities have some of the most advanced research equipment and world-class expertise, projects often have to be conducted within the academic schedule.

In July 2009, Simpson Strong-Tie in collaboration with researchers from Colorado State University conducted a 7.5 magnitude test on a seven-story wood-framed condominium tower – the largest seismic test ever. Image: Simpson Strong-Tie.



The procurement of buildings is informed by two distinct and frequently competing priorities.

- **Priority 1:** construction businesses need to make money in order to stay in business
- **Priority 2:** owners need to maximize value for money, in order that limited funds can deliver as much as possible.

3.2 Procurement barriers to innovation

Times are challenging for building owners. In BC, private developers are challenged with the rising cost of land and the public sector is under sustained pressure to maximize value for money, in order that limited funds can deliver as much as possible.

There are challenges that often preclude innovative designs/construction proposals from being considered. The fractured nature of the construction value chain and the pressure to deliver a project for the lowest possible price creates a procurement climate that is fundamentally hostile to innovation and alternate methods of project delivery. All parties to the procurement process can potentially shoulder some of the responsibility for the poor state of affairs.

Barriers identified by industry

- Short-term thinking.
- Owners are not sufficiently knowledgeable, which can lead to poor advice being taken and results in a project coming in over-budget, outside of timeframes, or to a poor standard.
- Low (first) cost of a project is almost always prioritized over Life Cycle Cost (LCC).
- Inability of to replicate a successful project team, preferring to “mix things up” in the hope of getting a better price but instead simply lock in the inefficiencies that come with unfamiliarity and lack of trust.
- Lack of transparency of the procurement process:
- Issues over responsibility & allocation of risk
- Lack of integration and standardization
- Lack of continuity of projects dissipates knowledge when teams were dispersed. The lack of continuity severs relationships resulting in a lack of captured learning and no ability to build on success.
- Inadequate incentives to exceed minimum standards
- Some practices in public sector construction procurement, such as pre-qualification, are frequently over-elaborate and increase costs for both the public sector client and the private sector contractor.

Barriers identified by owners

- Short-term thinking
- Most parties seek to minimize personal/business risk at the expense of another party to the contract. The wrong person is left “holding the bag”.
- Lack of integration and standardization across the value chain.
- Contractors are set up to perpetuate problems with business systems that encourage silo-based thinking.
- Lack of recourse against contentious behaviours such as suicide bidding (the industry has no code of ethics).
- Lack of clear leadership to ensure that construction is properly planned using a design-led approach.
- Lack of a culture of training leading to low levels of technical skill on site, as omissions of important procedures (e.g. weather protection) and incomplete/shoddy design documentation
- Lack of feedback loops and “captured learning” from previous projects.
- Current procurement models inadvertently promote an adversarial relationship between parties i.e. one’s profit is often based on the errors and/or omissions of another.
- Compressed project timelines and pressure on budgets work against the team’s ability to prepare and coordinate adequate contract documents. Inadequately scoped documents lead to price volatility in the bidding stage and price escalation (through contract changes) during the construction phase.
- Lack of experience and/or technical expertise within builders and consultants resulting in poor quality of the end product and poor team performance.

Creating a procurement process that is conducive to innovation starts with an owner who can:

- Identify a project with the potential to incorporate innovative solutions,
- Clearly, accurately and completely describe the project requirements,
- Establish a fair, open and transparent project team selection process by which to evaluate proposal responses, and
- Select a delivery model that, for the entire duration of the project, fosters full team collaboration, manages risk appropriately and ensures accountability of all parties.

“You always have to examine what you as an owner are doing when things don’t work out because relationships are a 2-way street.”

Owner

“Owners need to put procedures in place that formalize some of the informal methods and relationships that have led to past success.”

Owner

“Fostering a spirit of trust and respect across the entire project team is the single most important thing an owner can do. In reality, it is probably the most difficult and time consuming job.”

Architect

4 The role of the owner

The success of an innovative project relies on leadership from the owner who not only needs to lead by example, but also establish the structure and tone of key relationships, as well as the values and objectives of the project. This is especially important when assembling a team that has not worked together before.

It is the owner’s responsibility to seek best “value for money” in their building project – to deliver the functional program within the timeframe required, while meeting stakeholder and society’s expectations in terms of financial return, the health and safety of workers and occupants, environmental impacts, aesthetics and so on. Some owners attempt to “value” important but intangible benefits such as reputational impacts.

Owners that have successfully incorporated innovation into their projects (and benefited from the result) seek to provide a supply chain environment in which the ‘hands-on’ experience of the general and key trade contractors and suppliers is harnessed in such a way that the value created is documented and, if possible, quantified. These owners have found that it is possible to balance risk in the commercial structure without stifling innovation. The key to this lies in their approach to project definition and the team culture. A greater focus on how the ultimate end-user will work in the building once it is complete is leading to more ‘output-based’ definitions. This is not easily achieved, because it requires a major culture shift from the traditional ‘silo’ mentality of the past, where who does what was precisely defined.

This new approach gives the rest of the supply chain the opportunity to bring its experience to bear. This brings with it innovation, productivity gains and best value. The other benefit is that everyone in the team can have the opportunity to use their special knowledge which can be very motivating for the whole team. But on the other hand, this throws up the challenge of keeping the team together, for the knowledge that they have gained and for the relationships that they have built up.

The lack of continuity of projects has traditionally dissipated knowledge, as teams were dispersed. The lack of continuity also severed relationships. Now, there is a realisation that success depends as much on the ‘soft’ skills as the ‘hard’ skills. What these large experienced owners have learned is that creating supply chain environments that retain knowledge and relationships leads to building success. This is a new vocabulary for many in the construction industry.¹⁷

Examples of performance targets for building projects

Category	Target
Schedule	Construction completion date
Cost	<ul style="list-style-type: none"> • Capital cost Achieve budget cost • Life cycle cost Achieve budget cost (measured after start-up period)
Quality	<p>Owner satisfaction (measured by survey of end users)</p> <p>Defects & call-backs (e.g. no water damage for wood structures)</p>
Environmental performance	<p>Energy = Steady indoor temperature of (e.g. 20- 22°C)</p> <p>GHG emissions in kgCO₂/m²</p> <p>Acoustics = STC ratings</p> <p>Waste in tonnes of waste generated (total or per m²)</p> <p>Indoor Air Quality = presence of mould spores, VOCs (ppm)</p>
Safety	Accident rate

The three most common terms associated with the Value for Money concept are:

- **Value Management (VM)** is about getting the right project.
- **Value Engineering (VE)** is done to get the project right.
- **Value Analysis (VA)** relates to the improvement of a construction, manufacturing or management process and also to a post project review to establish value achievement.

5 Setting requirements and targets

The procurement strategy adopted for a project outlines the key means by which the objectives of the project are to be achieved.

The most influential decisions affecting cost, quality and sustainability performance are taken early in the project (during the planning and design phases). Regardless of the procurement procedure and contractual model followed, it is important that performance goals targets are also set early. Ensuring these targets are clearly communicated throughout the project and in all tendering documents helps to make sure that all involved are working with a common understanding.

Evidence shows that \$1 extra spent on design, is the equivalent of \$20 savings in construction and \$60 savings in operation¹⁸. No matter what type of construction project is being undertaken, the final result achieved will greatly depend on the requirements and targets set by the owner, and how effectively these are defined and communicated to those carrying out the work.

Focusing simply on lowest price can make it very difficult to realize the benefits of novel products, processes or solutions because the advantages may lie in achieving other results such as improved life cycle costs, construction speed, or environmental performance. To encourage innovative solutions, owners therefore need to award contracts based on both financial and non-financial criteria that, together, represent the “best value”.

Value can be described as the relationship between what you get (or want) and what you pay. Thus, value can be increased by improved function or reduced whole life cost. So, for teams undertaking innovative construction projects it is essential that value is managed, measured and quantified so that the benefits of the new technologies and processes can be evaluated.

Best value for money is defined as the most advantageous combination of cost, quality and sustainability to meet customer requirements.

Life-cycle cost (LCC) analysis is used to assess the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system.

The Government of Canada's Policy on Green Procurement¹⁹ takes into account both environmental performance and costs that occur throughout the life cycle of assets and acquired services, including planning, acquisition, use and disposal.

Some cost elements related to environmental factors that could be taken into account in assessing value for money in the evaluation of bids, offers or arrangements include:

- Operation costs, such as energy or water consumed by the product over its life
- Indirect costs (less energy efficient IT equipment will produce more heat causing the building's air conditioning system to work harder, and increase electricity costs)
- Administrative costs, such as complying to Workplace Hazardous Materials Information System (WHMIS)
- Investing up front to save costs later, such as specifying higher levels of insulation where extra expenditure can be recovered from lower energy costs
- Cost of disposal arrangements

The Government of Canada uses Product, Resource, Operating, and Contingent (PROC) costs relating to procurement for Major Crown Projects and in procurement in which operating costs are a major part of the total cost.²⁰

5.1 Capital cost versus life-cycle cost

Investing in innovation may have immediate short-term benefits in terms of the speed and cost of the project, it can also have much greater long-term economic and other impacts over the life of the building. In many construction projects, the initial capital cost may only account for around 20% of the total costs that the building owner will incur during the period of ownership – particularly when energy bills and maintenance costs are taken into account. If the costs of staff using buildings are included then this is reduced to just 0.5%.²¹

Life-cycle cost (LCC) can be a key enabler of the adoption of new and innovative construction products and techniques. Many innovative solutions may incur higher up-front costs but once operating costs are taken into account the overall investment may provide a better return.

LCC can be used as an evaluation tool within competitive tendering procedures so that investments in innovation can be valued correctly and completely. To allow project teams to respond effectively, owners need to establish clear and quantifiable criteria in terms of:

- The expected magnitude and timeframe of the return on investment (ROI)
- The value given to non-financial benefits (social, environmental, occupant wellbeing, etc.)

Although LCC is required for federal building procurement (see sidebar), published life cycle cost analysis information for most building types is sparse, particularly for wooden structures. (Indeed, current indices of the useful lives of various products allocate lower useful lives (to wood than other materials without clear basis for any of the chosen values. (Despite a pervasive perception that the useful life of wood structures is lower than buildings of other materials – there is no meaningful relationship between (the type of structural material and average service life. (

Owners should therefore be aware that, currently, the combined lack of LCC research on wood use in construction and the common availability of what appear to be non-research based estimates of useful lives of materials can create an unwarranted bias against the use of wood in structures. Development of definitive, research-based information on durability/longevity of wood structural and non-structural elements used in various building applications is needed.²² (

Investments in innovation are geared towards improving the balance between cost, time and quality



“Effort is required to ensure that the quality of sub-trades aligns with quality general contractors. Owners and consultants need to be involved down the line.”

Owner



The **BC Passive House (BCPH) factory** in Whistler, BC is an award-winning all-wood construction demonstration project. The building was the vision of a company dedicated to the concept of truly sustainable construction methodologies, typified by the international Passive House Standard. Image: Dürfeld Constructors.

5.2 Defining “Quality”

The notion of “Quality” means different things to different people: functionality, the absence of defects, performance, durability, fitness for purpose; standard relative to things of a similar kind and so on. One definition is, “a combination of **functionality** (how useful the project is in achieving its purpose); **impact** (how well the project creates a sense of place); and **build quality** (performance of the completed project).” Quality in a finished building is generally a factor of the owner’s proposal or briefing, design process, contract documentation and construction.

As quality has no specific definition in contract documents, it is very important that proposal or briefing documents set out clearly the level of quality that is required. Specific standards of quality can generally be defined, prioritised and measured quite precisely, and criteria weighting can help in the appraisal of design options, in particular where conflicting views exist amongst stakeholders.

When defining objectives for quality, the owner should consider:

- Available funding and time,
- Existing corporate policies (such as environmental policies),
- Key requirements of the business
- Key requirements of stakeholders
- The views of external organizations such as the local governments and community groups

“It is unwise to pay too much, but it is worse to pay too little. When you pay too much you lose a little money. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do. The common law of business balance prohibits paying a little and getting a lot - it can’t be done. If you deal with the lowest bidder, it’s well to add something for the risk you run, and if you do that, you will have enough to pay for something better. “

John Ruskin (1819 - 1900), English art critic and social thinker

Sustainable procurement is, “A process whereby organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis and generates benefits, not only for the organization but also to society, the economy and the environment.”

Minimizing the predicted v. actual performance gap

Operational energy performance can only be validated after the building is complete. The following steps may be helpful in addressing any gaps between predicted versus actual performance:

- Include incentive performance clauses based on energy performance,
- Include in contract a 5-year engagement for post-occupancy performance (long term energy performance agreement), and possibly a bonus at the end of the period if targets are met,
- Collaborative approach: have a life-cycle approach instead of only having warranties; engage people in the decisions being made around innovation in a life-cycle approach, because decisions from participants change when you consider the whole life-cycle,
- Acknowledge and pay for people’s time up front to undertake necessary analysis and testing.

5.3 Sustainability performance

Economic, social and environmental sustainability are interlinked. Increasingly, these three strands are afforded appropriate priority in construction procurement decisions. However, achieving these goals can only be validated once the project is operational. Therefore, not only do owners need to set clear and measurable sustainability goals for the purpose of project team evaluation but also to establish incentives for accountability.

5.3.1 Operating energy and GHG performance targets

The only way an owner can be sure that the project has achieved its energy performance goal is by looking at the utility bills. Building codes and green building rating systems (e.g. LEED) reference design models that make certain assumptions about how the building will be run.

Projects that plan to deploy innovative solutions to address energy efficiency and/or GHG emissions reduction can set measurable and absolute standards to be achieved (in kWh, MJ, kg.CO₂e, etc. per unit of gross floor area per year) to demonstrate that a return from the investment in innovation has been achieved. Incentives can then be put in place in the form of bonus for exceeding the goal and/or a penalty for failure. This can work well where the upfront budget for construction work is restricted. The owner can set an intermediate minimum standard and indicate a higher aspirational target, which the project team can be challenged to achieve, either through setting incentives within their contract, or through running a design contest to win the contract.²³

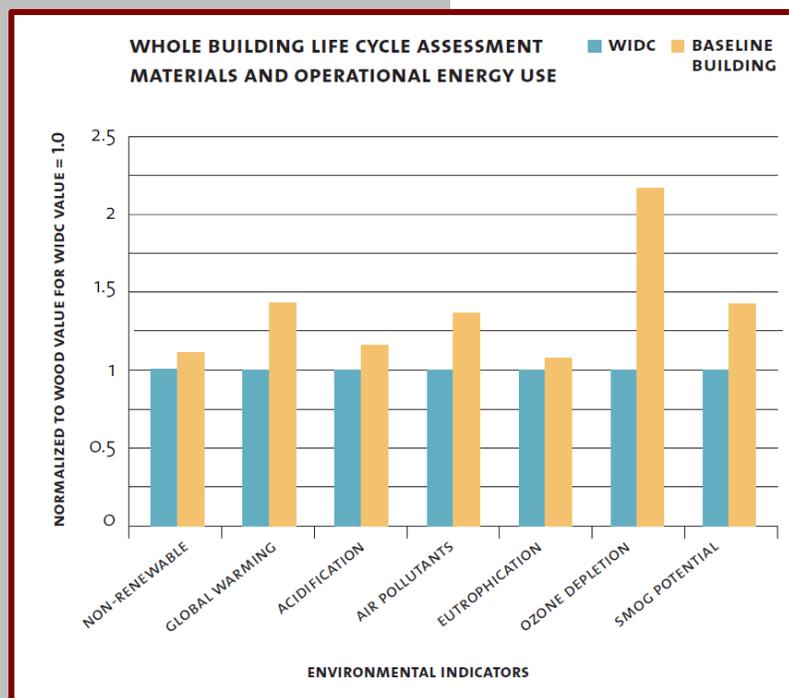
The Passive House standard represents a highly ambitious level of energy performance (max. 15kWh/m²/yr for heating and cooling), which many public authorities in Europe are now targeting in a wide range of construction projects. This standard provides a good level of certainty in terms of operational energy consumption early in the project process and owners can easily write a requirement to achieve Passive house certification into their proposal documents.

For renovation projects, an accurate baseline energy performance figure must also be determined.

Whole-building LCA

Using the Wood Innovation and Design Centre as a case study, research conducted by FP Innovations²⁴ shows that multi-storey office buildings in BC with mass timber structural systems and laminated veneer lumber curtain wall structures can have environmental performance improvements for non-renewable energy consumption, global warming potential, particulate matter formation and smog potential when compared to reinforced concrete buildings with aluminum-framed curtain walls. Reducing global warming potential requires future emphasis on reduced operational energy consumption.

Comparison of life cycle impacts between a concrete baseline building and WIDC. Image FP Innovations



5.3.2 Life-Cycle Assessment

The choice of construction products has a significant impact on the environment. Although still at an early stage of market adoption, the life cycle environmental costs (impacts) that occur outside of direct building operations are increasingly being factored into project decision-making.

Life cycle assessment (LCA) is a universally accepted science-based methodology²⁵ to evaluate the environmental impacts of products and services that go into buildings as well as the buildings themselves over their entire life cycle, i.e. from raw materials extraction to final disposal. LCA is finding its way into green building rating systems and in procurement models in Europe.

