BUILDER INSIGHT

BC HOUSING RESEARCH CENTRE

Bulletin No 4 | Vienna House

Digital Project Delivery and BIM

Vienna House is a National Housing Strategy project that demonstrates sustainability and innovation in construction. The project will be Passive House certified. It is the first non-market multi-family housing project in B.C. to use Building Information Management (BIM). BIM was used throughout concept design, project delivery and facility management.

The seven-storey mass timber and lightwood frame hybrid building will provide 123 units ranging from studio to four bedrooms. It is an efficient mid-rise building type, with the potential for it to be recreated in B.C. and across Canada. The project has a counterpart housing project in the City of Vienna, Austria. This provides a unique opportunity to share knowledge and best practices in housing design. It will be subjected to acoustical and vibration testing prior to occupancy and will be monitored for ongoing environmental and structural performance.

Figure 1. Rendering of Vienna House from Stainsbury Ave. (source: PUBLIC Architecture).

This bulletin series describes innovative technologies and processes of the Vienna House project. Find them all in the BC Housing Research Centre Library.

FACTS AND FIGURES

Construction timeline: November 2023 – late 2025
Construction budget: $54.9 M
Residential Units: 123
Site Area: 2,968 m^2, 31,945 ft^2
Total Gross Floor Area: 13,039 m^2, 140,334 ft^2
Net Floor Area: 10,446 m^2, 112,433 ft^2
Building Height: 22.64 m, 74.29 ft
Volume of Mass Timber: 1,194.67 m^3 of CLT
Annualized Whole Life Carbon Emissions: 7.8 $kgCO_2e/m^2$/year
Total Energy Use Intensity: 49 kWh/ m^2/year

PROJECT TEAM

Owner: More Than A Roof Housing Society
Land: Non-Market Housing Development & Operations
Architect: PUBLIC Architecture
General Contractor: Kindred Construction Ltd.
Owners BIM Consultant: Summit BIM
Design BIM Consultant: BIMOne
Construction BIM Consultant: Modelo Tech Studio
Structural Engineering: Wicke Herfst Maver Consulting Inc.
Mechanical and Electrical: Introba
Fire Suppression: Introba
Energy Modeling: Introba
Passive House Consultant: Introba
Embodied Carbon Modeling: Introba
Civil: Core Group Civil Consultants Ltd.
Landscape: Matthew Thomson Design Ltd.
Building Code: GHL Consultants Ltd.
Building Envelope: Morrison Hershfield
Acoustical: BKL Consultants Ltd.
Passive House Certification: Steven Winter Associates, Inc.
Elevator: GUNN Consultants
Project Management: CPA Development
Research Management: Scius Advisory

KEY STAKEHOLDERS

City of Vancouver
BC Housing
City of Vienna
Rüdiger Lainer + Partner

These bulletins discuss the Vienna House project as construction is getting underway. Completion is expected in November 2025.

The BIM Process

Digital data driven project delivery using Building Information Modelling/Management (BIM) provides opportunities for collaboration, early identification of construction issues, and facilitation of maintenance and operations activities. BIM allows project team members, including the owner, architect, engineers, operator, and others to share data about how a building is built. It also shares who has responsibilities for different data, data formatting, and how information is communicated.

Digital data driven project delivery provides a coordinated approach that has resulted in faster delivery, higher quality, better transparency, and cost savings, especially during the maintenance and operation phase of a building's lifecycle. Upfront planning and clash detection that BIM facilitates is particularly useful when using prefabricated components to prevent rework and limit waste. It shifts tasks to earlier phases of the design process, but results in material and labour efficiencies that ultimately save time and reduce cost overruns.

Vienna House is serving as a digital project delivery pilot project for several project team members. Part of the implementation process meant that BC Housing has had to adjust some operational processes. For example, the procurement team had to consider how to best introduce BIM requirements for the project without restricting responses to Requests for Proposals (RFPs) or adding costs to the project. BC Housing hired a BIM consultant, Summit BIM, to prepare a BIM Requirements Specification document that was appended to the RFP for architectural and construction service. This document was developed in collaboration with BC Housing and was used to describe expectations of the project team and how data could be shared and used to benefit the project.

