Prefabrication of Wood Buildings

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Literature Suggestion

Prefabricated Systems: Principles of Construction

by Ulrich Knaack, Sharon Chung-Klatte, Reinhardt Hasselbach

Publisher: Birkhäuser

ISBN-13 : 978-3764387471

Prefabricated Housing: Construction and Design Manual

by Philipp Meuser

Publisher: DOM Publishers

ISBN-13: 978-3869224275

Prefab Architecture: A Guide to Modular Design and Construction

by Ryan E. Smith

Publisher: Wiley

ISBN-13: 978-0470275610

Prefabrication of Wood Buildings

1) Lesson: Introduction and Classification
   a) History of prefabrication
   b) Driving factors for change
   c) Classification
2) Lesson: Prefabrication Process
   a) Influence on design process
   b) Influence on product
   c) Production process for panelized prefabrication
3) Lesson: Modular and Materials
   a) Pods production
   b) Modular production EU
   c) Modular production CAN
   d) Materials
4) Lesson: Pros & Cons and Case Studies
   a) Construction site
   b) Pros & Cons
   c) Case studies

Lesson 1: Introduction and Classification

- History of Prefabrication
- Driving Factors towards Prefabrication
- Classification

History of Prefabrication

- ***Objectives:***
- Summarize the history of prefabrication
- Identify the achievements throughout history

Early Examples of Prefabrication

1242 Heddal Stave Church, Norway
1494 Casa Mutabile, Leonardo Da Vinci
1500's Timber Framing, Central Europe



Photos: Wikipedia

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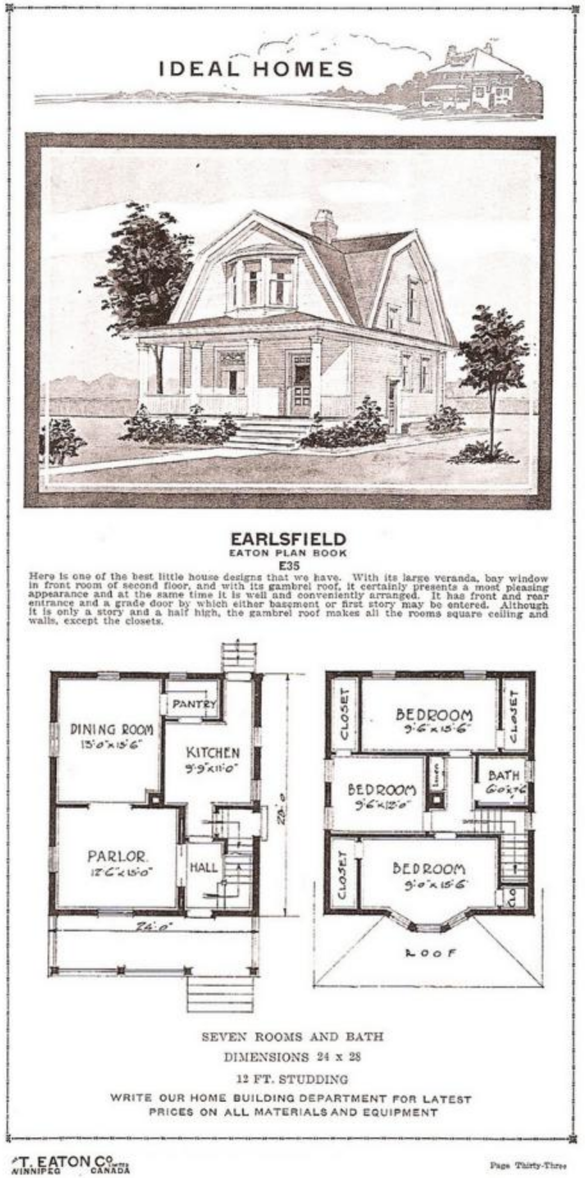
Historic Timber Framing Details

Photos: Wimmers

19th century

1840 Manning Cottage in Adelaide, Australia
1850's Gold Rush, North America
1885 Villa Udine in Binz, Germany
1895 Villa Blumenthal in Bad Ischl, Austria

Canada at the beginning of the 20th century


IDEAL HOMES

EARLSFIELD
EATON PLAN BOOK
E35

Here is one of the best little house designs that we have. With its large veranda, bay window in front room of second floor, and with its gambrel roof, it certainly presents a most pleasing appearance and at the same time it is well and conveniently arranged. It has front and rear entrance and a grade door by which either basement or first story may be entered. Although it is only a story and a half high, the gambrel roof makes all the rooms square ceiling and walls, except the closets.