Using LCA, the project team can evaluate a broad range of environmental considerations (such as embodied energy, global warming potential, impacts on water quality, impacts on human health, etc.) against explicitly declared criteria and give a summary of environmental performance. Such assessments can be used for benchmarking performance and monitoring progress towards improvement of performance. LCA is therefore a powerful way to inform owners and the project team of the impacts associated with a material, product or entire building and also provide a basis for demonstrating and communicating the result of efforts to improve environmental performance in construction works (assemblies, structures, civil infrastructure, etc.).

LCA largely addresses the non-financial impacts of buildings and is therefore not considered in life-cycle costing in current practice. However, as owners begin to integrate the economic, social and environmental goals into a triple-bottom line procurement model, LCA will become increasingly important.

Owners can ask for LCA to be conducted on the proposed building (or any portion) to determine the lowest environmental footprint for specific factors such as embodied energy, carbon and more. To meaningfully inform decision-making, LCA should be undertaken early in the design process.

When contemplating an innovative project, an owner should strive to create an integrated, collaborative team in which the construction expertise is brought on as early as possible.

“Primarily, the importance of communication and collaboration between all parties remains a very important element in facilitating high quality documentation.”

**Canadian Construction Association,
“Quality of Documents Workshops
Report”, April 2016**

“Certainly, pre-construction services can give us a leg up on the contract bid but we decide to bid on a case-by-case basis. For example, on one job where we provided pre-construction services, we decided not to participate in the construction bid because it didn’t fit with our other commitments. Sometimes there is an advantage to knowing the project too well.”

General contractor

6 Creating an integrated, collaborative team

A typical project team involves a diverse group of individuals who need to work together to find creative solutions within physical, cost and time constraints. It is widely accepted that one of the primary success factors of an innovative construction project is the assembly of a multi-disciplinary team with experience and chemistry, preferably before 25% of project design is completed.²⁶ The objective is to utilize every participant’s knowledge through all projects phases. Bringing all the key participants together in the early stages of design allows them to develop a better understanding of the project. Procurement models that encourage early contractor involvement will enable new concepts to be tested for constructability and compatibility with the project goals.

A formalized approach to integration is the Integrated Design Process (IDP). This approach is based on the principle that a multi-disciplinary, collaborative team is working together with a mutual trust and understanding this process enables the team to optimize systems, reduce operating and maintenance costs and minimize the need for incremental capital. IDP has been shown to produce more significant results than investing in capital equipment upgrades at later stages.

The most important attributes by which to judge the suitability of a consultant or contractor to carry out a particular project, regardless of the selection process stages, generally are:

- Professional and/or technical competence
- Managerial ability
- Availability of resources (financial, people, equipment, etc.)
- Professional integrity

The owner should seek detailed information on all these qualities at the short-listing or selection stage by:

- Obtaining comprehensive written pre-qualification information appropriate to the scale and scope of the project
- Interviewing permanent senior personnel of the candidate at the short listing stage and the key staff identified for the assignment
- Examining systems and methods of services as well as hardware and software capabilities
- Talking to previous owners and clients.

“Getting us involved early - it’s the single most important thing owners can do. Then, we can propose all kinds of new ideas as part of the preconstruction process.”

General Contractor

“It is important to look beyond a company’s corporate resume and evaluate the skills of the people that work there. It is not always the company that has the skills but the people inside it. This encourages “new blood” into a particular field of construction and broadens the field of competition.”

Consulting engineer

Protecting intellectual property rights

Early market engagement activities may involve a supplier or group of suppliers providing details of a new, innovative solution or technology to an owner ahead of a formal contract process. This benefits suppliers as it allows them to demonstrate their competitive advantage and ensure that what they can offer will be taken into account in the tender process or included in the project specification.

However, it also creates significant risk for the supplier in terms of the potential loss of their intellectual property rights in regards to their innovative solution and the associated development costs. This risk may result in suppliers withholding innovation during early market engagement processes unless they feel their rights will be sufficiently protected.

6.1 Early market engagement

The benefit of construction expertise at the critical early stage(s) of a project cannot be overstated – particularly for projects that intend to employ novel technologies or processes, or which will impose major constructability challenges.

Early Market Engagement (EME) can be an invaluable method of capturing intelligence on innovations, new processes, project feasibility and market capacity/capability which can then be factored into options appraisal, specification and procurement of a construction project. EME comprises in-depth dialogue between the owner and potential suppliers prior to tendering for design or construction work. EME can cover a wide range of issues including:

- **Feasibility:** whether what is sought is possible, or has ever been done;
- **Capability:** the ability of the market to achieve what is required;
- **Maturity:** whether there is an established market for the requirement and whether there are enough suppliers in existence for competitive procurement;
- **Capacity:** whether the market can achieve what is required quickly enough, or on a large enough scale.
- **Cost:** whether the desired material or technology can be procured and incorporated into the client’s project at reasonable cost.

Different methods for EME exist ranging from a market survey through to “meet the buyer” events or industry days, where interested suppliers are informed in detail of the owner’s plans, and can raise questions and pose solutions.

Any EME activity needs to be undertaken with due regard to the principles of transparency, non-discrimination and mutual recognition. No advantage or disadvantage should be given to any supplier or group of suppliers. It is important that suppliers understand that the competitive phase of procurement will be carried out separately and all suppliers will be treated on equal terms. This can be stated in any invitation to open discussions.

EME is different to early contractor Involvement, which is based on the conditional appointment of a main contractor on an individual project in order to obtain additional input to the design process.

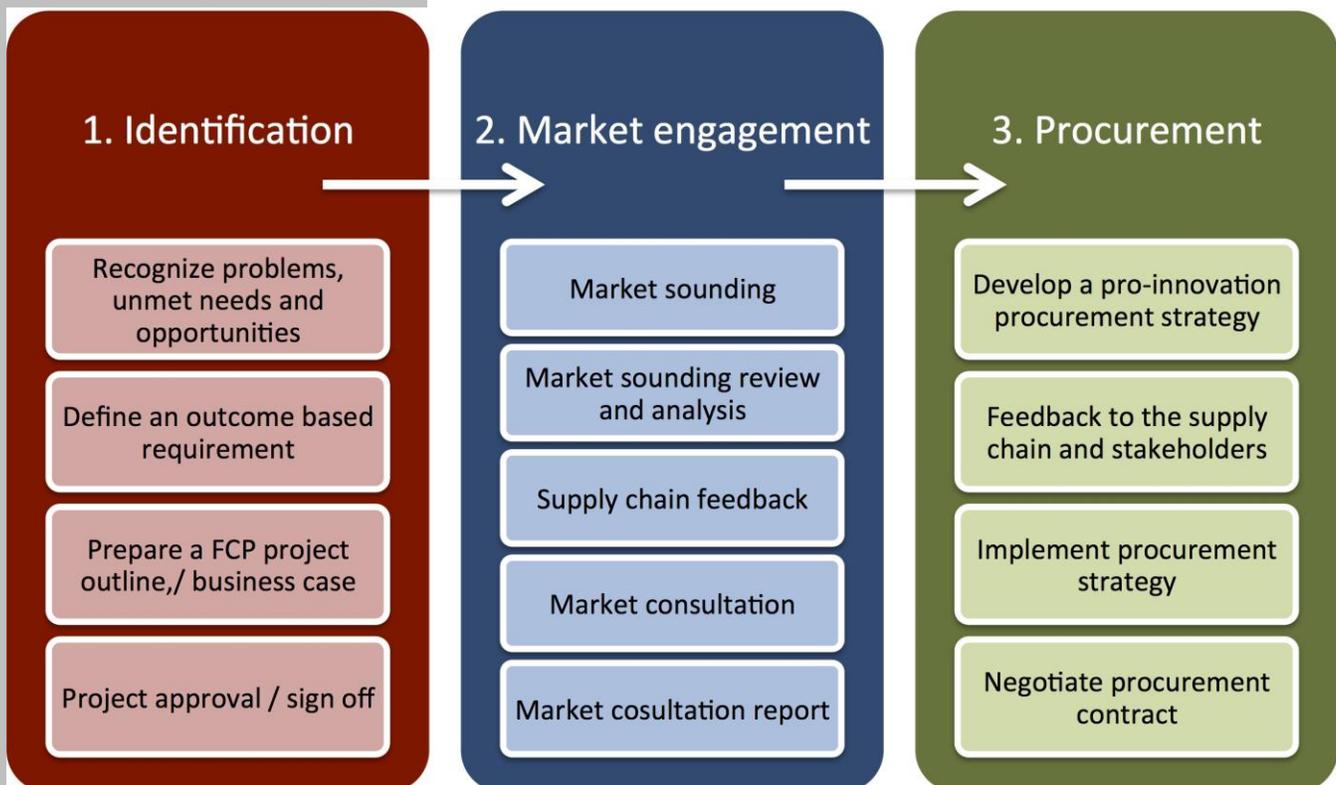
Case study: UK's Forward Commitment Procurement Tool

Forward Commitment Procurement (FCP) has been developed in the UK specifically for local government procurers and wider public sector procurers as an early market engagement tool. FCP creates the conditions needed to deliver innovative, cost effective products and services. Designed mainly for use by the public sector, the FCP approach was developed to be consistent with value for money policy and the legal framework that governs public sector procurement.

FCP brings together progressive thinking and best practice from the private sector and the innovation and procurement communities, together with understanding of the demand side barriers to the commercialization of innovative goods and services to bring new cost effective goods and services into the market.²⁸

In brief, FCP provides the supply chain with information of specific unmet needs and, critically, with the incentive of a Forward Commitment: a commitment to purchase a product or service that currently may not exist, at a specified future date, providing it can be delivered to agreed performance levels and costs. FCP provides the incentive, confidence and momentum for suppliers to invest and deliver innovative solutions.

Forward Commitment Procurement procedure step-by-step overview. Source UK Government²⁷





While competitions can be used to procure “out of the box” solutions to challenging projects, they can also reward exemplary solutions.

The Liyuan Library, on the outskirts of Beijing, China was the 2014 winner of the Moriyama RAIC International Prize²⁹ in 2014. The glass structure is protected by a brise soleil created from branches so it blends into the natural surroundings.

The prize recognizes the social values architects can foster with thoughtful design. The award is unique for its focus on the qualities of buildings in use. It is about how buildings create opportunities for individuals and communities.

Images: Inhabitat.

6.2 Sanctioned design competitions

Competitions to procure design (or design and construction) services, though not common in British Columbia, are a proven method of delivering innovation in other countries, especially in Europe. They tend to attract firms which are newer, younger, hungrier and more predisposed to exploring the boundaries of what is possible in practice. A competition can be ‘open’ whereby any qualified architect (or firm) can enter or it can be based on a preselected shortlist of architects chosen by the competition organizers. Based on the competition terms, the participants are asked to develop an initial (schematic) design concept based on the defined project requirements, which is then evaluated by a jury of experts and the project is awarded to the successful proponent.

The design competition for procurement can be a useful method of leveraging innovation into the design and construction processes. There are administrative and regulatory challenges to holding design competitions in BC because they must be sanctioned by the AIBC³⁰ and there must be financial compensation for all participants. To be successful, design competitions should be launched on the basis of a very clear project brief, including design excellence, minimum and aspirational energy (and other) performance targets and the openness to innovative solutions such as the inclusion of mass timber structures.

6.3 Competitive dialogue

Included in the 2014 EU Public Procurement Directives, “Competitive dialogue” is used in European countries to create a separate phase for dialogue with suppliers on the assumption that more and better dialogue results in a better project, product or service. It allows for bidders to develop alternative proposals in response to an owner’s outline requirements. Only when their proposals are developed to sufficient detail are tenderers invited to submit competitive bids. The aims are to increase value by encouraging innovation and to maintain competitive pressure in bidding for complex contracts.

Although competitive dialogue takes longer and requires more upfront investment of time and money by the owner, experiences in the UK suggest that it can be a powerful method for encouraging and evaluating innovative solutions – particularly for complex projects. It is designed to be applied to projects where the owner is able to state its requirement at the outset, but either cannot or does not want to define what the solution should be.

Resources



Sci-Network's 2011 report "Procuring Innovation" investigates how Early Market Engagement and Supplier Relationship Management procedures can be used to drive the development and application of innovation and sustainability within the construction sector. It provides deep descriptions of the processes and the state of uptake across Europe.³¹

"Don't give them what you think they want. Give them what they never thought was possible."

Orson Wells

For the owner, competitive dialogue makes it easier to confirm that "all necessary elements" are in place before bids are submitted, resulting in more robust tenders. Active dialogue should prevent the possibility of misinterpretation by either the tenderer or the owner and hence cost escalation later in the contract. For bidders, the process provides better information flow, together with the opportunity to test the owner's requirements through a progressive development of their proposal. Despite the substantial difference in process between negotiation and competitive dialogue, the outcome should be similar: an affordable and compliant preferred bid on which the parties can proceed to contract. The benefits from competitive dialogue are primarily related to the more detailed testing of the preferred proposal – an important consideration for an innovative project.

Competitive dialogue requires detailed development by multiple bidders. On the owner side, the management and resourcing of the dialogue has to be considered. Competitive dialogue requires owner engagement in design, contracts, service standards and payment mechanisms. The owner must be equipped to respond promptly to proposals or changes. Although the owner is expected to benefit from faster financial close and a better, more secure solution, bidders are exposed to a greater risk of unrecoverable expenditure. Also, there is no binding offer on the table during the process until final bids are requested. Although the overall objective of the dialogue is to progressively develop proposals that are compliant and affordable, there is no discipline imposed on a tenderer (in other words, they can act how they wish) other than the competitive pressure from other bidders.

Where innovative solutions are being sought, competitive dialogue may be highly desirable. The iterative process of solution development fits well with the development of innovative solutions and so competitive dialogue can generate alternative design proposals, giving greater potential for added value in project delivery. Done well, both the owner and the delivery partner have greater confidence in the quality of the solution and the submission, particularly if it has been progressively tested during the dialogue process. Despite increased interest in Europe, competitive dialogue is not yet done in Canada. Any owner who considers using the "competitive dialogue" process should be extremely cautious to avoid the possibility and perception of unfair bidding practices (particularly in the public sector). Thorough preparation must be undertaken so that the owner can fully brief participants and respond appropriately to bidders' proposals during the dialogue using a clear, well-defined and consistent process that has been openly communicated to all parties.

Performance incentives can be financial or non-financial

Financial incentives

- Penalties such as damages, hold backs, etc.
- Performance bonus in accordance with an agreed target: e.g. schedule, quality, budget, etc.

Non-financial incentives

- Experience & knowledge
- Marketing
- Reputation
- References and testimonials
- Opportunity to bid on future work



Developed by Vancity and its partner Windmill West, **Dockside Green** is transforming 15 acres of Victoria's harbour-front industrial land into a community of the future, complete with residential, office, retail and commercial space.

The project team was incentivized to achieve LEED Platinum through a commitment to pay a \$1 million penalty to the City of Victoria if they failed to hit the mark. The goal now is to continue to achieve this rating through the remainder of the project.³²

6.4 Performance incentives

Aligning both owner and project team's individual and collective objectives can be a powerful catalyst for good project performance. For this reason, contract incentives can be employed to identify and ensure focus on the owner's goals. Incentives can be financial or non-financial (see side-bar).

Traditionally, owners have relied on contract penalty clauses whereby the owner will claim a specified amount in damages (e.g. for every day the project is late) and/or may include hold back penalty clauses whereby the owner retains a portion of payment until the project is complete. However, penalties tend to foster defensive, risk-averse behaviour. They may not create the spirit of trust and respect necessary to ensure the project's best interests are always put first.

When dealing with a new type of construction process or technology, an experienced team can make all the difference to the process and resulting performance of the project. For example, there are design and construction firms that have become specialists in working with mass timber. Although there is no guarantee, a team with a proven track record of delivering the required quality of project on time, on budget, and are comfortable working together, will get the project off to a strong start. In fact, some owners prefer to hire project teams en masse instead of each consultant and contractor individually to ensure smooth and fast "onboarding". To get the right people on the project it may be necessary to modify the procurement documents. For example:

- Depending on its wording, an "owner's privilege clause" can permit it to accept a bid which was not the lowest bid and award to the bidder whose reputation and named project manager and key staff have the most satisfactory history; and
- Irrespective of the procurement model, the construction contract may also requires that those individuals named as being key members of the bidder's team in the bid and / or the contract must exclusively work on the owner's project and they can only be changed by the owner in writing, thus giving the owner a timely opportunity to assess and negotiate the scope, price, and completion time.

“If an owner wishes to see innovative and sustainable solutions presented by the market this ambition must be clearly communicated at the outset. It is important to clearly state in tender documents any desire for a sustainable outcome and the degree of openness to innovative technologies and techniques being offered. “

General contractor

BCCA Policy Statement on Pre-Qualification

BCCA and its regional associations recognize the need for Pre-qualification in limited circumstances. Generally the ability of the Contractor to secure the necessary bonds is the sole criteria by which Contractors should be pre-qualified. Where it is deemed through the use of the BC Government’s Pre-Qualification Best Practice Checklist that a pre-qualification is appropriate, the use of the CCDC 29 A Guide to Pre-qualification should be implemented to ensure a fair, open and transparent pre-qualification process, for General Contractors and Trade Contractors.³³

Incentive contracts

Incentive contracts feature compensation based on the contracting and/or engineering performance. Incentive contracts commonly fall into one of two common categories: Fixed Price Incentive Contracts and Cost Reimbursement Incentive Contracts.