The digital project delivery process is ongoing, and the construction phase and operations will demonstrate how the project benefitted, what could be done better, and what specifically can be adjusted for future success.

Use of BIM

The BIM process aids in the design, construction, and operation of a building by creating a data-rich three-dimensional representation of its contents from input provided by architectural, structural, and mechanical, electrical, and plumbing (MEP) services. The digital model, and the information it provides, is intended to streamline coordination and communication. BIM involves members of the design team, the owner, developers, and construction manager to limit conflicts, reduce waste and rework, and provide common reference.

The information in the digital model can help generate accurate bills of materials that help to simplify calculations for life cycle assessments and to assist with cost estimates. It has also proven to be a valuable reference for facilities maintenance and operations by specifying details for maintenance schedules, part numbers for items that may need replacement, and manuals for equipment.

Many countries have used BIM for some time but the process is fairly new to Canada. International standards such as ISO 19650 are available for use in Canada, but this suite of standards have yet to become mainstream. Unlike in other countries, there is no BIM mandate for public projects in Canada and there is no Canadian-specific national standard for what data is required in the model, how the data is used, and if that data is updated to reflect the as-built design to aid in operations. Without such a mandate and standards, implementation varies between projects and across the country.

Complex buildings such as hospitals often take full advantage of the features a digital project delivery process offers to ensure efficiencies and limit overruns. The investment in time and money earlier in the project to do this has been shown to be worthwhile. Returns on investment are not limited to hospital projects. Multi-family housing development is a complex process with a variety of inputs and stakeholders that will benefit from the use of digital project delivery and BIM. This is particularly true in the face of increasingly stringent energy efficiency standards and growing interest in prefabrication. As its implementation becomes more common, current challenges will likely diminish, costs will reduce, and housing can be provided more efficiently.

Benefits for BC Housing

BC Housing is using Vienna House as a platform to develop its capabilities for managing BIM projects and to identify best practices, workflows and techniques. Increasing the organization's familiarity with the requirements, processes, and software will allow better implementation of digital project delivery and its benefits. This includes better coordination and transparency, improved logistics and faster delivery, clash detection, easier access to prefabrication and documentation to facilitate operations and management. Leveraging these advantages will enable BC Housing to expedite the provision of affordable, high-quality housing.

BC Housing also chose Vienna House as a pilot project for the use of BIM in multi-family housing to increase its knowledge of BIM implementation and its benefits. This will allow BC Housing to better incorporate BIM in future requests for services and managing contracts. Lessons learned can be shared through its platforms and incorporated into education and training. Funding from the Canada Mortgage and Housing Corporation (CMHC), Natural Resources Canada (NRCan) and Forestry Innovation Investment (FII) provided the resources to the BC Housing Research Centre to investigate strategies for efficient project delivery using BIM and outlining best practices for its use on mass timber affordable housing projects.

BIM Requirements

Defining how BIM will be used on a project is essential for clear communication and efficient collaboration. The technical requirements and workflows that support the generation of design models are set forth in the BIM Requirements Specification. This document expresses the goals and expectations of BC Housing. It includes an outline of the requirements to be addressed in the BIM Project Execution Plan (BEP) as per ISO 19650.

The BEP is a document that defines uses for BIM on the project (e.g. design authoring, cost estimating, design coordination) along with details about how processes will be modified to best use the BIM data. It outlines the duties and responsibilities of everyone involved in the process and includes the timeline, model standards, and collaboration techniques. It makes clear who will be delivering which geometry or asset information at each stage. By defining these details up front, the BEP clarifies the processes for all team members. It also aids the owner in maintaining the property after handover.

The BIM requirements specification includes information about tracked assets in the Data and Geometry Specification (DGS) and Data Collection Specification (DCS) documents. These are spreadsheets containing a list of all tracked assets and information about each of them. The DGS contains information about parameters required in the design phase and the level of model development. The DCS contains information about parameters required in the construction phase such as vendor, manufacturer, model number, serial number, warranty, or installation date. These documents include assets such as prefabricated components, HVAC and plumbing equipment, light fixtures, doors, windows, cladding, and anything else anticipated to be maintained or replaced.