SEVEN ROOMS AND BATH
DIMENSIONS 24 x 28
12 FT. STUDDING
WRITE OUR HOME BUILDING DEPARTMENT FOR LATEST PRICES ON ALL MATERIALS AND EQUIPMENT

T. EATON Co. WINNIPEG CANADA

Page Thirty-Three

Earlsfield catalogue house build in 1916 in Fielding Sask., by Eaton Co. Ltd, located in Winnipeg.

Photos: Les Henry and 1919 advertisement in Plan Book of Modern Homes

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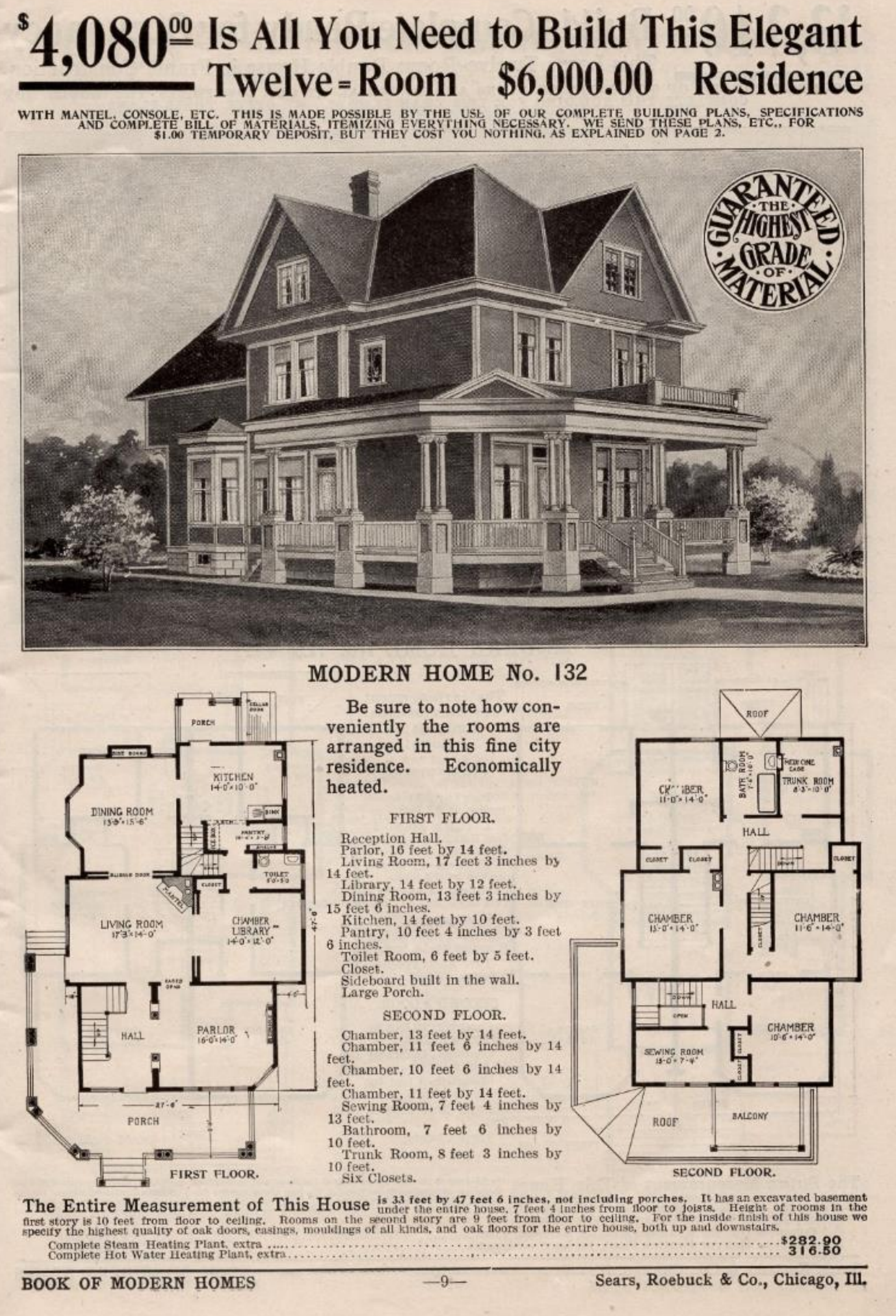
Model homes or catalogue homes by Sears 1920's