7 Tenders and Requests for Proposal (RFPs)

To allow for innovative responses to a construction project requires a flexible approach that allows for discussion between the owner and the proponent.

Construction projects are normally procured using either a “Call for Tenders” or a “Request for Proposals” (RFP) process. Both approaches are predicated upon adherence to the terms and stipulations of the tendering system selected.

An RFP is a submission to an owner by a contractor responding to the owner’s needs for procurement of construction services based on the owner’s self-defined considerations. The response to an RFP could be fixed price and/or fees for service, as required at the owner’s discretion. BCCA recommends that prior to an RFP the owner issue an RFQ to qualify a subset of contractors who would then proceed to the RFP stage. The successful proponent in the RFP stage is awarded the contract.

BCCA also notes that a negotiated RFP in the public sector contravenes the public obligation to fair and transparent procurement practices. However in the private sector, negotiation is at the discretion of both parties.

A Tender is a submission to an owner by a contractor responding to the owner’s needs for procurement of construction services based on a fixed set of criteria (project documents) usually created by a design team, resulting in a fixed price.

The BC government offers a wealth of resources for developing and responding to RFPs for public projects, generally.³⁴ When it comes to evaluating innovation, outcome-based specifications, procedures that invite dialogue, being open to alternative proposals, and the awarding of contracts based on the best fit-for-purpose solution, at the best value, are the most important prerequisites to facilitating the procurement of innovative solutions.

“To make sure the right people are working on your project, you should:

- Consider the complete package of what a firm can bring to the table
- Write the names of the individual project team members into the contract documents so they are committed to your project. Any changes need to be approved by the owner (in writing).
- Take into account the firms’ investment in innovation (within the company and in past projects).”

Building owner

However, these conditions may contribute to making the evaluation and selection of innovative proposals both challenging and resource intensive. Clear, complete and measurable criteria are essential for describing the desired outcomes and the degree of latitude the project team has in delivering the required project.

A scoring system that allocates points and weighting for specific project outcomes is recommended where performance-based outcomes are required (e.g. total life cycle cost, GHG emissions ($\text{kgCO}_2\text{e}/\text{m}^2$)), as opposed to prescribed deliverables (such as gross floor area).

Frequently, “innovation” is a deciding factor between proposals that may otherwise be similar. Therefore, the definition of what innovation means to the owner (and the project) and how it will be evaluated, must be included in the RFP. For example, an RFP might rank an innovation that shortens the construction period more highly than one that improves the environmental footprint beyond what is required. It may also be valuable to ask firms to describe the innovation and/or R&D that they have undertaken in the past both corporately and on projects.

Case Study – Van Dusen Gardens Visitor Centre, Vancouver



The Centre’s complex petal roof structure utilizes a glulam post and beam assembly. The beams are spanned with secondarily curved joists suspending a lengthwise fir plywood slat exposed ceiling. The assembly is topped with two layers of plywood and conceals all MEP services.

A parametric 3D model was developed to rationalize the complex geometry of the petal shapes, and then used to produce fabrication information to shape each double-curved and tapered beam. The 3D model was used to digitally panelize the roof’s series of overlapping petals and the central atrium area. The geometry of each of the 70-plus panelized roof panel sections was unique and each described compound curves.

The 3D modeling helped to optimize the number and thickness of laminations and keep the costs down. By using larger radii for the curves, stock laminations could be used. The modeling was also used to identify appropriate locations for the low points in each panel segment for the most favourable placement of down pipes to drain the sprinkler system and for placement of the roof drains, as well as to ensure visual continuity of the ceiling.



The **Wood Innovation & Design Centre** (WIDC) in Prince George, BC was completed in 2014.³⁵ The building incorporates a structural system that includes a variety of solid engineered wood products including CLT, glu-lam and LVL.

As an innovative demonstration project and a precedent setting building, the WIDC showcases B.C.'s growing expertise in the design and construction of large wood buildings.

Evaluation process

When Partnerships BC (PBC)³⁶ put out the proposal for WIDC, they stipulated that if two or more proposals ranked highest based on their financial and technical requirements (i.e. had the same points total), then the points awarded based on the level of achievement of criteria relating to structure and structural system would be considered. These additional criteria were weighted as follows:

- Innovation - 60 points
- Aesthetics - 15 points
- Private sector participation - 25 points

The proponent providing the proposal with the highest points total in these areas as determined by PBC, in its discretion, would then be designated the preferred proponent.

Case study: the Wood Innovation & Design Centre in Prince George (WIDC)

The following criteria were used to evaluate innovation for the WIDC project³⁷:

A. Wood Optimization (25 Points)

Optimization of wood content in the following building areas:

- Structure (minimum 50%; maximum 74%)
- Interior partitions (minimum 25%; maximum 38%)
- Non-glazed Exterior Cladding (minimum 25%; maximum 38%)
- Total wood volume (minimum 35%; maximum 50%)

Scoring: the FP Innovations Wood Calculator Tool was provided.

B. Value-added Wood Product Use (20 Points)

Extent to which the proposal utilizes Value-added Wood Products as an alternative to contemporary design and construction approaches in the following areas:

- **Structural system:** The structural system including columns, load-bearing walls, core walls and shear walls, lateral system bracing, stairs, and floor and roof framing elements such as beams, joists, trusses, sheathing, and mass timber panels, extensively utilizes Value-added Wood Products in an effective and appropriate manner.
- **Interior partitions and finishes** Interior partitions and finishes including permanent and moveable partitions, doors, floors, ceiling, wall finishes and fittings and fixtures extensively utilize Value-added Wood Products in an effective and appropriate manner.
- **Building envelope:** The building envelope, including roof finish, walls above and below ground floors, windows, exterior doors, balconies, canopies and screens extensively utilize Value-added Wood Products in an effective and appropriate manner.

Scoring: Minimum: Value-added wood products not extensively utilized as an alternative to contemporary design and construction approaches or utilized in an inappropriate manner.

Maximum: Proposal demonstrates extensive and appropriate use of value-added wood products as an alternative to contemporary design and construction approaches.

8 Delivery models

There is no “one size fits all” solution to fostering innovation and none are without shortcomings. Indeed, examples of innovative wood projects were found that followed all the different forms of procurement, which are summarized below and described in the following sections.

Summary of common forms of project delivery in Canada Source: Canadian Handbook of Practice for Architects³⁸

Method of construction project delivery	Standard form of contract	Description
Design-Bid-Build	RAIC Document Six: Canadian Standard Form of Contract for Architectural Services <i>Followed by</i> CCDC 2 Stipulated Price Contract (CCDC 3 or CCDC 4 may also be used)	Owner engages the architect to provide design services and prepare construction documents which are issued for competitive bids. General contractors submit bids for the project and the construction contract is typically awarded to the lowest bidder. The architect administers the construction contract.
Construction Management	CCDC 5a - Construction Management Contract for Services CCDC 5b - Construction Management Contract for Services and Work	Owner engages the architect to provide design services and prepare construction documents. The Construction Manager works for the Owner as a consultant providing services that normally include design input on constructability, cost estimating, scheduling, bidding, coordination of contract negotiations and award, timing and purchase of critical materials, cost control and coordination of construction activities. Depending on the type of contract used, the Owner may or may not engage the Trade Contractors directly.
Design-Build	CCDC 14 Design-Build Stipulated Price Contract CCDC 15 Design-Builder / Consultant Contract (subcontract)	A method of project delivery in which the Owner contracts directly with a single entity that is responsible for both design and construction services for a construction project.
Public Private Partnership (P3)	No standard form of contract	A form of partnership between the public and private sectors where a combination of financing, design, construction, operation and maintenance of public projects relies on alternate sources of financing and revenue to cover all or part of the capital costs (including debt servicing, principal payment and return on equity), as well as operating and maintenance costs of for the project.
Single Purpose Entity for Integrated Project Delivery (IPD)	CCDC form of contract for IPD to be released 2017 In the UK, JCT Constructing Excellence In the US, AIA Document C195	This new form of project delivery creates a new single purpose entity or limited liability company, which includes members such as the owner, architect, construction manager and other key project participants in the design and construction the project. The entity enters into contracts with non-members for design, trade contractors and suppliers for services, labour and materials. The entity enters into a separate agreement with the Owner to obtain project funding.

SFU UniverCity ChildCare Centre



Simon Fraser University identified its UniverCity neighbourhood as a demonstration sustainable community and sought innovative ways to embrace all aspects of that ideal.

The UniverCity Childcare Centre served partly an experiment with and investigation of the Living Building Challenge³⁹ that encourages holistic thinking in design and construction; partly an exercise to determine what technologies might provide opportunities to improve the performance of the market buildings it commissions.

The SFU UniverCity ChildCare Centre followed a traditional design, bid, build process. The RFP clearly stated performance outcomes (i.e. to pursue Living Building Challenge). The project team's experience with innovation was considered as part of the bid process. These factors may not be traditionally valued in a bid process, which can offset some upfront costs and time delays that could come with an award to a less qualified low bidder.

8.1 Design-Bid-Build

Suitable for:

- All owners, including inexperienced owners
- Complex projects and projects where functionality is a prime objective
- Time predictability
- Cost certainty

Not suitable for:

- Fast track projects
- An uncertain or developing owner's project scope of requirements / brief

Potential for facilitating innovation

Moderate

Design-Bid-Build is the most commonly used method of procurement. The owner develops the business case for the project, provides a brief and budget and appoints a team of consultants to prepare a design, plus tender documents.

After the bid process the owner then retains the general contractor to construct the project to the design prepared by its team of consultants, by the contract completion date and for the agreed price. Usually much of the work is sub-contracted to specialist firms but the general contractor remains liable. The consultants administer the contract on behalf of the owner and advise on aspects associated with design, progress and stage payments, which must be paid by the owner. The absence of input from the contractor during the design process can mean missed opportunities for the general contractor or a specialist contractor to provide input.

This strategy is a low-risk option for owners who wish to minimize their exposure to overspend, delays or design failure. However, the conventional competitive low bid process is adversarial to whole systems thinking, as it typically encourages estimates based on conventional construction, with a percentage added on for 'innovation'. It ignores the cost-benefit equation of truly integrated and sustainable design and delivery, where savings are made up in non-traditional avenues, but may be costed by the bidder (i.e. heavily reduced mechanical in energy efficient envelope). Where the potential for such issues is foreseen, the owner could ask for a more detailed breakdown in key cost categories in the tender documents to ensure that prices are correctly allocated and apportioned. Extra time to provide this information may be necessary.

Two-stage tendering for social procurement



Social Public Procurement leverages existing purchasing to achieve social value. For example, contractors may be required to include social contributions – such as apprenticeships, youth jobs, First Nations economic development, or other community benefits – in their bids at no extra cost. The **Village of Cumberland**'s social procurement framework⁴⁰ for road building is a form of 'two-stage open book'.

Qualitative requirements are evaluated first on a pass-fail basis and then those that pass will be reviewed for the price). In this format, the owner develops a detailed design brief and from a list of pre-qualified contractors, selects a proponent to prepare an initial project budget based on the brief. Once the owner has accepted the design brief and the initial project budget, the work collaboratively with the contractor to deliver the project for the stated budget in an open book format.

The Village of Cumberland on Vancouver Island was recognized as the first certified Buy Social municipality in Canada in 2015.

8.1.1 Two-stage tender

Contractor's tenders are based on a partially developed consultant's design (stage 1 tender). The contractor then assists with the final development of the design and tender documents, against which tenders for the construction works are prepared (stage 2 tender). Whoever puts forward a first stage tender has the opportunity to tender or negotiate the second (construction) stage. This approach increases the risks of an increase in overall price and a less certain completion date but contractor involvement is likely to increase the likelihood that both these criteria are realistically established.⁴¹

8.1.2 Two stage open book

This variant sees the owner (normally public sector) invite suppliers to bid for a project on the basis of an outline brief and cost benchmark. A number of contractor-consultant teams compete for the contract in a first stage with bidders being chosen based on their capacity, capability, stability, experience and strength of their supply chain, and fee (profit plus company overhead). The winning team then works up a proposal on the basis of an open book cost that meets the owner's stated outcomes and cost benchmark as a second stage.

Robust, expert, milestone reviews with independent scheme verification are applied throughout this model to ensure appropriate scheme definition, stimulate competition in the market, monitor scheme development and highlight any unnecessary scope, risks and potential missed opportunities. This verification will also provide clear recommendations to the owner and contractor for improvement of the proposition. Any such verification must deliver greater benefits in terms of savings than its cost of implementation. It is also essential that steps are taken to ensure that those appointed to carry out this verification have the skills to do so effectively. Additional capacity may need to be generated in terms of these skills should the model be rolled out more widely, in order to meet expected increased demand for competent verifiers.

Note that two stage tender processes can be challenging in the public sector due to the expectation of transparency in procuring construction services using public funds. For example, if any contractor putting forth a Stage 1 Tender is automatically entered into the Stage 2 Tender without a competition, transparency is compromised.

Brock Commons, UBC



UBC Properties Trust engaged Urban One⁴² on a construction management basis and other key project team members by way of a series of parallel individual contracts. Urban One was then responsible for letting the various the sub-contracts.

This is important because it allowed the offsite pre-fabricator, Seagate Structures,⁴³ to commence work while building foundation systems, concrete cores and services are being constructed but before final decisions have been made about building envelope or finishes. Image www.naturallywood.com

“The option of a convertible contract (Construction Management to Fixed Price) is currently considered the most effective in offering the opportunity for innovation while affording the owner the certainty of a fixed price if desired. That said, in our recent wood projects, we did not convert.”

Owner

“Consecutive, non-coordinated engagement of team members leads to traditional behaviour and predictable results.”

Contractor

8.2 Construction Management

Suitable for:

- Complex buildings
- Fast track projects
- A developing client brief

Not suitable for:

- An owner that has its own in-house project and/or construction management team.
- A market with rapid escalation and/or material/supply challenges
- An inexperienced construction management company

Potential for facilitating innovation

High

In this arrangement, a Construction Manager (CM) is typically appointed early in the construction process, who works alongside the design team to contribute to design decisions, “constructability” and budget development. This form of Construction Management is commonly taken on as ‘Construction Management at Risk’. “At risk” means that, because the CM has contracts directly with the trade contractors (using CCSC 5B), the CM will be responsible for completing the project to the budget, paying for any overages. By comparison, the CM is not “at risk” where the owner contracts directly with the trade contractors (CCDC 5A). This model of construction procurement is particularly suited to promoting innovation because it:

- **Facilitates the early involvement of the construction manager** which has been shown to optimize the opportunity for creative, integrated thinking across the entire project team, and therefore offers the greatest potential to incorporate innovative solutions.
- **Allows the team to ‘risk take’** within the context of a framework where the budget is fixed but funds can be allocated to different aspects of the work if there is support within the team to do so (assuming fixed price trade contracts have not been entered into).

This integrated approach allows the entire project team the ability to explore innovative system and material choices as well as procurement options with the overall project budget and schedule in mind.

Resources

CCA 26 A Guide to the Construction Management Project Delivery Method

CCA 26⁴⁴ explains what Construction Management (CM) is and the two fundamentally different forms of Construction Management contracts:

- For Services where the Construction Manager acts as an agent for the Owner who contracts separately with multiple Trade Contractors to perform the work.
- For Services and Construction (aka Construction Management at Risk) where the CM contracts with the Trade Contractors to perform the work and is responsible for the construction as a whole.

Construction Management allows the letting of contracts to occur sequentially rather than concurrently (as is typically the case with conventional procurement). This enables site works to start even if an entire package of construction documents is not yet complete.

The sequential tendering of scope packages does not necessarily mean that an owner foregoes price certainty at the expense of contract flexibility. Under CM At Risk, the owner may, with agreement of both parties, be able to fix the price under a construction management contract at a certain point and convert the management of the 'Services' to the management of the 'Work' effectively converting the CM's role from that of consultant to that of General Contractor (GC). In this case, a 'stipulated sum' contract is executed between the owner and the CM/GC and the CM/GC holds all of the trade contracts. If – at the time of signing the contract – all of the scopes of work are not yet 'bought out' from the trades by the CM/GC, cash allowance(s) for those items will be carried, which will be converted to trade contracts later.

A significant risk in this scenario is in a market experiencing significant and rapid price escalation so that even the most experienced CM/GC may be caught by surprise by the market and find that his cash allowance isn't sufficient for the scope of work. However, if the owner has already converted to a stipulated-sum contract, this risk is borne by the CM/GC not by the owner.

Case Study – National Avenue Works Yard, City of Vancouver



The National Avenue Works Yard for the City of Vancouver was commissioned in 2001. Omicron Architecture Engineering Construction Ltd was the successful respondent to a Request for Proposal that asked for integrated design and construction services (essentially a CM contract). Featuring a Parallam roof structure, the project was to replace the aging City Work Yard with a new, purpose built facility on the False Creek Flats near Vancouver Central (Rail) Station. The project budget was set at \$21 million for the 12-acre site and multiple new buildings. The project 'client' from the City of Vancouver was the City's Engineering department.