The BIM Requirements should also contain sufficient information to define the scope of work clearly during the bidding phase of a project. Different parties can make assumptions about what is required based on their previous projects but those assumptions may not align and cause subsequent issues. Understanding what data is required at each stage of a project is critical to provide a common vision of the level of effort and accurate bidding.

BIM Implementation on Vienna House

BC Housing Research Centre hired BIM consultants from Summit BIM and BIM One to assist with implementation of BIM processes. Consultants also provided BIM process education to BC Housing representatives and other members of the project team and owner group. Summit BIM helped to generate a BIM standards strategy and managed overall compliance with the process, while BIM One provided initial software implementation support for the design team. The consultants worked with BC Housing to create the BIM Requirements Specification, which was included in the RFPs for architectural and construction services. For some, the pilot project was their first experience using digital data driven project delivery. This created some challenges with implementation. Lessons learned on this project will be transferred to future projects, but BIM implementation benefitted Vienna House in ways which will be discussed below.

Tools

Collaboration for Vienna House was achieved through use of Autodesk Construction Cloud as a common data environment. Each discipline was able to share their most recent models to the platform for ease of access for the others. This collaboration allowed the teams to avoid conflicts and reduce errors. By linking models, they were able to work together more effectively and efficiently. A federated model was produced that combined individual models from each discipline into one (Figure 3). The federated model helps to identify conflicts and reduce the need for rework and delays through virtual coordination.

To limit repetitive work tasks, the architectural and MEP models used typical units and floors to represent details on one floor that are identical on other floors. This simplified the process until the design reached the Issue for Construction (IFC) stage, at which point the data was copied to all units and floors. While this simplified processes for the designers, it complicated calculations of materials and components for determining quantities and identifying potential conflicts on all floors. It is important that the timing of providing complete floor data instead of typical floor data be discussed and agreed upon at the outset to accurately plan activities for the whole team. If that data is required before IFC it should be stated at the beginning of the design phase.

Figure 2. Rendering of Vienna House, communal balcony (source: PUBLIC Architecture).

Virtual coordination used a variety of software tools to track and create the federated model and conduct clash detection, including:

- **Revit** – design software,
- **Navisworks** – a platform to provide virtual clash detection,
- **Navisworks Freedom** – provided the ability for owners (and other stakeholders with access to the model) to visualize and review the design virtually,
- **ACC** – cloud-based sharing platform,
- **BIM Track** – aided in communicating issues and questions, adding comments and assigning tasks to team members, leading to improved quality of design.

Initially, BIM data was intended to be used for the following processes:

- Virtual coordination through a shared 3D platform,
- Prefabrication through optimization of building components to support off-site fabrication,
- Cost estimating through automated quantity takeoffs,
- Energy analysis using the geometric and non-geometric information in the models,
- Asset information delivery for facilities maintenance and operations using BIM as a database,
- Design review through BIM based automated queries for QA/QC and program compliance checks.

Most of these goals were achieved, however cost estimation and energy analysis did not fully utilize the BIM data.