$4,080.00 Is All You Need to Build This Elegant Twelve-Room $6,000.00 Residence

WITH MANTEL, CONSOLE, ETC. THIS IS MADE POSSIBLE BY THE USE OF OUR COMPLETE BUILDING PLANS, SPECIFICATIONS AND COMPLETE BILL OF MATERIALS, ITEMIZING EVERYTHING NECESSARY. WE SEND THESE PLANS, ETC., FOR $1.00 TEMPORARY DEPOSIT, BUT THEY COST YOU NOTHING, AS EXPLAINED ON PAGE 2.

MODERN HOME No. 132

Be sure to note how conveniently the rooms are arranged in this fine city residence. Economically heated.

FIRST FLOOR.

Reception Hall.
Parlor, 16 feet by 14 feet.
Living Room, 17 feet 3 inches by 14 feet.
Library, 14 feet by 12 feet.
Dining Room, 13 feet 3 inches by 15 feet 6 inches.
Kitchen, 14 feet by 10 feet.
Pantry, 10 feet 4 inches by 3 feet 6 inches.
Toilet Room, 6 feet by 5 feet.
Closet.
Sideboard built in the wall.
Large Porch.

SECOND FLOOR.

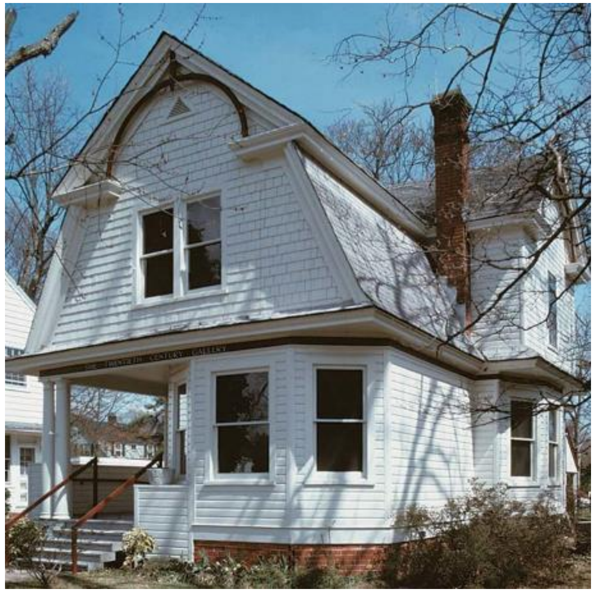
Chamber, 13 feet by 14 feet.
Chamber, 11 feet 6 inches by 14 feet.
Chamber, 10 feet 6 inches by 14 feet.
Chamber, 11 feet by 14 feet.
Sewing Room, 7 feet 4 inches by 13 feet.
Bathroom, 7 feet 6 inches by 10 feet.
Trunk Room, 8 feet 3 inches by 10 feet.
Six Closets.

FIRST FLOOR. SECOND FLOOR.

The Entire Measurement of This House is 33 feet by 47 feet 6 inches, not including porches. It has an excavated basement under the entire house, 7 feet 4 inches from floor to joists. Height of rooms in the first story is 10 feet from floor to ceiling. Rooms on the second story are 9 feet from floor to ceiling. For the inside finish of this house we specify the highest quality of oak doors, casings, mouldings of all kinds, and oak floors for the entire house, both up and downstairs.