After the contract had been awarded, the City requested that the design team and CM consider the adoption of the LEED rating system and set a target of LEED Silver for the facility. Working within a fixed budget, the design and CM team was able to make decisions prioritizing sustainability. The team was greatly assisted by City staff who – because this was their own facility – were able to consider leading edge innovations which the Vancouver Building Bylaw would not otherwise have allowed. When completed, the project was 40% more energy efficient than code and had incorporated a geo-exchange thermal field, the use of captured grey water for sewage conveyance, extensive use of recycled materials and diverted over 90% of construction waste while achieving LEED Gold. The team believes that this could not have been accomplished if the project had been conventionally designed and tendered.

Bella Bella design-build project



Vancouver Coastal Health had a desire to reduce operating costs and the environmental impact of its remote housing project in northern BC. Weather was a risk along with the inaccessibility of the site. These risks were mitigated by the inclusion of specific clauses in the contract related to these kinds of delays.

The project⁴⁵ was procured using a Design-Build model, requesting competitive fixed price bids for the prescribed program and scope of work, including the requirement that the project be certified to the Passive House standard. The procurement process made sense given the small scale, clear functional program, simple building form, experienced owner with a good understanding of construction cost and time constraints. Images SABMagazine

“I’ve seen the most problems when design-build is used in public procurement process. The construction team is not invested in the long-term future of the project and design-build is driven by the cheapest solution.”

Construction Industry expert

8.3 Design-Build

Suitable for:

- All owners, including inexperienced owners and those requiring distance from the project
- Faster track
- Cost certainty

Not suitable for:

- An uncertain or developing client brief
- Complex buildings

Potential for facilitating innovation

Moderate

This model allows for significant interaction between the design and construction teams, however the owner maintains less direct control over the process, and appropriate monitoring may require more in-house expertise. The general contractor takes responsibility for both design and construction and will use either in-house designers or employ consultants to carry out the design. Sub-contractors will carry out most of the construction work. The success of this approach is highly dependent upon the owner’s level of sophistication and desire to have innovative construction in the initial project brief.

An initial design brief is typically developed by the owner, and a fixed price for completion is agreed with the selected contractor. The contractor will develop the design (contracting with consulting professionals directly).

Design-Build gives the owner a single point of contact. However, the owner commits to the cost of construction, as well as the cost of design, much earlier than with the traditional approach. Whilst risk is shifted to the contractor, it is important that design liability insurance is maintained to cover that risk. Changes made during design can be expensive, because they affect the whole of the Design-Build contract, rather than just the design team costs. There are variations on this approach:

- **Develop and Construct:** where the owner has the design prepared to schematic design stage and the contractor takes on ‘finishing off’ the design and construction. The contractor may re-employ the original designers to complete the design.
- **Package Deal:** where the contractor provides an off-the-shelf building (e.g. farm, factory, warehouse buildings). The building type is often modular so that its size can be adjusted.

“Now, there is a realisation that success depends as much on the ‘soft’ skills as the ‘hard’ skills. What large experienced owners have learned is that creating supply chain environments that retain knowledge and relationships leads to building success. This is a new vocabulary for many in the construction industry.”⁴⁶

Constructing Excellence

‘Building Success: Lessons from Clients who got it Right’

“Public – Private Partnerships (P3s) are a long-term performance-based approach to procuring public infrastructure where the private sector assumes a major share of the risks in terms of financing and construction and ensuring effective performance of the infrastructure, from design and planning, to long-term maintenance. The emphasis on risk management is considered key from an innovation perspective, as the risks associated with more innovative/sustainable types of construction is one of the factors identified for limited take-up in Canada.”⁴⁷

PPP Canada

8.4 Public Private Partnerships (P3s)

Suitable for:	Not suitable for:
<ul style="list-style-type: none"> • Owner, operator client • Complex projects and projects where functionality is a prime objective • Time predictability • Cost certainty 	<ul style="list-style-type: none"> • Inexperienced owners • Small projects

Potential for facilitating innovation

High

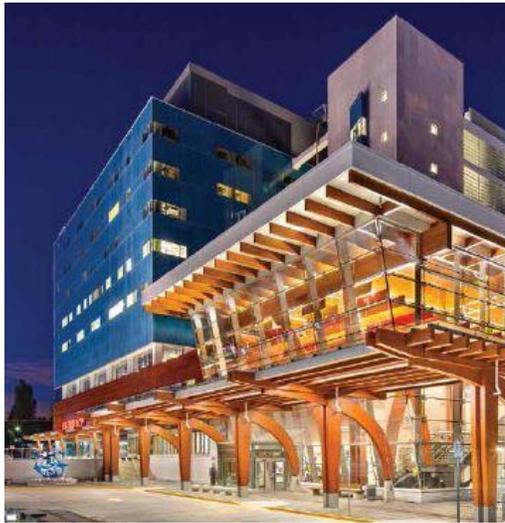
Public Private Partnerships (P3s) are applied in the construction sector to harness private sector involvement in order to achieve defined development objectives. They combine the operation and maintenance of a building/facility with its design and construction. They are typically associated with larger-scale projects carried out over a number of years. This form of contract is difficult to adapt to (smaller) building projects.

P3 models may involve elements of private financing and are primarily driven by two complementary advantages:

- **Attractive financing arrangements:** The pressure on public finances means that many authorities are examining alternative ways of funding construction projects. P3s allow authorities to share costs, or finance them through future savings
- **Incentivizing efficiency:** Making suppliers responsible for certain operating costs, in addition to construction/renovation work provides a clear incentive for them to maximize the efficiency gains.

A variety of models exist, differing in terms of responsibility for raising finance, the extent to which they effectively allocate risks between the parties and how the service provider receives payment/generates income (e.g. through payment of an operating fee by the owner, or through the commercial exploitation of the asset).

Surrey Memorial Hospital Redevelopment and Expansion: Emergency Department and Critical Care Tower Project



The Surrey Memorial Hospital project⁴⁸ was a major P3 project that required the project team to take responsibility for design, build and ongoing operation. The project was designed and built to achieve LEED Gold certification and also maximized the interior and exterior use of wood, in keeping with BC's Wood First Act.

The motivations to innovate were primarily based on Life Cycle Cost considerations and a desire to simplify the operating requirements.

The partnership agreement between Fraser Health Authority and the project consortium - Integrated Team Solutions - is expected to achieve value for taxpayers' dollars of \$31 million (net present cost) compared to the traditional procurement delivery method. Additional benefits from the partnership delivery method include:

- Competition and innovation: The competitive nature of the bidding process encourages the private partner teams to develop innovative solutions in all aspects of the project from design and construction through to operations.
- Schedule certainty: The private partner receives a significant portion of their payment through monthly availability payments once the facilities are available for use, thereby providing a financial incentive to complete the project on time.
- Cost certainty: The project agreement is a fixed-price contract.
- Integration: The private partner is responsible for the design and construction, long-term operations, maintenance and rehabilitation of the asset. This creates opportunities and incentives to integrate these functions to optimize performance of the facilities over the duration of the project agreement.
- Life cycle maintenance: The private partner is responsible and accountable for ensuring the facilities are maintained and rehabilitated over the duration of the project agreement otherwise the annual service payment may be reduced.

Linking P3 with R&D

The EU Energy-efficient Buildings (EeB)⁴⁹ PPP is devoting €1 billion to boosting the construction sector by researching methods and technologies to cut the energy consumption and CO₂ emissions of new and renovated buildings.

The goal of EeB, financed jointly by industry and the European Commission, is to introduce green technologies and develop energy-efficient systems and materials across the construction sector at large.

Assessing value for money and injecting opportunities for innovation into the context of P3 projects can be challenging.⁵⁰ In many cases, public owners will have entered into such arrangements in the absence of other viable means of financing and contracting construction projects. In some cases, their stake may be limited to the granting of development approval or the lease or sale of land to the private developer – activities which do not fall within the scope of procurement and so are not generally subject to value analysis against the same criteria. In other cases the public owner may have an active financial stake in the partnership, but the award and assessment of the P3 is carried out by a separate department without direct involvement of procurement staff.

Lean design and construction

Originated by Toyota, "Lean" is a production management-based approach to project delivery. Lean enhances value on projects and uncovers wasted resources, such as wasted time, wasted movement and wasted human potential.

Lean changes the way work is done throughout the project delivery process. It extends from the objectives of a lean production system - maximize value and minimize waste - to specific techniques, and applies them in a new project delivery process. As a result:

- The facility and its delivery process are designed together to better reveal and support customer purposes.
- Work is structured throughout the process to maximize value and to reduce waste-at the project delivery level.
- Efforts to manage and improve performance are aimed at improving total project performance, because this is more important than reducing the cost or increasing the speed of any particular activity.
- "Control" is redefined from "monitoring results" to "making things happen." The performance of the planning and control systems are measured and improved.

The reliable release of work between specialists in design, supply and assembly assures value is delivered to the customer and waste is reduced. Lean is particularly useful on complex, uncertain and quick projects. It challenges the belief that there must always be trade-offs between time, cost, and quality.⁵¹

8.5 Single Purpose Entity for Integrated Project Delivery (IPD)

Suitable for:

- Complex projects
- Fast track projects
- Time predictability
- A developing owner's brief

Not suitable for:

- Cost certainty before starting construction
- Small projects
- An inexperienced construction company

Potential for facilitating innovation

Highest

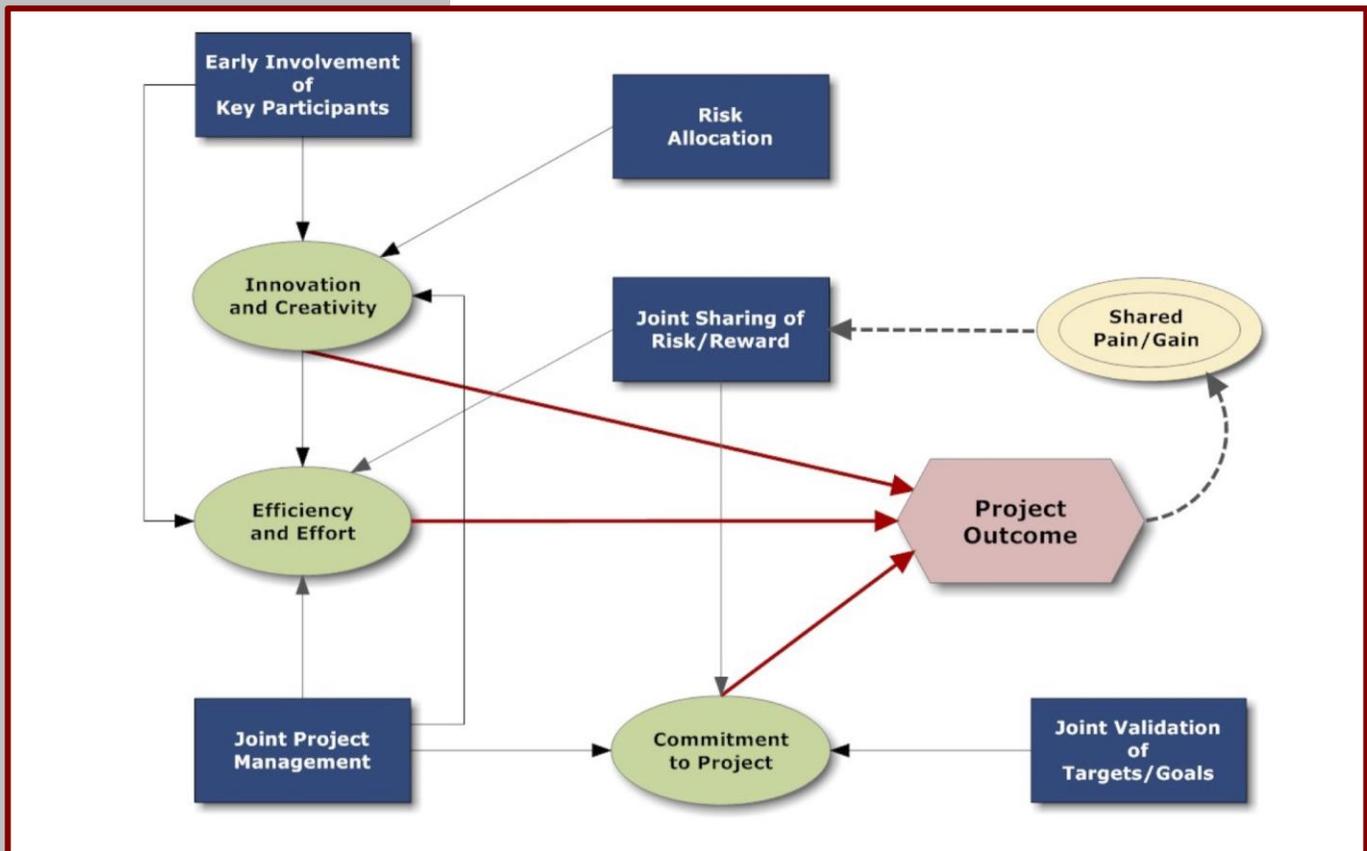
On large complex buildings (such as hospitals, airports) and projects with very demanding performance standards and/or schedules, project teams are turning to Integrated Project Delivery (IPD) as a way to harness the efficiencies of a seamless dedicated project team that is assembled as early as possible (ideally during the schematic design phase) and led by the builder.

IPD is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize the project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication and construction. IPD and Lean construction principles go hand in hand.

- Early involvement of key participants;
- Shared risk and reward based on project outcome;
- Joint project control;
- Reduced liability exposure; and
- Jointly developed and validated targets.

The collaborative construction contracts used for IPD are substantially different in philosophy and approach. They establish a fundamentally different type of relationship to the established systems with which the industry is much more familiar. Project management processes need to be changed and, as with anything new, there may be a perception that collaboration will cost more and be more time consuming.

IPD elements and outcomes



“We can do IPD using any form of agreement. We prefer to start with CM (CCDC 5A) and convert to a stip-sum at an appropriate point”

General Contractor

To facilitate IPD, multi-party agreements are starting to be used. These put the Constructor, the Consultants and Key Specialist sub-contractors/suppliers on the same terms and conditions through a single contract, so that they are fully aware of each other’s roles and responsibilities and owe each other a direct duty of care. This avoids the risk of inconsistencies, gaps or duplications otherwise present in a series of two party contracts and thereby establishes a much stronger contractual base for all activities. It also avoids the Owner having to act as the conduit for communication and resolution of problems between other team members.

The Canadian Construction Documents Committee (CCDC)⁵² is developing a multi-party agreement but in the interim, various proprietary solutions are being developed leveraging work in the US (AIA C-191 2009⁵³) and the UK (e.g. the PPC2000 suite of Partnering contracts⁵⁴). Early feedback from these forms of agreement suggests that consultants are expected to shoulder a great deal more risk than usual (potentially more than their insurers may be comfortable with).

“We are looking at international model contracts that are multi-party, with the expectation that these might eliminate any downstream conflicts between consultants and contractors, should there be a future warranty or liability issue. We are also looking at contracts that might provide a greater guarantee of post-occupancy and in-service energy performance.”

Owner

“Whatever innovations may be brought to bear within the construction industry, they will rely on performance-based forms of contract that can open the door for wood solutions alongside traditional ones.

They also need a supportive code and bylaw environment. The City of Vancouver has given its staff the discretion to negotiate exceptions to bylaw requirements, but this requires both political commitment and experienced staff capable of negotiating bylaw exceptions that are mutually beneficial.”

Researcher

These forms of agreement create the contractual structure to harness the maximum input to design development and risk management from the contractor and its specialist sub-contractors/suppliers at the earliest opportunity by providing for the contractor, consultants and specialist sub-contractors/suppliers to be appointed as early as possible in the design development process and to work in accordance with a single integrated timetable to achieve all necessary pre-conditions through to commencement of the project on site.

As a project management tool, these agreements are intended to establish a clear structure and set of processes to govern the pre-construction phase of the project, which is the time when value can be added by the contractor, consultants and specialist sub-contractors/suppliers in terms of design development, value engineering of existing designs, value management by the assessment of alternative solutions, and analysis/management of project risks with a view to reducing or eliminating their costs.

“Don’t over-specify – as this can kill innovation. Performance-based or functional specifications are one way of allowing for flexibility for suppliers to propose solutions. Allowing variants is another. There is a fine balance between making sure the market knows exactly what your requirements are and leaving the door open to different and new ways of meeting those requirements.”⁵⁵



The JCT-CE sets out amplified obligations in relation to acting in the spirit of mutual trust and respect, to, for example:

- Give and receive feedback on performance;
- Draw each other's attention to difficulties;
- Share information openly at the earliest practicable time; and
- Support collaborative behaviour and address behaviour that does not comply with the "Overriding Principle".

The JCT-CE Risk Register

The main purchaser of the project (the owner) must ensure that each project-specific risk is identified and recorded in a "risk register". This is a separate document which is prepared and updated from time to time, and is intended to be an important project management tool.

Case study: the JCT Constructing Excellence Contract

Developed by the UK's Joint Contracts Tribunal (JCT), the **Constructing Excellence Contract** (JCT-CE)⁵⁶ has been specifically prepared for use in partnering and where the parties want to utilize the concepts of collaborative and integrated working practices.