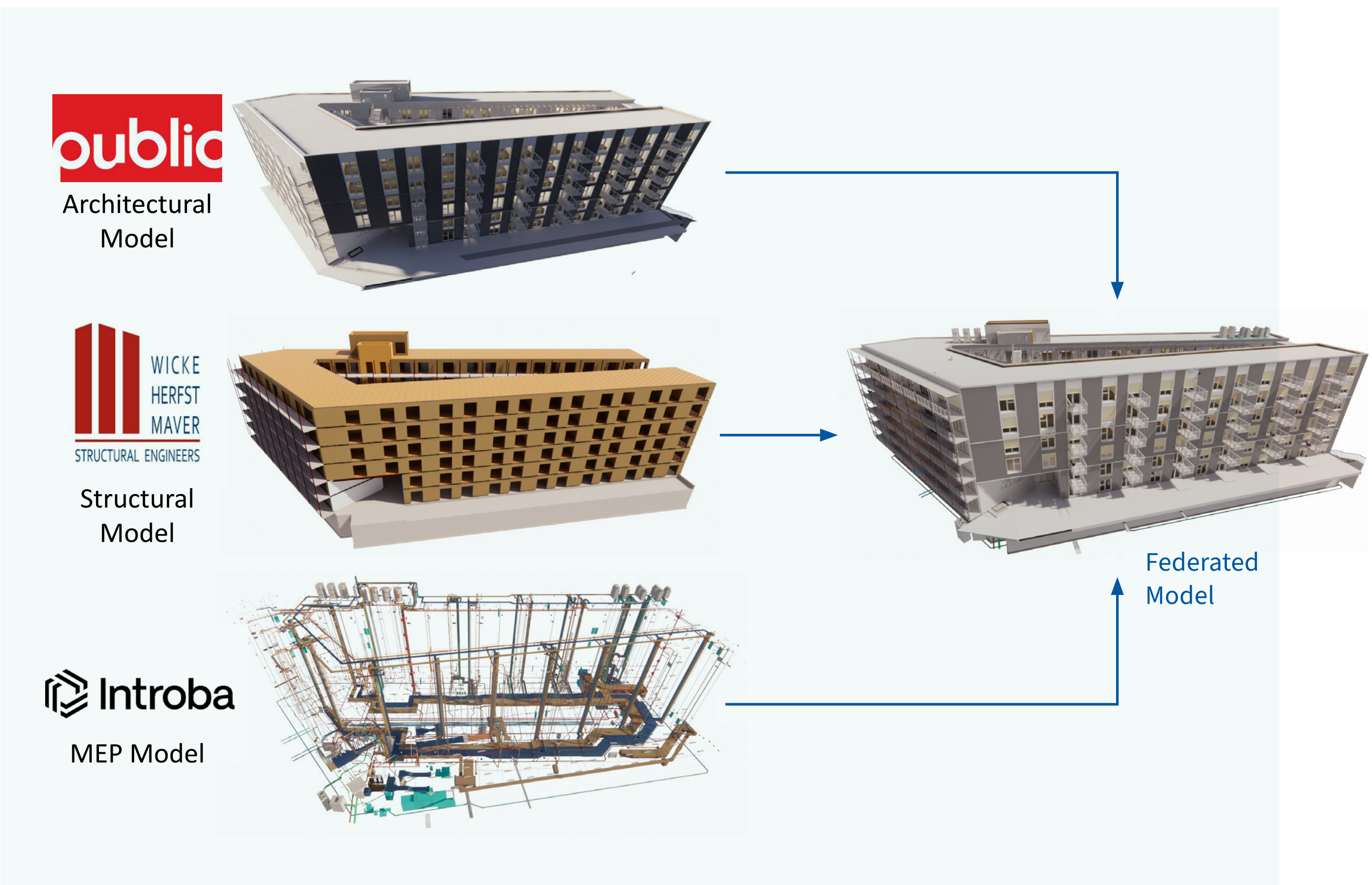

Figure 3. Models combined to create federated model (source: UBC BIM Topics Lab).

Cost Estimation

Several issues were identified at early stages of design modeling that affected accuracy and limited the ability to use the Vienna House BIM data for cost estimation. Issues that may be able to be addressed for future projects include:

- The process and expectations must be clearly defined at the outset,
- Naming conventions and classification systems must be clarified,
- Methodology is required to determine which data is included for items that exist in multiple models (architectural, structural, MEP),
- Items which are not modeled (e.g. rebar) or do not have details in early design stages should be defined along with quantity assumptions similar to those made in a traditional cost estimating process.

Feedback from the Construction Manager and Quantity Surveyors indicated that they are open to using BIM for cost estimation in the future and identified the following elements as potentially benefiting:

- Formwork take-off,
- Concrete volumes take-off,
- Structural steel take-off,
- Wood framing itemized bill of quantities (BOQ),
- Mass timber itemized BOQ,
- Window opening itemized BOQ,
- 4D modeling for logistics and schedule,
- Clash detection based on modeling full structural and mechanical system.

Energy Analysis

The BIM models were not used for the energy analysis on Vienna House. Most of the considerations for energy analysis were part of the design team's conventional workflows for making design decisions and meeting requirements for rezoning and development permits. Precise information requirements for accurate energy analysis in Revit such as material R values, U values, light transmittance, and solar heat gain were not specified in the BIM requirements. The BIM model was not used for whole-building energy modeling or Passive House calculations. The design team advocated that to do so would have added extra work without an added benefit.