Complete Steam Heating Plant, extra $282.90
Complete Hot Water Heating Plant, extra 316.50

BOOK OF MODERN HOMES —9— Sears, Roebuck & Co., Chicago, Ill.



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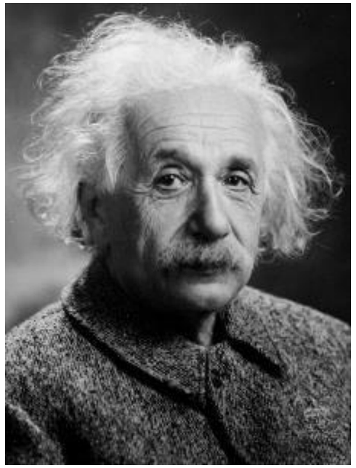
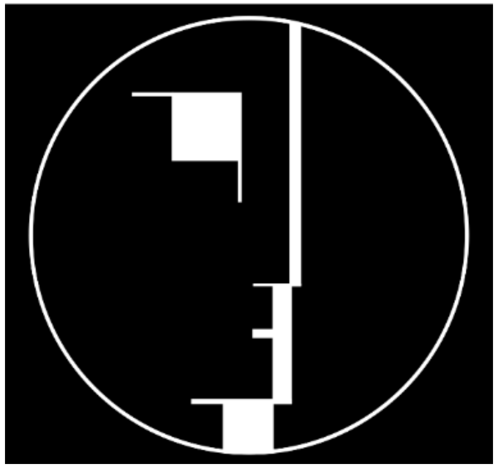
1920’s influential architectural school BAUHAUS




1950’s – 1990’s

1990’s development or revival of EWP

Photos: DATAHOLZ, SOHM and STRUCTURECRAFT

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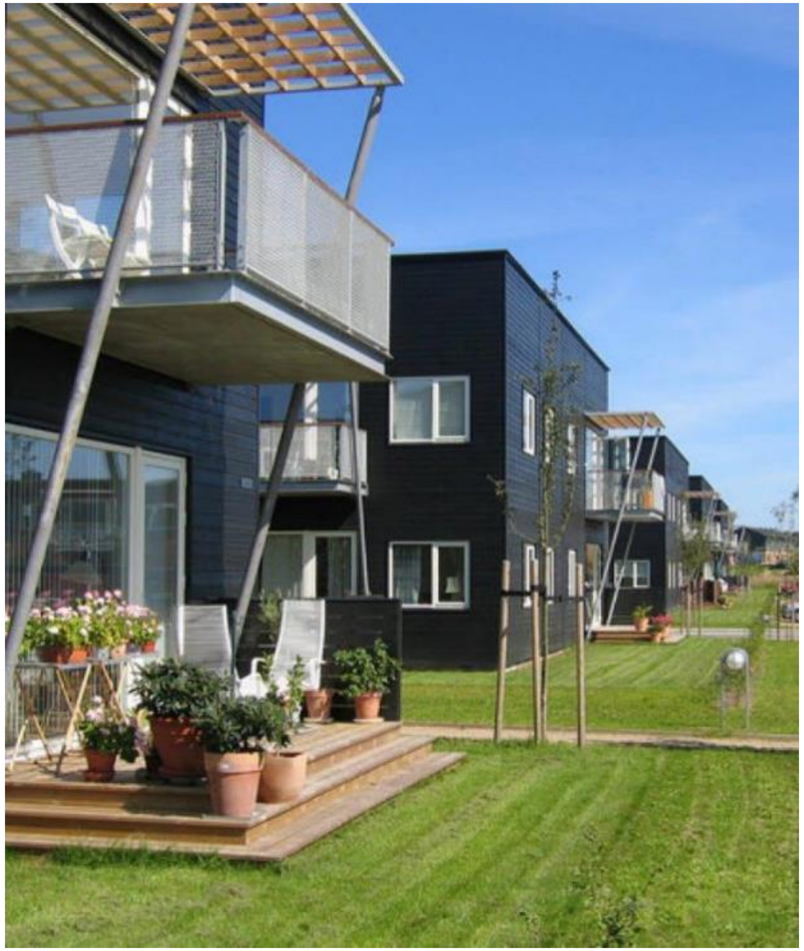
2000….