There is no legal barrier to the use of collaborative construction contracts such as JCT-CE. As long as the duties and obligations are sufficiently clear, the contract should be enforceable. The JCT-CE model can be used in Canada and is probably best suited for large and/or complex projects.

The JCT-CE can be used for the appointment of contractors, subcontractors, material suppliers and consultants. In so doing, integrated obligations can be passed through the various tiers of the supply chain. It can also be used whether or not the "supplier" (contractor) is to carry out design, and the "supplier's" design input (as either contractor, subcontract, material supplier or consultant) can vary.

A separate **Project Team Agreement** is drafted to accompany the JCT-CE, and can be used to formalize the integration of the project team and includes options that provide for risk and reward sharing arrangements between team members. This mechanism establishes clear incentives for team cooperation and puts the interests of the project first.

The JCT-CE states that, "*The Overriding Principle ... is that of collaboration.*" It requires the parties to have the "*intention to work together with each other and with all other project participants in a cooperative and collaborative manner in good faith and in the spirit of mutual trust and respect*". In any dispute relating to the contract the adjudicator, court or arbitrator is required to take into account whether the parties have adhered to this "Overriding Principle".

The JCT-CE can use either a contract sum or lump sum payment option, whereby payments are made when agreed targets are achieved throughout the duration of the project.

The JCT CE contract has a unique way of dealing with risks. The contract requires the parties to identify potential risks and record them in a risk allocation schedule. The parties must agree in advance how the financial and time consequences of each risk are to be allocated between them. The risk allocation cannot be amended. The purchaser/owner also has to assess the risks included in the initial contract sum and any external risks that will impact on that contract sum.

8.6 Summary of procurement models in the context of innovation

“Innovation within the construction industry is not a linear model but closer to the concept of complex products and systems which is highly reliant on knowledge transfer and the flow of information.”

University researcher

There is no one procurement method suitable for all circumstances and there are excellent examples of innovation resulting from all the common forms of delivery. However, in the context of innovation, some models of delivery may be better suited to certain types of project and market conditions than others. In all cases, public sector projects have an expectation of transparency, which must always be considered. Standard documents, best practice guides and other resources are available from BCCA.⁵⁷

Summary of delivery models with project and team characteristics

	Design-Bid-Build	Construction Management	Design-Build	Public Private Partnership	Single Purpose Entity for IPD
Time predictability	✓			✓	✓
Cost certainty	✓		✓	✓	✓
Requires an experienced owner		✓		✓	
Requires an experienced construction company		✓		✓	✓
Suitable for a market experiencing rapid price escalation	✓		✓	✓	
Suitable for small projects	✓		✓		
Suitable for complex projects	✓	✓		✓	✓
Suitable for fast track projects		✓	✓	✓	✓
Suitable for an uncertain or developing brief		✓			✓

“Although owners profess to seek value for money in their building projects, procurement for most public and/or non-residential projects in BC is all too frequently based on selecting the lowest compliant bid within a climate of regulations and risk allocations that make it extremely difficult to realize the benefits of novel products, processes or solutions.”

General contractor

Risk management

Risk management is an organized method of identifying and measuring risk and then developing, selecting, implementing and managing options for addressing those risks. There are several types of risk that an owner should consider as part of risk management methodology. These include:

- Schedule risk
- Cost risk
- Contractual risk
- Health & Safety risk
- Reputational risk
- Organization/mission risk
- Technical feasibility
- Building performance risk (i.e. the intended return on investment in a system doesn't materialize)
- Risk of technical obsolescence
- Dependencies between a new project and other projects
- Physical events beyond direct control

8.7 Dealing with risk

The topic of risk management in construction is large and complex, and outside the scope of this report. Simply, risk management seeks to identify and ultimately control possible future events and should be proactive rather than reactive.

However, selection of an absolute optimal procurement method is difficult, because even the most experienced owner or contractor does not know all the potential benefits or risks for each method. Procurement is, therefore, a succession of ‘calculated risks’ that need to be managed through the use of appropriate methods of procurement. Where problems potentially occur is when risk is deflected and transferred down the supply chain. Owners need to be aware of how risk is apportioned and to which member of the project team.

Owners are rightly concerned to guard against the risk of challenge to the procurement process, but over lengthy documentation and processes can reduce transparency and have the opposite effect of what is intended by increasing costs for both parties, as well as the possibility of challenge. In the implementation of our recommendations, a guiding principle should be to seek to reduce costs by removing unnecessary procedures and simplifying the procurement process.

8.8 Encouraging small businesses

Given the fact that the significant majority of contracting companies in British Columbia have fewer than 10 employees, highly elaborate (and expensive) procurement processes act as a disincentive for small to medium sized enterprise companies (SME’s) participating in public procurement processes.

Encouraging greater participation by SME’s will only be achieved if procurement can be simpler and that the results be made more transparent. Public procurement agencies can lower the barriers to participation for SME’s by increasing the pool of participants, thereby encouraging younger and less established firms who will be the catalyst for increased innovation in the procurement process and industry generally.

Digital techniques are central to improving the design, construction and, performance of buildings and, indeed, the transition to a digital economy will drive fundamental changes in all aspects of everyday life. In the coming years they will drive a step change in how the built environment operates.

Adopting these innovative technologies will provide building owners with a full understanding of the performance of their assets, both during construction and throughout their design life. This will result in smarter designs, requiring less material, reducing carbon and needing less labour for construction, whilst still ensuring full resilience of the assets.

In recognition of the scope and scale of benefits of BIM, all public projects in the UK over £50m must be procured using BIM.

BIM authorities and resources

- Canada BIM Council
- Institute for BIM in Canada (IBC)
- RAIC Centre for Architecture

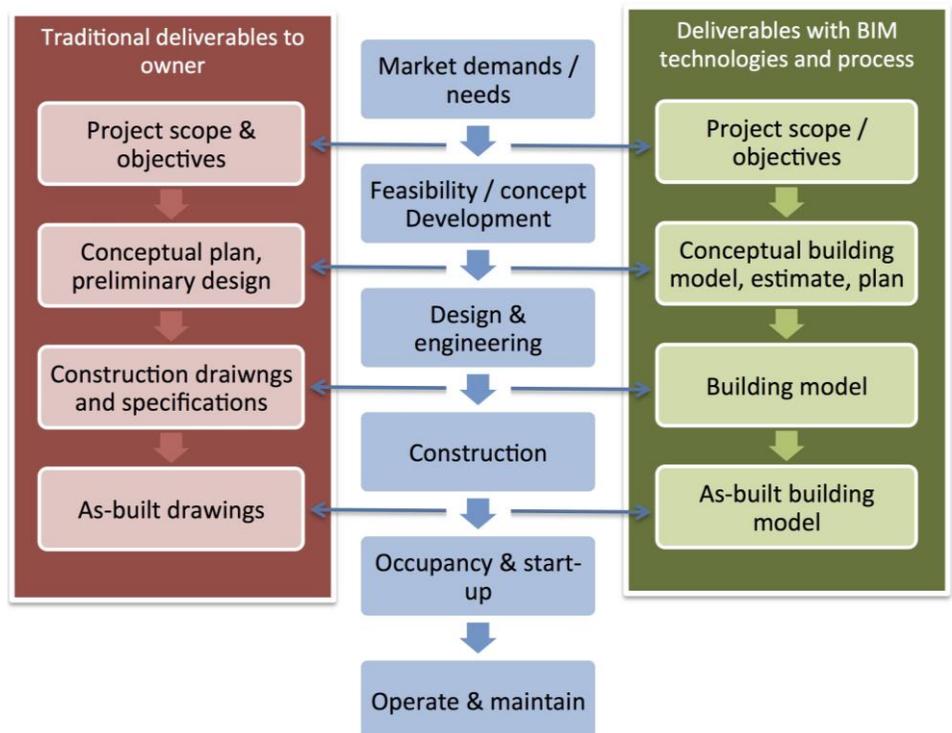
Project delivery process and lifecycle – traditional v BIM. Source: BIM Handbook⁵⁸

9 Tools to facilitate innovative solutions

9.1 Digital design and construction

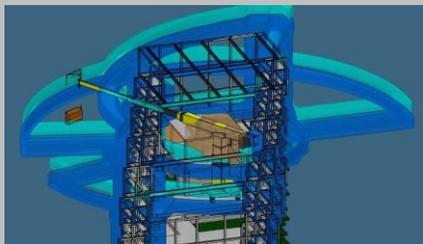
Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM model is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. BIM is intended to optimize collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder. In addition to facilitating the coordination of different software and project personnel, BIM improves productivity, communication and quality control.

At each project stage, further information is added to the shared model by the responsible professional. This approach helps to reduce information losses that occur when a new team takes ‘ownership’ of the project, and can help lead to substantial design and construction cost savings, and performance optimization.



The power of virtual design and construction⁵⁹

- **Detailed evaluation of construction assembly sequencing with “time motion” studies.** These analyses are used to optimize the full construction process by drilling down into the assembly of live construction processes, either at a larger macro level or in minute detail.



Representation of the swept volume path of a crane. Image: CadMakers

- **Process planning:** defines and quantifies each material, element and manufacturing item to automatically generate a Bill of Materials. The real life sequences of installation are analyzed and bottlenecks are identified so that inventory management and scheduling are optimized based on lead time analysis from subcontractors and suppliers.
- **4D modeling:** The linking of 3D geometry and a 1D project schedule is not novel but a good start in terms of planning and scheduling. It also helps think through site logistics, crane locations, lay down areas, temporary hoarding, etc. and DELMIA has 4D clash detection capabilities which can help for crane swing analysis.

Extremely powerful software tools that are used in the shipbuilding, aerospace and automotive industries are now being applied to construction. They can be used to manage the risk associated with designing and building innovative projects.

Because it is rarely possible to “experiment” on a real construction project, “digital mock ups” are the most cost effective and timely way to test designs and assist with optimization for later design iterations.

Using digital design and construction tools will affect procurement process and owners will need to change contracts and language to promote the use of BIM primarily in the following areas:

Scope and detail of the model information: includes defining the format of the project documentation and changing from 2D paper to a 3D digital model. Owners may incorporate detailed language to best reflect the types of BIM applications desired and the information the owner demands throughout the delivery process and subsequent operation.

Use of model information: includes specifying services more readily performed with BIM tools, such as 3D coordination, real-time review of design, conflict analysis, frequent value engineering using cost estimating software or energy efficiency analysis.

Organization of model information: describes the breakdown of project work. Although information management standards for building models are emerging, owners or the project team need to establish an initial information organization structure.

To meet these requirements, some modifications to the fee structure and relationships between project team members may be necessary or may require the use of incentive plans that define workflow and digital hand-offs between disciplines.

Owners can demand projects be designed using BIM with the models shared across the entire project team from conceptual design through to hand-over.

Digital fabrication relies on computer numerically controlled (CNC) machinery that can cut, mill and rout components to complex shapes with great precision. However, taking lessons from the manufacturing world, construction researchers are now developing solutions that can also be used to power robotics and CAD/CAM integration, among other applications. Images: Canadian Wood Council / Woodworks BC



9.2 Encouraging a manufacturing mindset

Powerful digital tools have ushered in a new way of delivering construction solutions. “Modern Methods of Construction” (MMC) encompass the use of composite new and traditional materials and components often with extensive factory produced sub-assembly sections and components. This may be in combination with accelerated on-site assembly methods and often to the exclusion of many of the construction industry traditional trades.⁶⁰

Wood lends itself well to a variety of off-site construction methods. Modular construction and pre-fabrication has the potential to substantially reduce the amount of on-site construction time by as much as 50% while enabling greater quality control during fabrication and less time on site reduces the risk of weather damage.

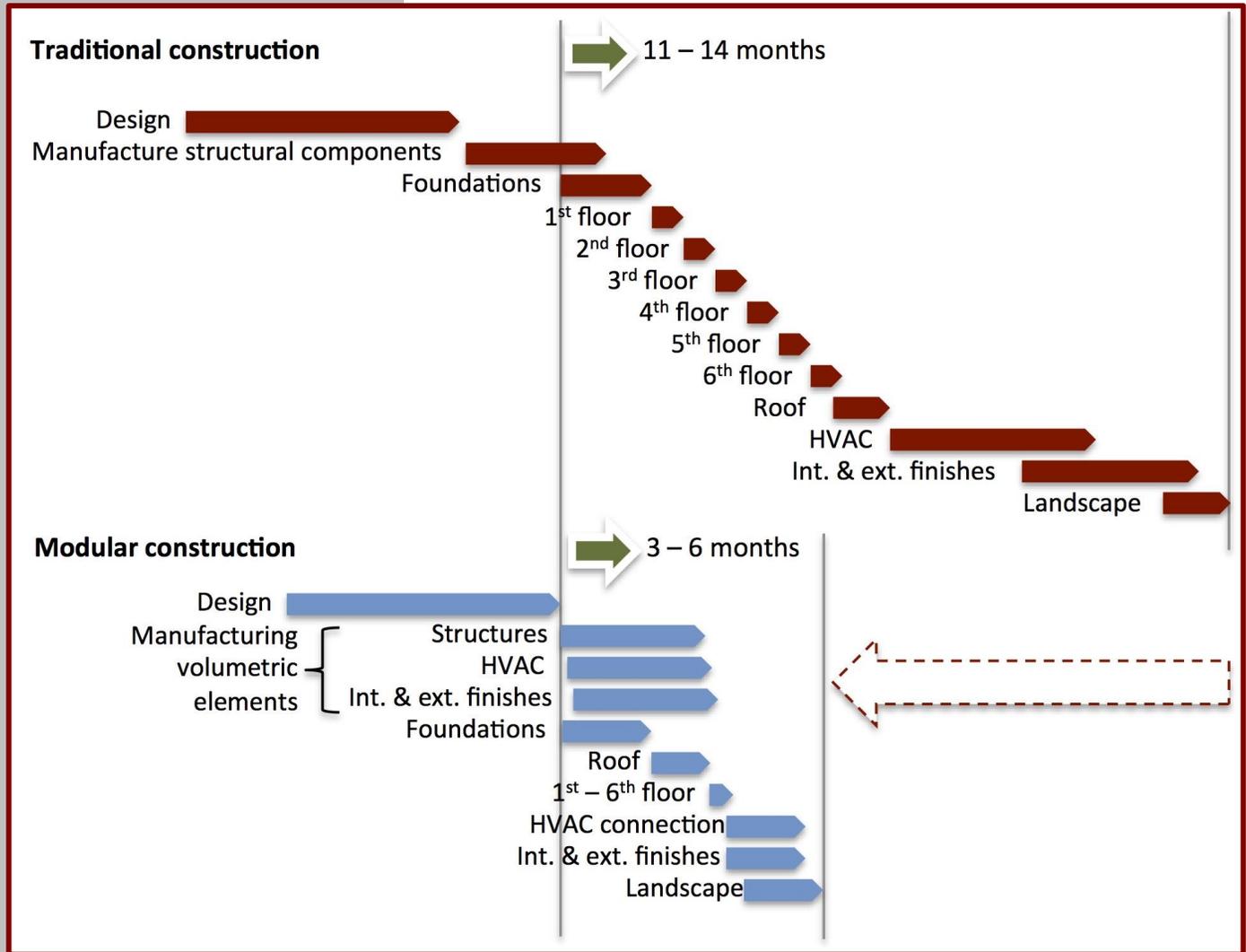
The manufacturing process for EWPs minimizes or eliminates the natural variability inherent in traditional wood products. Enhanced dimensional stability in particular makes the precision of digital fabrication techniques worthwhile. CLT panels and other components can now be manufactured with tolerances as little as +/- 0.5mm and this in turn can result in more durable, high performance buildings that will maintain their integrity throughout a longer service life.

It is becoming increasingly common for building elements (walls, floors, roofs) or completely finished “volumetric modules” (or “boxes”) to be prefabricated and shipped to site on a “just in time” basis. This approach translates into overlapping (and therefore shorter) construction schedules in which fabrication can be taking place while (for instance) concrete is being poured on site.

Equally importantly, in an era when neighbourhoods and communities are mixed-use, the disruption in terms of site traffic, noise and dust is greatly reduced.

“Procurement should include the tools to be used for collaborative process such as 4D models, Time & Motion models and physical models early in projects to develop methodology & check performance.”

Building owner



The typical procurement process for modular buildings requires that the owner, designer and manufacturer work together at all phases of the project to maximise the benefits of the off-site process and manufacturing efficiency.

Moving towards more off-site manufacture, pre-fabrication and use of proprietary components means that significant elements of design are carried out by the suppliers of the components rather than by the design team directly responsible to the owner. The implications of this on the design and build responsibilities of the project as a whole must be considered and documented.

BidCentral™

BidCentral is BC's largest online construction bidding marketplace. Features include:

- Posting projects in BC's largest construction database
- Intention to submit
- Invitation to bid
- Prequalification
- Digital document distribution
- Instant addenda and notice alerts
- Fully integrated online bonding
- True online bid submissions
- Instant results tabulation
- Audit trail
- Direct sync with BC Bid (the province's public tender procurement site)

9.3 Digital procurement

Digital technologies are increasingly being used to support the execution of all aspects of the construction procurement process, including the procurement process itself.