Code Compliance

Building codes and regulations have specific requirements such as fire codes, accessibility requirements, or environmental regulations. Data from BIM models can be used to automate code compliance checks. To streamline operations and increase capacity, there is growing interest in some municipalities to implement this ability, allowing their workforce more time to focus on complicated issues. However, currently, there are no systems in place to do this. BIM models are also not considered legal contract documents for Vienna House. Printed and digital 2D drawings derived from the models constitute the legal contract documents, per BC Housing guidelines. The BIM model was not used for code compliance on Vienna House.

Prefabrication

Vienna House aims to help increase industry capacity for offsite fabrication, which is critical to affordable, low-carbon construction. Identifying strategies to increase the use of offsite fabrication will improve quality through accuracy and efficiency of construction, reduce construction waste, disturbance, and on-site noise pollution.

The use of BIM was intended to facilitate prefabrication by sharing data for the creation of fabrication models and the coordination of building system layouts, for example for penetrations and cutouts. However, the project delivery method does not align well with this approach. For the prefabrication process to be improved through the use of BIM, prefabrication manufacturers must be engaged earlier in the design phase, rather than with the standard tendering process. This would allow manufacturers to coordinate their fabrication data with the design team BIM model. Currently, the architectural model provides a design intent, but does not include specifics about details that will vary between vendors.

For Vienna House, the BIM model is provided as a reference for coordination, but the 2D drawings contain the details required for fabrication. Standard practice for fabricators is to recreate the models from scratch, incorporating fabrication details that are more specific than what is provided in the design model. This practice reduces risk because each trade is liable for its own outputs. Design models were not created with the intent to be a starting point for prefabrication models and do not contain the precision required for fabrication.

The construction team and their BIM consultants, Modelo Tech Studio, are creating a new BIM model with precise specifications for construction. The model combines the various fabrication models, modeling of various components, and specifying sequencing and onsite fabrication.

For BIM models to be used efficiently throughout the fabrication process, overall changes to the project must be made. Changes to project delivery methods, standard contracts, professional liability, input from fabricators during design, and design level detail must be considered. The specifics of what needs to be contained in the design model must be identified by the owner in the BIM Requirements Specifications so that team members understand it at the bidding stage. Creating a national BIM standard will aid in clarifying these issues.

Facilities Maintenance and Operations

The asset registry, which was created from information in the federated BIM model, tracks information for 1577 MEP assets and 88 architectural assets within the building. Information including maintenance manuals, shop drawings, installation dates, model numbers and vendor identification provides significant value to facilities management and improves planning for maintenance. While the asset registry is used for building operations, its contents must be defined early during the development of the BIM Requirements Specification, so information can be tracked appropriately. Including it earlier in the process also clarifies to the design and consultant teams the effort needed to collect this information. Before construction is completed, warranty information can be made available and a maintenance strategy can be put in place.

It was noted that coordinating such a large number of assets can be a daunting task. However, by tracking them digitally, assets can be sorted into those that need regular maintenance, require service by specific personnel, or are not regularly attended to but should have data available if a need arises. Service manuals, part numbers and vendor information can be associated with each asset, so that when maintenance is required, necessary information is readily available. There was also a question about whether the correct assets were being tracked, if something was missing, or if some assets were not necessary. As owners and operators become more experienced with using an asset registry to manage a building, that question can be more easily answered.

Lessons

Use of BIM on Vienna House has provided several benefits. Primarily, it has improved collaboration, visualization, and access to information. Working in a common data environment, the architects and engineers were able to more effectively collaborate and coordinate their efforts, resulting in fewer errors and delays and enhancing teamwork. Visualization allowed team members to identify potential issues that could have caused costly rework during construction. The large amount of data contained within the BIM model allowed for a variety of scenarios and designs to be investigated to make more informed decisions.

Digital project delivery requires an adjustment to assumptions and details about data requirements, schedules, and responsibilities. The process and the BIM software are intended to facilitate communication and collaboration, but those involved must actively participate. As a pilot project, Vienna House identified some areas where the assumptions made were not the same for all participants. It brought to light some questions that should be asked earlier in the process to avoid confusion and facilitate collaboration. These questions are being compiled as construction continues and will be reviewed as part of the lessons learned upon completion.