There are several websites, databases and other software tools in use in Canada that can be used across the procurement process others focus on specific steps in the procurement process such as:

- Establishing what is to be procured
- Soliciting tender offers
- Establishment of procurement strategy
- Tender evaluation
- Award of contract
- Contract administration and contract lifecycle management

Key to the success of web-based procurement systems is the facilitation of real-time communication and collaboration across construction supply chains. However, despite the progress made in the evolution and use of digital technologies in construction, there is, as yet, no single digital technology, which integrates all construction procurement activities into a system that procurers can adopt to manage the entire construction procurement lifecycle.



Kingsway Bridge, Burnaby, BC. Spanning 145 feet across a major arterial roadway, Kingsway Pedestrian Bridge's one-of-a-kind construction consists of a timber-steel arch with the post-tensioned segmental precast concrete walkway acting as tension tie.

Source: Fast+ Epp

The objective of undertaking innovation in construction projects is to capture the learning from potential process, business and technological improvements for application to future projects.

“A major challenge is the lack of established knowledge transfer and opportunities for technical learning from leading-edge projects.”

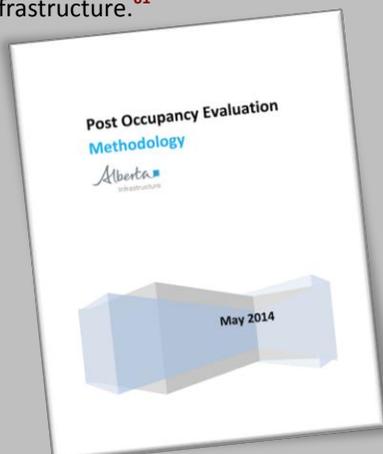
Researcher



Scott Kennedy, principal with Cornerstone Architects, tours visitors through The Heights: a 5 storey Passive House residential building in Vancouver. Image: MetroNews

Resources

Post Occupancy Evaluation Methodology from Alberta Infrastructure.⁶¹



9.4 Project feedback loops

Innovative projects offer valuable learning opportunities for industry, researchers and the public. However, project documentation and demonstration can take time and be a distraction to the project team. It is important to build requirements for case study documentation, building tours, etc. into the procurement process so that the project team can accommodate them into the budget and schedule.

A post-completion assessment by those stakeholders that were involved at the outset will enable both the owner and the project team to learn from the experience and assess whether the project objectives have been fully achieved. This is particularly useful if future projects are planned or where stakeholders have not been directly involved with the project during its development.

Going further, a Post Occupancy Evaluation (POE) is a structured review of the functional, operational and strategic performance of the building during occupation, which includes the regular collection and review of data to identify key occupier and/or building performance issues:

- Occupier satisfaction (very tricky to accurately assess)
- Space utilization
- Resource consumption (energy, materials, water, waste, etc.)

Owners requiring and using POE consistently report significant benefits. In financial terms, they range from reduced in-use energy consumption (reduced costs & carbon emissions), reduced construction and maintenance costs, and improved occupier productivity.

Conducting a POE can be included in construction contracts to provide an additional performance incentive for the contractor, to reward outcomes which exceed initial expectations, and to penalize under-performance. However, this could get tied up with liens and delay claims. The end of a construction process is almost always fraught and 'end-of-contract' incentives can be challenging to implement. It may be more realistic to hire a contractor for a multiple year or multiple building project and awarding them bonuses based on performance improvements over time.

Division 15's BIM research study



Working with researchers at UBC's Civil Engineering & Mechanical Engineering (CEME) Department, Division 15 Mechanical⁶² undertook a research project that looked at Building Information Modeling (BIM) adoption and implementation process from a specialty contractor's perspective.

Division 15 decided to adopt and implement BIM in 2010, thus putting in motion a process that would transform how they operate as well as how they interact with the remainder of the project supply chain. The research team studied the company over a ten month period with a focus on the following research objectives:

- Document the BIM adoption and implementation process for a specialty contractor in the AEC industry from an organizational and project supply chain perspective;
- Evaluate the impact of this transformational process within the organization and across the organization's project network;
- Determine avenues of development for productivity gains using BIM and other IT tools.

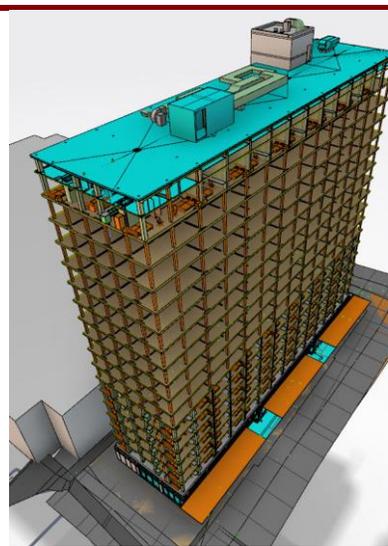
The report describes this transformation at the organizational level within Division 15, and at the supply chain level throughout several projects.

10 Engaging the R&D community

It is generally accepted in most industries that there is an additional up-front expenditure to explore, crystalize and commercialize innovation. However, investment in R&D will return dividends by optimizing the design and eliminating most of the conflicts that would otherwise arise on the site. Also, economic constraints can be alleviated by numerous grants and funding programs (see **Appendix B**).

When it comes to the application of R&D in the context of specific construction project, many research opportunities occur as a result of an unforeseen technical or logistical challenge. The costs to undertake this type of R&D are substantially borne by businesses outside the terms of the project contract and therefore inherently under-resourced.

Unfortunately, the academic research community moves slowly. Working with the research community takes more than an acceptance that financial outlay may be necessary. Academic research is very careful and exact. It has to fit within the academic calendar which means that projects can take time to ramp up. Without industry input, the research can also lack direct "real-world" application and take a great deal more work and investment to be market ready.



Brock Commons 3-D simulation
Image CadMakers

UBC Brock Commons was one of two projects in Canada awarded a grant by Natural Resources Canada⁶³ to facilitate the construction of Tall Wood buildings.

A portion of this funding went into an enhanced integrated design process, which involved not only the construction manager and main consultants, but also major subcontractors, such as 3-D model simulation for constructability and coordination guidance, the CLT/glulam installer and the company responsible for the concrete stair and elevator shafts. Other extraordinary costs included consultation with the provincial government departments responsible for the site-specific regulation required to permit the construction of an 18-storey wood building.

Open standards and the Finnish Runko-PES system

To accelerate the adoption of new or alternative structural systems into an entrenched traditional market requires the standardization of measurement, design conventions and assembly details. This is particularly important for pre-fabricated elements so that proprietary solutions do not require sole sourcing and a competitive marketplace is maintained.

The Finnish Runko-PES system prescribes standard modular dimensions, jointing principles and basic structural solutions for both frame and panel-based systems, meaning that the products and solutions of different manufacturers are compatible. Designers can plan a building without having to know who is going to build it. Because only the connection system for the structural elements is standardized, neither the freedom of the architect to design nor the development of company-specific applications is limited. The system is also expected to standardize the interpretation of regulations relating to wood construction across the country, which has been very variable up to now.

The RunkoPES system⁶⁴ also addresses issues of buildability and quality assurance. For example, the airtightness of structures can be more easily guaranteed in the controlled conditions of a factory, rather than relying on site-applied sealing compounds. Similarly, thermal insulation, acoustic and structural fire safety requirements can be built into the prefabricated components.

10.1 Working with specialists

Innovative buildings require the project team to work with specialist suppliers and installers who can provide a variety of services.

In the context of mass timber, there are a growing number of local companies in BC that support market adoption. There are digital design and construction service providers, mass timber floor and wall panels manufacturers, and integrated service providers that offer full design, fabrication and erection services for the whole structure including the roof.

In Europe, companies such as Urban⁶⁵ have evolved to take on a “turn key” responsibility for the design, manufacture and installation of the mass timber structural system, which is usually offered as a lump sum fixed price. These experts need to be part of the design process from an early stage which means they should be pre-qualified and retained either in a pre-construction advisory capacity or to follow through with construction. During tender negotiation these firms should be part of a competitive dialogue so the owner is familiar with the construction process and logistics. For example, Urban One (the construction manager) and Seagate (the installation contractor) for UBC Brock Commons started working closely together since well before construction started on site.

Early Market Engagement of key suppliers is an effective model that holds true for any sub-contractor whose involvement requires new or unfamiliar applications. It was frequently mentioned in interviews that a common problem with energy efficient buildings was that the HVAC system installers are not part of the design team and therefore not sufficiently motivated to provide the a simple, easy to maintain solution. Frequently, M&E systems are over-complicated, inadequately commissioned and expensive to run.

Owners cannot bid an innovative project the same way as a conventional one. The time and costs required for R&D and testing need to be factored in and the response times for tendering will also need to be extended.

“Because mass timber is still a new concept, everyone is being super-careful around contractual arrangements. Much more planning is going on up-front. So, our mass timber projects, so far, have run far smoother than our business as –usual ones.”

Specialist contractor

“One thing the UK has done very well to support the adoption of innovation is to fund intermediaries such as consultants and specialists. The Social Value Act made funding available on a multiyear basis for intermediaries to support industry on issues such as procurement.”

Procurement consultant

The “Campus as a Living Lab” initiative is based on the idea that the UBC campus itself is a major operation that can be leveraged for R&D purposes. It’s got the research and knowledge generation agenda, the sheer purchasing power of a small city, and an important operational agenda.”

UBC professor

10.2 Further work for researchers and industry stakeholders

Preparing this report uncovered several barriers to advancing innovation in construction generally and increasing the uptake of mass timber as an alternative structural solution in particular. These challenges offer opportunities for further research.

Large non-residential contractors may be staying away from mass timber because of perceived poor health and safety reputation of wood trades (based on experience with traditional timber framing). Effort and resources may need to be applied to developing standards for occupational health and safety and for fire protection in wood projects (e.g. the use of mobile hydrants adopted in the UK) to build industry confidence.

- There are still only a few mass timber suppliers in Canada and the available choice of product may be a constraint. Some Canadian project teams are opting to ship in European products on account of their quality, price and construction support services.
- There is a lack of consistency in how “Best Value” is defined and evaluated in the bid selection process.
- There is no harmonized open standard for prefabricated construction in Canada, which allows wood structures to compete with other systems and the development of multiple proprietary approaches.
- Construction-specific education is required to address the technical issues of mass timber construction such as protection of the wood elements for transportation requires plastic wrapping but this needs to be removed to prevent mould. Protection during storage and construction may require different approaches. Template language for specifications would be an asset.
- There is little training available in BC on pre-fabrication techniques and management for builders and trades.
- There are issues of efficiency and optimization for all members of the project team. Consultants and contractors need to improve their margins and owners need to get more “bang for their buck”. There is fertile ground for researchers in helping businesses become more resilient - so they can deliver more it without costing more. This is as much to do with improving business culture and processes as it is about the adoption of technology.

11 Summary of best practices

The following table captures the best practices for procuring innovative construction projects identified throughout this report. It is worth re-stating that:

1. The best practices set out below are based on the assumption that the owner will always strive for a **fair, open and transparent procurement process** regardless of the delivery model they choose to pursue.
2. Opportunities for innovation will vary widely depending on the specific circumstances of the project and that this document is geared towards supporting innovators and those interested in the early adoption of new technologies and processes. There is no question that **some of the best practices described below are challenging in practice** and effectively impossible in a “lowest cost” driven tendering situation.

Objectives and goals

Best practice

1. Owners engage with the market early to ensure the right level of technologies, skills and resources are available for their project.

- Undertaking early market engagement activities can help to identify new technical solutions, achievable targets and appropriate performance assessment schemes.
- Owners can encourage innovation by engaging with specialist contractors, product manufacturers and suppliers well in advance of tendering to ensure that the market can respond appropriately.

2. Early involvement of all key project team members including the general contractor and specialist trades

- Early involvement of all key project team members fosters close team integration, a team-wide spirit of collaboration and trust. It maximizes the opportunity for innovation in the design, procurement and construction processes.
- Dialogue with the project team early in the project planning phase will help to identify what could be achievable and the true short and long term cost implications.

3. When incorporating innovative products and processes in buildings, more time and resources are allocated (and budgeted for) early in the project process to adequately understand the owner’s requirements.

- Virtual mock-ups and digital models offer a powerful way to research design and construction ideas early in the project process.
- Demonstration projects should be documented to institutionalize lessons learnt, but education sessions, building tours and case study preparation can take time and be a distraction for the project team. Adequate time and Budget needs to be factored into the project at the outset for resources (tour guides, social media, etc.) and documentation equipment (webcams, monitoring equipment, etc.).

Objectives and goals

Best practice

4. Clear measurable project goals and Key Performance indicators (KPIs) are in place to demonstrate the value of investing in innovation

- Innovative projects that are intended to address energy efficiency and/or GHG emissions reduction should set measurable and absolute standards to be achieved. In the future, this will include the embodied impacts of construction products and materials.
- Performance-based requirements provide the project team with the flexibility to meet them effectively and efficiently. This approach can lead to a better result for the project than specifying a particular technology or technical solution. This is also important where the project scope and brief are uncertain or are still to be developed.
- A clear performance monitoring mechanism must be applied throughout the project, to ensure the sustainability and other important aspects of the design are followed.

5. Owners make every effort to create a highly effective and collaborative project team that puts the interests of the project first.

- Owners may – when appropriate – consider multi-project engagements of consultants and contractors to foster collaboration, learning and team cohesion.
- There is an emerging body of research that shows greater collaboration is more likely to lead to successful outcomes and high-level team performance. Given that the project “innovation champion” may be the owner, consultant or builder, the procurement process should allow collaboration to start as early as possible in the project process for creative ideas to blossom.
- The project team should be allowed input into when opportunities for R&D, tours and project documentation activities can best occur from the perspective of maintaining an efficient and safe site.
- Construction Management at Risk or Single Purpose Entity for IPD contracts (such as Multi-Party Agreements) that encourage collaboration may be best suited for innovative projects that are not well defined in scope.

6. Businesses of all sizes should be encouraged to participate because some SMEs are the most innovative.

- Some of the most innovative companies are SMEs. Owners can reduce barriers to participation by simplifying the procurement process as much as possible. For example, bidders could be admitted who may not have directly relevant project experience but may have transferable expertise with a similar project type.
- Owner can provide greater opportunities for smaller, more innovative firms by focusing on the quality of the references rather than quantity. They can also request evidence of the quality of work, not just a list of relevant projects. For example, this may include the extent to which project sustainability and cost targets and time schedules were met.
- To enable SMEs to participate in projects requiring advanced and/or expensive technology (e.g. BIM), training and financial assistance may be necessary.

Objectives and goals

Best practice

7. The business case for innovation may best be articulated using life cycle costing (LCC).

- Focusing on Life cycle Costing (LCC) rather than lowest cost will deliver owners greatest value overall and is a powerful motivator of innovation. Lowest first cost also does not reflect the financial and non-financial gains that are offered by environmentally and socially preferable assets as they accrue during the operations and use phases of the asset life cycle.
- Owners should identify a suitable model for LCC at project planning stage to inform decisions throughout the procurement process. This should at least cover:
 - Total construction costs,
 - Annual operation costs,
 - Annual maintenance cost, and
 - End of life costs.
- Owners can evaluate the cost of bid during competitive tendering for design and/or construction work using the selected LCC model, and communicate this, together with the weighting and associated scoring, in tender documentation.
- If an owner does not have the internal capability to undertake robust LCC calculations, it is recommended to either:
 - Provide training for employees on LCC to enable cost consultants, designers and engineers to incorporate LCC in the design and planning stages of construction projects (preferred option), or
 - Consider outsourcing the calculation to a third party expert. This is only advisable if the cost does not exceed the cost of increasing internal capability.

8. The technical and logistical considerations of building with wood are factored into the procurement process

- Opening up the procurement process to encourage innovation may allow wood to be considered as an option in a greater number of situations and project types.
- Managing for moisture in wood projects and fire protection during construction needs to be incorporated into the contract documents – in particular the budget (for protection) and schedule (to allow for drying out).
- Lean construction encourages “just-in-time delivery” of products to site. This may help to limit potential damage of wood products.
- Working with wood requires fire safety to be hard-wired into the contract documents (e.g. into the General Conditions of the project specification) and on-site activities.

9. Creativity and “out-of-the-box” solutions may be sought through sanctioned design competitions.

- Design competitions can offer a good way for owners to gather a broad range of creative responses. Although not available at present, governments could consider establishing an innovation fund to assist owners with the costs of holding a design competition.
- When conducting a design competition, owners should seek sanction from the AIBC, which means following AIBC guidelines.

Objectives and goals

Best practice

10. Long-range market signals help to boost business confidence and encourage investment in new equipment and training.

- Public sector and large corporate owners can produce an annual ‘pipeline’ of business opportunities for contractors leading to greater market confidence in the potential for work. The purpose is to send clear market signals so that construction companies will have confidence to invest in equipment, technology and management processes for innovation.
- Regulators can issue regular code updates along with long-range policy goals so companies are not caught off-guard.

11. Project risks are understood, managed and apportioned fairly.

- Procurement models that strive to manage as opposed to transfer risk are more conducive to nurturing innovative solutions. This way, the risk can be quantified, accounted for and apportioned fairly.
- High levels of commitment and trust are needed to realize efficiency gains and encourage greater receptivity to innovation. Breaking down team silos and working to eliminate attitudes of “each man for himself” can help to reduce the potential for delay or cost over-runs.

12. Incentives are leveraged to encourage construction innovation.

- Governments and industry can partner to create an ongoing innovation investment fund for all types of construction innovation to help project teams bridge the cost of upfront involvement, exploration and testing of new products and establish innovation management processes.
- If upfront costs to explore innovative solutions (e.g. pre-fabrication) are expected to be recouped from downstream construction efficiencies, an interest-free innovation loan program may be appropriate that is not repayable if the project does not go ahead.
- Owners may consider the use of incentives in construction contracts to encourage innovation. Examples include introducing performance payments and negotiating contract extensions. However, incentives related to environmental performance need to consider the impacts of a validation period, which may extend beyond completion.

13. A qualified experienced project team includes the owner, contractor AND the specialist trades. It may also include operations and maintenance personnel.

- Owners should require evidence of qualification of individuals as part of the evaluation process. The names of key project team members (including in important trade companies) need to be written into the contract documents to ensure their expertise is being applied to the project and not passed to others in their company.
- The owner should ensure it has the capacity to carry out project leadership and oversight effectively, potentially through an external project manager.
- Operations and maintenance personnel should also be involved in the project process.

14. There are education and training opportunities to ensure project team members stay up to date with the latest technologies and processes.

- To stay up to date, owners may include “best available technology” and “technology refresh” clauses, and an ‘innovation pool of funds’ to cover any additional costs for operation of building systems and facilities.

Objectives and goals

Best practice

15. Feedback loops are in place to foster a culture of learning at all key points of the project and at the industry scale.

- At the conclusion of the procurement process, owners should offer to provide feedback to both successful and unsuccessful participants.
- Teams that have worked together successfully over multiple projects tend to be more likely to find project efficiencies and improvements over a period of time.
- Construction procurement is complex and owners need knowledge and experience before contemplating the inclusion of innovative solutions. Procurement training for all industry stakeholders needs to be readily available. Also, procurement agencies could establish forums with contractors to regularly share and receive feedback on the bidding process and to seek opportunities for improvement and new ideas.
- Depending on the procurement model, owners may be able to incorporate a Post Occupancy Evaluation into design and construction contracts, together with a clear indication of sanctions (and on which party) for non-compliance with designed performance (e.g. consequences for failing to achieve certain airtightness requirements).
- Owners can hold “lessons learnt” workshops with suppliers and their sub-contractors once projects are completed, to help carry forward innovative ideas identified after design and during construction of a project to future initiatives with the supplier.

16. Intellectual property (IP), proprietary knowledge and expertise of project team members are respected and protected.

- When issuing procurement prospectuses or requests for expressions of interest (REOIs), it is important to put in place legal assurances that suppliers’ IP rights will be protected, or that they will be compensated if it is used in conjunction with another supplier.
- R&D can be time consuming and expensive. Owners can explore potential opportunities for cost-sharing via collaboration with other owners, and the option of establishing longer multi-project contracts with suppliers with a priority on innovation.

17. High quality contract documents that are thorough and complete are critical in order to adequately describe the proposed innovation

- Innovative projects require far greater quality of documents and coordination than is current practice in the construction industry.
- The accuracy and reliability of construction price and schedule, and the quality of the overall project, are all dependent upon how complete the contract documents are. Complete and accurate documentation is especially important when new or unfamiliar technologies are being contemplated.
- Peer reviews, checklists and proofreading can enhance, or in their absence be detrimental, to the quality of documents and the success of innovative solutions.
- With P3 projects, owners can engage a ‘shadow’ team to prepare indicative design and costing documentation prior to engaging the project consortium. The shadow team can monitor and provide QA/QC reviews of the consortium’s work at each project stage.

Objectives and goals

Best practice

18. R&D support in the form of resources, money and/or equipment is available to help companies take ideas from the lab and incorporate them successfully into construction projects.

- Multi-tiered (in the lab, in the office, in the field) region-specific R&D support is needed to help companies take ideas from the lab and incorporate them successfully into construction projects.
- Technical support in the form of template language for incorporation into contract documents helps to ensure proper steps are taken to deal with unique or unfamiliar issues (such as weather protection, installation techniques, etc.).

19. Modern Methods of Construction (such as digital design, pre-fabrication and Lean principles) are leveraged to improve productivity, profitability and performance of projects.

- Owners can support the widespread adoption of virtual design and construction tools (e.g. BIM) and digital procurement (via BidCentral) throughout the entire project lifecycle to encourage greater completeness, quality and coordination of project documentation.
- Owners can demand projects be designed using BIM with the models shared across the entire project team. Online bidding can facilitate the uptake of BIM by contractors and trades. However, training and support may be necessary for SME contractors and trades.
- When done well, BIM can optimize information flows between project actors. It can also reduce the likelihood of conflicts within the documents and accelerate the construction process by using the model for material take-offs, shop drawings and the like.
- Time and motion studies can be effective for managing speedy and/or complex installation schedules.

Appendix A: Research methodology

The findings contained in this document are the results of a review of local efforts and international best practices, engagement with industry leaders and a deep dive into recently completed projects into BC in order to understand how projects came about, the procurement processes involved, who the innovation champions were, cost implications (if any) and specific issues and challenges encountered.

Oversight of the development of this report was provided by the BC Construction Association (BCCA) Construction Innovation Committee, which reports to the BCCA board of directors.

The research methodology comprised the following activities:

- Literature review of publicly available reference materials
- An assessment of procurement methods available for building construction projects to achieve the best environment for innovation and best value for key stakeholders.
- An in-depth review of traditional and innovative project procurement approaches.
 - Published literature, procurement guides and requests for proposal have been reviewed to identify common objectives to create best value.
 - Identification and assessment of challenges for achieving the innovation in non-residential wood construction projects.
- Interviews with 10 industry experts as identified in the research, by Wood First, BCCA members and by the authors to validate findings and hear about specific issues facing B.C. companies.

Preliminary findings were used to develop the agenda of an industry workshop held September 30th, 2016 at the Vancouver Regional Construction Association). Using fictitious but “close to realty” case study projects (summarized below) that were developed in consultation with owners in advance of the workshop, 32 invited industry leaders (owners, architects, engineers, contractors and specialty sub-contractors) were set the task of identifying potential innovations, evaluating the procurement challenges and recommending best practice solutions.

The workshop was conducted under Chatham House Rule whereby the findings were documented for the purpose of informing this report but nothing is attributed to individual participants.

The sessions were documented by Liz Johnston, principal of CrossPoint Strategies and Diana Lopez, MSc Civil Engineering candidate, UBC.

GROUP 1: SFU, City of Coquitlam, Translink
Student residence, library and station upgrade

• **Location:** Lower Mainland



GROUP 2: UBC
Urban agriculture building and indoor farm

• **Location:** Vancouver



GROUP 3: City of Vancouver
Zero emissions fire hall, community room and social housing

• **Location:** False Creek Flats, Vancouver



GROUP 3: BC Housing
30 unit seniors resident, cafe and school room

Location: ocean front site, remote community



Images were sourced from the web and used for inspiration only.

Summary of functional spaces

Housing for 250 students in studio and quad format

100,000sf of commercial /retail space

100,000sf municipal learning centre and digital archive

Station upgrade and platform extension

Reconfigured bus bays

200 parking spaces for park and ride plus parking for the new development

Constraints and goals

The project (excluding parking) must be achieve Passive House standard.

The project will be a “Design for the Environment” case study whereby the building is designed for ease of reconfiguration and disassembly.

The residential portion will be designed so that accommodation for a further 150 students can be added in the future.

The station must remain operational throughout the construction process.

The completed project must manage acoustical issues that arise from proximity to the station and commercial centre.

Project brief: Group 1

Student residence, municipal library and Skytrain station upgrade

SFU Community Trust is partnering with the City of Coquitlam and Translink to develop a 4 acre suburban Skytrain station site for student housing that will be close to one of SFU’s major campuses. There will be a variety of commercial uses (including a small format supermarket) on the lower levels along. The university and local municipality will collaborate on a state of the art library and learning centre that will be a major public amenity, also serving as the community’s digital archive. The station will be upgraded and the platform extended. Underground parking needs to accommodate an existing “park and ride” scheme as well as sufficient parking for the new development.

SFU is a university with a global reputation. To attract students and faculty, it is committed to developing iconic, state of the art projects. This project is viewed by the local municipality as pivotal to not only kick starting the development of this neighborhood but also establishing the benchmark for 21st century place making.



Summary of functional spaces

Preliminary planning suggest that this building will have 6 floors

GF: Produce shop, café, indoor growing area

2F: Laboratories

3F & 4F: Classrooms

5F: Library and seminar rooms

6F: Faculty offices and common areas

Rooftop growing area

Constraints and goals

Demonstrate the benefits and practicalities of “biophilic” design

UBC would like to systemize the process whereby researchers, educators and industry work side by side. Lessons learnt from the project will establish educational feedback loops for both industry and faculty.

A condition of the bequest is that the building is open to receiving the first cohort of students in less than 3 years.

Several labs and growing areas will be wet and involve high degrees of humidity.

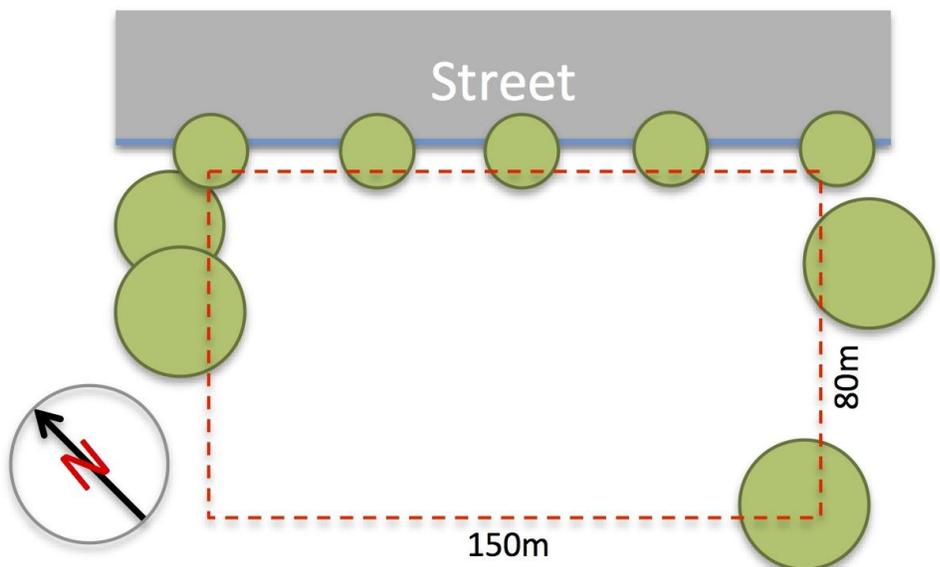
Lessons from UBC’s pioneering Brock Commons building will be brought to bear on this education and research project.

Project brief: Group 2

UBC urban agriculture building and indoor farm

UBC has received a sizeable bequest from an alumnus who is the founder of a major medical marijuana business. With growing demand for intensive agriculture production in urban environments for food and pharmaceutical purposes, UBC is exploring the development of a new institute, which brings together research and education from its faculties of agriculture, viticulture, medicine and other areas.

Continuing to lead the way in building design and leveraging the “campus as a living lab” initiative, UBC is interested in using the design, construction and operation of this building to not only achieve Canada’s first environmentally “restorative” building but also, given the linkage between food and medicine, the benefactor wishes that the building research and demonstrate the benefits of biophilic design. Biophilia, like air quality, thermal comfort and acoustics, is an essential component of environmental quality that expands the conversation from daylight, materials toxicity, and air, water and soil quality, to include human



biological health and well-being.

Summary of functional spaces

It is anticipated that the fire hall will have 2 floors above grade with an additional 4 - 6 floors of social housing above.

1,500 ft² – Public Rooms

3,000 ft² – Offices

3,500 ft² – Dorms

9,000 ft² – Vehicles Bays / Service Spaces

30,000 – 40,000 ft² – Housing

Constraints and goals

The fire hall is required to be built to a post-disaster seismic standard. The housing component cannot compromise the building's seismic performance.

The project is to include the development of a temporary fire hall facility on a nearby site for the duration of construction, hazmat abatement and green demolition of the existing facility, and remediation of soils contamination from a buried fuel tank.

Funding for the housing is coming from another level of government and a not-for-profit operator with requirements for transparent competitive procurement.

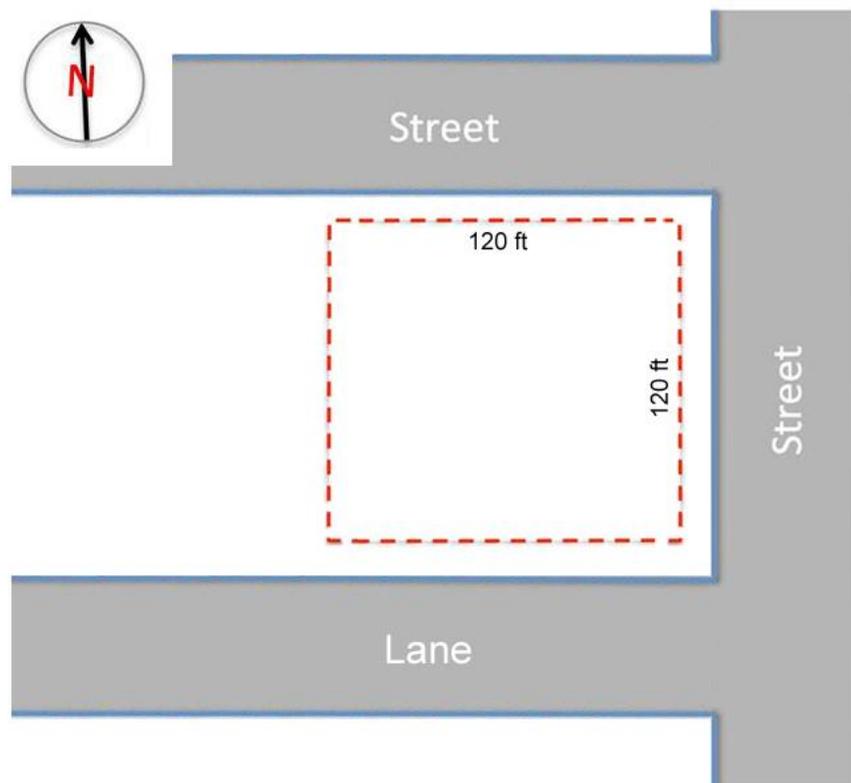
The building will be a demonstration project for the City's 2030 renewable energy vision.

Project brief: Group 3

Zero emissions Fire Hall, Community Room, and Social Housing

The City of Vancouver Zero Emission Building Plan calls for a step-wise reduction in energy consumption by 2020. By 2030, it is expected that all new buildings will use 100% renewable energy. To demonstrate leadership and the fact that expertise and technology exists today to achieve these goals, the City aims to adopt the equivalent of Passive House or better performance for its own projects with a view to achieving the 100% renewable standard as soon as possible.

As part of the City's ongoing optimization of essential fire and rescue services, the capital plan includes the redevelopment (replacement in situ) of an existing neighbourhood fire hall to accommodate two crews and three vehicle bays, and to include a community room with separate access for public events. The site is a corner site on a lane. The site has been deemed appropriate for social housing and the City requires the project to include as much social housing as the site will support through rezoning.



Summary of functional spaces

30 x 2 bedroom rental apartments
(to be operated by a non-profit agency)

Café and lunch room

School room for 25 children

Constraints and goals

Given weather and access issues, construction can only take place between April and November.

Site soils are uncertain. It appears to be primarily sand and, with climate change, sea-level is expected to rise about 2m.

The community does not have any municipal sewage treatment or natural gas service.

With the new hotel, electrical service capacity will be reached and the community believes that new service sends the wrong message about its sustainability intentions. It has therefore set a total power demand limit of $10W/m^2$ and for any new development.

Some seniors are concerned that noise from the school should be minimized.

Speed of delivery is less important than full achievement of the project's objectives and performance in the long term.

Project brief: Group 4

30 unit seniors residence, cafe and school room

The prominent ocean front site is located close to the harbour in a small community (pop. 250) in North Vancouver Island. The treed site looks northwest across the mouth of a broad inlet and out to the Pacific Ocean. The site is next to the location of a new general store and fishing lodge / hotel that will start construction soon. A new year-round access road is being built with the hotel, but will not be ready in time for construction of this project. All construction components will need to be flown or barged in.

The close-knit community comprises many retirees who want to stay and young families moving to serve the hotel and local tourist jobs. Town Council are keen to implement a progressive European approach, which shows that communities can be enhanced when elders and children intermingle. As a result, the seniors' residence will incorporate a schoolroom on the ground floor for K -7 children. A café will not only serve tourist traffic but also provide hot lunches for the children and seniors.