BIM allows for conflicts within a building design to be resolved at an early stage. To take full advantage of this, team members must participate earlier in the process. This includes the owner, architect, engineers, construction manager and key trades (notably, prefabrication). Traditional design, bid, build contracts that are currently used at BC Housing do not accommodate early involvement by trades. Without the details for prefabricated components, architectural design models only provide design intent and cannot include the detail needed to use a BIM model as a contract document.

In Vienna House, design specifications and measurements are provided as 2D drawings in the contract documents. The 3D BIM models are provided as a supplemental reference for coordination. Confusion has arisen with prefabrication trades referencing the BIM model for their designs instead of 2D drawings. If 3D BIM models were intended to be used by trades to generate their fabrication models and shop drawings, much greater detail would need to be input to that model. This detail would require fabrication information from the respective trades involved. Using the 3D model as a starting point for fabrication models would also bring up liability issues.

The construction team have a BIM consultant, Modelo Tech Studio, who is building a more precise version of the federated BIM model to clarify potential clashes and coordinate fabrication models from the manufacturers for construction. However, 2D drawings must still be generated as the official contract documents.

Owners are responsible for enforcing the BIM Requirements Specifications and ensuring that the goals and intentions for that data can be met with the details provided in the dataset. If the intent is to use the BIM data for fabrication, it must be specified and the BIM model should have the detail required for it to be part of the official contract documents.

It is not yet clear how BIM data will be best incorporated into standard workflows. Without a national standard there are many variables and process differences between stakeholders.

Lessons from Vancouver House in Vienna, Austria

In Vienna, Austria the “developers competition” for the design contract for Vancouver House required use of modularization, digitalization, and BIM to minimize costs and optimize planning and construction methods. The design team in Vienna shared experiences with use of BIM data during online workshops with the Vienna House team.

The Viennese team identified several ways in which digitization and use of BIM adds value to their projects, compensating for additional planning efforts:

- Improved communication,
- Cost reduction,
- Efficiencies for changes and execution,
- Integration into facilities management,
- Evaluation for sustainability.

They added that BIM aided in coordination of the different models and inspired confidence in the constructability, providing a clear vision of how to build a project. Solving conflicts early and working out complex situations virtually reduces construction time and cost. Use of BIM provides more efficient prefabrication and allows processes to be optimized. One such example compared different approaches to ceiling systems. It looked at the materials required and the costs associated with them. Design options could then be easily visualized alongside cost analysis.

The Vancouver House project has encountered some challenges with rising labour costs with inflation and supply chain difficulties, causing increased prices and shortages of materials. As a result, a cost cutting process similar to what Canadians would call value engineering was conducted. The architect identified the use of BIM in that process as extremely helpful in assisting with the complex information involved.

Their view is that if BIM is implemented successfully, everyone on the project prospers. Communications are more efficient, building costs are controlled and possibly reduced, and the model can be used for quantity takeoffs and verification. Other bidding processes lead to uncertainties about the completeness of the tender and what they refer to as “extra fear” costs, which can be avoided with a BIM model. The modular structure of the BIM model allows for ease of planning for prefabricated parts and assembly. In the execution phase, the BIM model allows them to immediately react to changes and understand the effects of those changes. The data provides an overview for management and can be used as a basis for calculations for sustainability certifications.

The extra effort to use BIM and the work that goes into planning with the digital model requires additional fees that need to be understood by the client. However, this fee is financed by the added value of the BIM process and potential savings during construction. Clients who have been involved in a project using BIM react positively because the problems are worked out in the planning and simulation and not during construction, costs are controlled, and the process provides a sense of security. Overall costs are lower, but clients need to invest more in the planning stage. The problem is they never know what could have happened if they didn't use BIM, so it is difficult to identify savings.

Figure 4. Rendering of Vancouver House in Vienna, Austria (source: Rüdiger Lainer + Partner).

NATIONAL HOUSING STRATEGY

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BC HOUSING RESEARCH CENTRE

1701-4555 Kingsway, Burnaby, BC V5H 4V8

Phone: 778-452-6454
Toll-free: 1-866-465-6873

Email: research@bchousing.org
www.bchousing.org