Workshop agenda

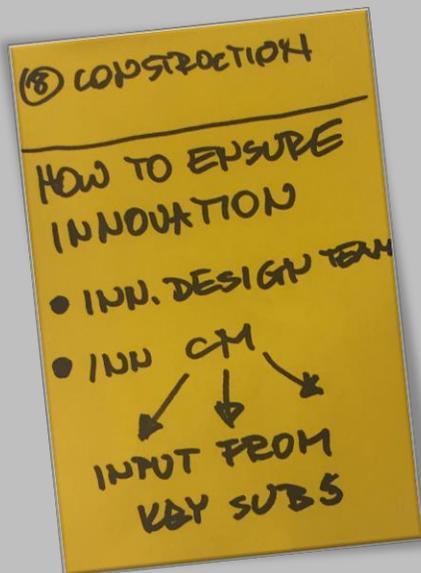
8.00 – 8.30	Registration and breakfast	
8.30 - 8.40	<p>Welcome: Fiona Famulak, President, Vancouver Regional Construction Association</p> <p>Opening remarks: Warren Perks, Vice President and Director of Industry Practices, BC Construction Association</p>	
8.40 – 9.30	<p>Setting the scene</p> <ul style="list-style-type: none"> • Workshop logistics and objectives • Lessons from phase 1 of the research 	
9.30 – 10.30	Innovation identification	
	<p>Consultants and contractors</p> <ul style="list-style-type: none"> • Brainstorm technical and logistical innovations to meet project requirements • Discuss how best to present the team in the competitive context. What is your approach to the owner? • Develop proposed technical and logistical innovations to meet project requirements • How would you compete for this project? 	<p>Owners</p> <ul style="list-style-type: none"> • Review and refine project scope • Identify key success factors – how do you describe best value? • How you would select your team? • Outline key considerations for RFP structure and evaluation • Propose project delivery method • Summarize procurement models and rationale so the project scope is refined
10.30 – 11.15	<p>Procurement process issues and challenges</p> <ul style="list-style-type: none"> • Round table – consultants and contractors present innovations for the project • Owners to consider the means by which they might structure and evaluate a RFP – how do you define “best value? Where are the uncertainties? • Discuss - what is the best form of delivery for the project? • Document issues and challenges 	
11.15 – 12.30	<p>Debrief</p> <ul style="list-style-type: none"> • Introduce the projects • Summarize innovations proposed and the procurement approach • Discuss barriers and challenges 	
12.30 – 1.00	Lunch	
1.00 – 1.30	Introducing JCT Construction Excellence Agreement - Tyler Galbraith. Jenkins Marzban Logan	
1.30 – 2.30	<p>Innovation refinement</p> <ul style="list-style-type: none"> • Identify at least one technical or logistical improvement over previous version • Review the project key success factors and document proposed improvements • Review the procurement challenges identified in morning session and discuss what it would take to resolve them. • Describe risks associated with proposed solutions and suggest how to manage them. • Ongoing responsibility and feedback loops 	
2.30 – 3.15	<p>Debrief</p> <p>Discuss optimal procurement approach for each project, problems resolved, trade-offs and outstanding knowledge gaps</p>	
3.15 – 3.45	<p>Lessons learnt</p> <ul style="list-style-type: none"> • Discussion of persistent challenges and what can be done • Suggestions for refinement of the final procurement report. 	
3.45 – 4.00	Workshop wrap-up and next steps	

Key findings from the workshop

On the procurement process

Best practices

- Owner relationship with contractors, architects, construction managers, etc.:
 - Value and trust are fundamental to having a good working relationship
 - Identify success factors in past projects to determine guiding principles and formalize a trusting relationship
- Procurement is evaluated both in a qualitative and quantitative way (both established in the RFP). This means not awarding the contract to the lowest bid, also taking into account qualitative measures and past experiences
- Definition of risk beforehand and have a discussion about what “value” means to make sure that it is properly reflected in the procurement documents. Many public owners have non-financial priorities.
- Education of sub-trades to align objectives. IPD methodology has the capacity to involve (engage, educate and include) critical sub-trades early on in the project.
- To address the concern about procurement fairness (hiring new teams and not just the ones that have proved to work well in the past):
 - Consider the complete package of what a firm can bring to the table
 - Take into account firms’ investment in innovation (within the company and in past projects)
- Incentives for contractors, sub-contractors and CM:
 - Don’t only have to be financial.
 - Motivation through procurement models such as IPD
 - Creation of strong relationships that lead to contractors respecting the rules (and have it written in the contract for shared understanding)
 - Opportunity to repeat business
 - Establishing the values with the entire team early on makes it easier to set the incentives
 - Execute the project and incentivise the team according to the chosen delivery method



- Having holistic debriefs allows the team to look at the project from different perspectives
- The procurement process and delivery method chosen for any project has to be competitive, and the complicated ones are not worth the effort, time and risk
- The use of BIM and 4D CAD models, as well as physical models of the prefabricated units are very useful to develop and inform the methodology and validate performance targets
- To address the issue of estimated vs actual performance gap:
 - Include incentive performance clauses based on energy performance
 - Include in contract a 5-year engagement for post-occupancy performance (long term energy performance agreement), and possibly a bonus at the end of the period if targets are met
 - Collaborative approach: have a life-cycle approach instead of only having warranties; engage people in the decisions being made around innovation in a life-cycle approach, because decisions from participants change when you consider the whole life-cycle
 - Acknowledge and pay for people's time up front
- To address the challenge of public institutions to create relationships with teams but keeping the procurement process transparent and giving a fair chance to everyone:
 - Owner should bring leadership to the project, lead by example, and establish a way of working and relationship guidelines
 - It's not necessary to bring the same companies that you have worked with well in the past, because you can create those same good relationships with new companies through that leadership, conversations and example
 - Also, examine what you as an owner are doing when things don't work out because relationships are a 2-way street
 - You can't promise future jobs, but you can give good references and opportunity for future work.
 - Working always with the same companies/people is actually not a recommended practice because as you involve more new people you get more innovation.
- A potential solution to accommodate the needs and interests of all stakeholders is to set up a project office with project and development managers as consultants, in order to accommodate needs and desires of multiple stakeholders

The following procurement process was proposed by one group to foster innovation:

First: owner/developer should educate themselves on the innovations and sustainability features they wish to include (e.g. passive house, mass timber, etc.)

Second: RFP issued for design team only. Big points assigned to innovation, teams with history of innovation have the highest chance to get the job

Third: Schematic design between owner and designer

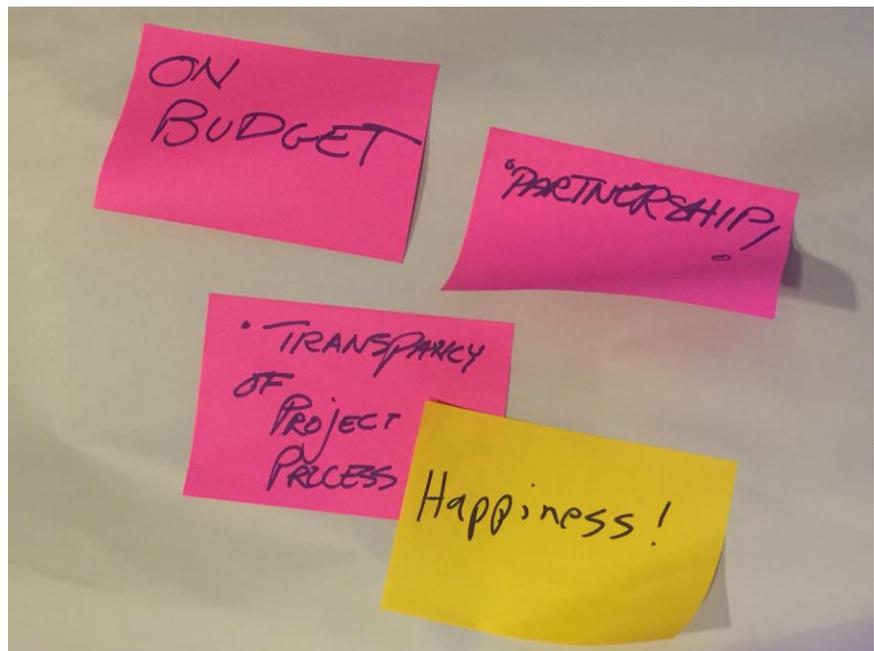
Fourth: RFP issued for CM (and same innovation criteria for selecting the CM as in the RFP for designers)

Fifth: Finish design and issue tender packages to sub-contractors known to the CM and with a history of innovation

*CM runs the project 100%, but owner always has the option to disengage with any of the hired teams if it notices problems

* This process promotes innovation because it ensures the innovation capacity of the design team and CM, which are crucial; and the owner has to trust the CM about the timing in which he wished to engage the key sub-trades

- A good practice is to mitigate the division of the construction industry into specialized group of contractors that only engage in one sector (which in turns makes it very difficult for new people to get into the market, as well as limiting growth opportunities):
 - Recognize the skills of the people that work for the companies, because it isn't always the company that has the skills but the people inside it
 - The contractor community has become more accepting of this method, but the limited competition is still a challenge
 - Put actions into place to increase the opportunities for others
 - Applies to CM, contractors and consultants



Key Findings

- Cost effectiveness has to be proven, specially when dealing with public institutions, group of owners and owners with risk adversity
- Collaborative work is something that can't be taught (within a project). Either a firm works that way or they don't,
- The aspects that owners consider most important are: quality, time, capacity and knowledge of the team, and alignment between budget and program.
- Best value criteria: public organizations are open to award contracts based on best value (and experience), not lower price. But the value has to be demonstrable vs. the financial increase

- Innovation means not having done it before which automatically has uncertainties associated with it. To deal with uncertainties: experience is what points in the direction you need to go, and also consultants to tell you which is the best value. Also knowing how to be a manager mitigates many risks associated with innovation.
- When a project has several constraints, the design and project delivery solutions ought to have a high level of innovation (outside the box ideas) to address and try to solve as much constraints and challenges as possible. Although high level of innovation is associated with high risk, and contractors might not want to bid on the project (expertise procurement problem)
- Having discussions on potential solutions for a problem among people with diverse backgrounds is a way to develop new and innovative ideas and solutions
- The procurement method chosen has to be one that ensures engagement of key team members and key sub-contractors.
- Owners are open to try new types of contracts (such as JCT) as long as they promote building relationships and trust
- Procurement solutions depend on the location of the project, and there is no “one size fits all” procurement approach
- The following is another procurement process proposed to address a project with multiple owners, and based on Partnerships BC P3 with variations:
 - Partnerships BC involved in the early stages doing the business case and managing the procurement process and assist the owners
 - Owners procure the design team and prepare an indicative design
 - To maximize innovation from private sector: only give design specs (e.g. passive house requirement but open design)
 - Owner design team would do the design with assistance for the mass timber and passive house, to have a complete design for the proponents to do their proposals on
 - Once the design is ready, issue the RFQ and then shortlist 3 proposals.
 - This is followed by a consultation process to propose innovations and changes to the design to the stakeholders. After that, the contract can be awarded
 - Remuneration process: lump sum at completion of the project.

○

On lessons learned

Best Practices

- It is very important to capture the lessons learned from each project in order to promote continuous improvement
 - A way to achieve it is to have more debriefs and round table discussions to determine what worked, what didn't, and why, and essential capture the lessons learned
 - Share these insights within organization, with involved third parties and with general industry
- Have more input from academic experts, specially for innovative projects in University campuses

On design

Best Practices

- A design priority should to design the building having in mind the uses of the building and the users' needs, rather than just for the innovations of the building itself.
- When doing the design, also keep the operation and maintenance of the building in mind.
-

Key Findings

- Owners are open to industry input on aspects such as materials and the best way to use them

On sustainability

Key Findings

- Owners and developers are creating projects with more aggressive sustainability targets (e.g. restorative buildings), which means more opportunity and need for innovation

Appendix B Selection of innovation funding programs



BC Housing Building Excellence Research and Education Grant

• <https://hpo.bc.ca/building-excellence>



BC Innovation Council

• www.bctic.ca



BC Innovative Ideas Program

• www.bcbid.gov.bc.ca



Build In Canada Innovation Program

• <https://buyandsell.gc.ca>



City of Vancouver Green & Digital Demonstration Program

• www.vancouvereconomic.com/gddp



Forestry Innovation investment - Wood First program

• www.bcfii.ca



MITACs Accelerate program

• www.mitacs.ca



National Research Council Industrial Research Assistance Program (IRAP)

• www.nrc-cnrc.gc.ca/eng/irap



Natural Sciences and Engineering Research Council of Canada (NSERC)

• www.nserc-crsng.gc.ca



Real Estate Foundation of BC

• www.refbc.org



Scientific Research and Experimental Development Tax Incentive Program (SR&ED)

• www.cra-arc.gc.ca/txcrdt/sred-rsde



Western Economic Diversification Canada

• www.wd.gc.ca

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2 The most comprehensive suite of information (video, case studies, factsheets/storyboards) on the Brock Commons and other UBC mass timber projects can be found at www.naturallywood.com/emerging-trends/tall-wood/ubc-brock-commons

3 On January 14, 2013, the British Columbia Construction Association (BCCA) officially published a fourteen-page review of industry concerns, providing practical recommendations to improve the planning, implementation, and operation of assets in BC's public sector. "Fair and Transparent: Implementing the CAMF for Construction Procurement" stresses the need for partnership and outlines the struggle to successfully establish reasonable standards for government, Crown corporations and publicly-funded agencies' use in capital asset planning. Available at: www.bccassn.com/resources/procurement/reports/fair-and-transparent--implementing-the-camf-for-construction-procurement.

The BCCA's recommendations for public procurement policy include:

- Facilitating a variety of procurement approaches, instead of favouring a single approach
- Ensuring qualification criteria are actually relevant to the bidder's ability to deliver the service
- Requiring disclosure of public procurement results
- Requiring audits with published results
- Ensuring entities such as Shared Services and Partnerships BC do not compete with the private sector
- Creating formal mechanisms for ongoing collaboration between industry and government in regard to procurement practices

4 BC Construction Association information about procurement www.bccassn.com/resources/procurement and policy statements and resources www.bccassn.com/about-us/policy-statements

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6 Adapted from the Technology Adoption Life Cycle https://en.wikipedia.org/wiki/Technology_adoption_life_cycle

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8 T. Bock, T. Linner, C. Georgoulas, M. Mayr, J. Meyer-Andreas "Innovation Deployment Strategies in Construction", Technische Universität München (TUM), Germany, 2012

9 www.archdaily.com/554132/ad-classics-yokohama-international-passenger-terminal-foreign-office-architects-foa

10 www.bidcentral.ca

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16 National Research Council, “Fire endurance of cross-laminated timber floor and wall assemblies for tall wood buildings”, <http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/object/?id=7deab8cb-6636-43d6-93d2-e97ef30f2ef1>

17 Constructing Excellence ‘Building Success: Lessons from Clients who got it Right’, <http://constructingexcellence.org.uk/wp-content/uploads/2015/10/frecl-r.pdf>

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19 <https://buyandsell.gc.ca/policy-and-reportlines/supply-manual/section/3/140>

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21 The Royal Academy of Engineering in the UK developed the 1:5:200 model in 1998 which suggested that if the initial construction cost of a building is 1, then its maintenance and operating costs over the years are 5, and the business operating costs in that building are 200. The 1:5:200 model should not be seen as an absolute but rather a rule of thumb. Cited in Sci-Network, “Procuring Innovative and Sustainable Construction: A Report for European Public Authorities” (www.sci-network.eu/report)

22 Dr. J. Bowyer, K. Fernholz, Dr. S. Bratkovich, Dr. J. Howe, Dr. S. Stai, M. Frank. “Life Cycle Cost Analysis of Non-Residential Buildings”, Dovetail Partners, October 2013
www.dovetailinc.org/report_pdfs/2013/dovetailccareport1013.pdf

23 The Architects Institute of BC has rules about how to run a sanctioned design context: <http://aibc.ca/programs-services/rfps-competitions>

24 B. Grann, “Wood innovation and design centre whole building life cycle assessment”, FP Innovations, 2014. Available from <https://fpinnovations.ca>

25 The International Standards Organization (ISO) has developed a suite of protocols under which LCA is to be conducted, data is to be collected and information is to be reported. LCA methodology is set out in the ISO 14040 series. Supporting documents include Product Category Rules (PCRs) described in ISO 14025 and Environmental Product Declarations (EPDs) outlined in ISO/CD 21930 (see below). An additional standard—ISO 21931-1:2010—establishes a framework for methods of assessment of the environmental performance of buildings and related external works. An additional standard—ISO 21931-1:2010—establishes a framework for methods of assessment of the environmental performance of buildings and related external works. ISO 21931 does not set benchmarks or levels of performance relative to environmental impacts and aspects. Instead it aims to bridge the gap between regional and national methods for the assessment of the environmental performance of buildings, by providing a common framework for their expression.

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31 Sci-Network, “Procuring Innovation Preliminary Report on 1) Use of Early Market Engagement and Supplier Relationship Management to promote innovation, and 2) Supplier perspectives on innovation through public procurement, 2011 www.sci-network.eu

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33 More information available at: www.bccasn.com/about-us/policy-statements#prequalification

34 BC Government procurement resources are available at: www.pss.gov.bc.ca/psb/procurement/procurement-policy-and-procedures.html

35 For more about the Wood Innovation and Design Centre, visit: www.naturallywood.com/emerging-trends/tall-wood/wood-innovation-and-design-centre

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