Photos: Arch. Melis-Melis-Wimmers

IKEA's BoKlok and Moxy Hotels



Photos: IKEA

Tall Wood Buildings

Photo: WAUGH THISTLETON ARCHITECTS

2010's

Photo: BLUMER-LEHMANN

Parametric Wood Construction

Photos: BLUMER-LEHMANN and SPEARHEAD

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Driving Factors towards Prefabrication

- ***Objectives:***
- Productivity
- Automation
- Lean manufacturing
- Industry 4.0
- Tall wood buildings
- Energy efficiency requirements

Stick frame 150 years ago

Evolution of wood construction in North America over the last 150 years?

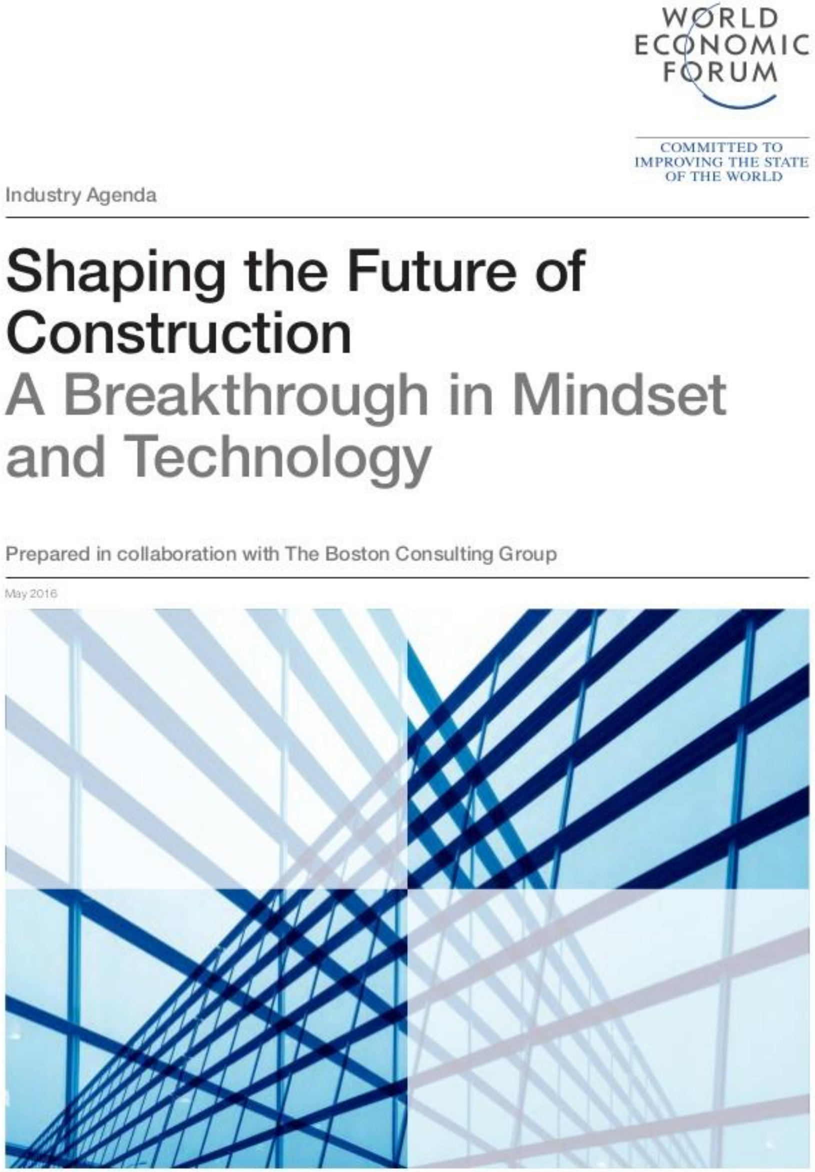
Photo: William Henry Jackson

Stick Frame Today

Not much progress was made!

Photo: Habitat for Humanity

Future



WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

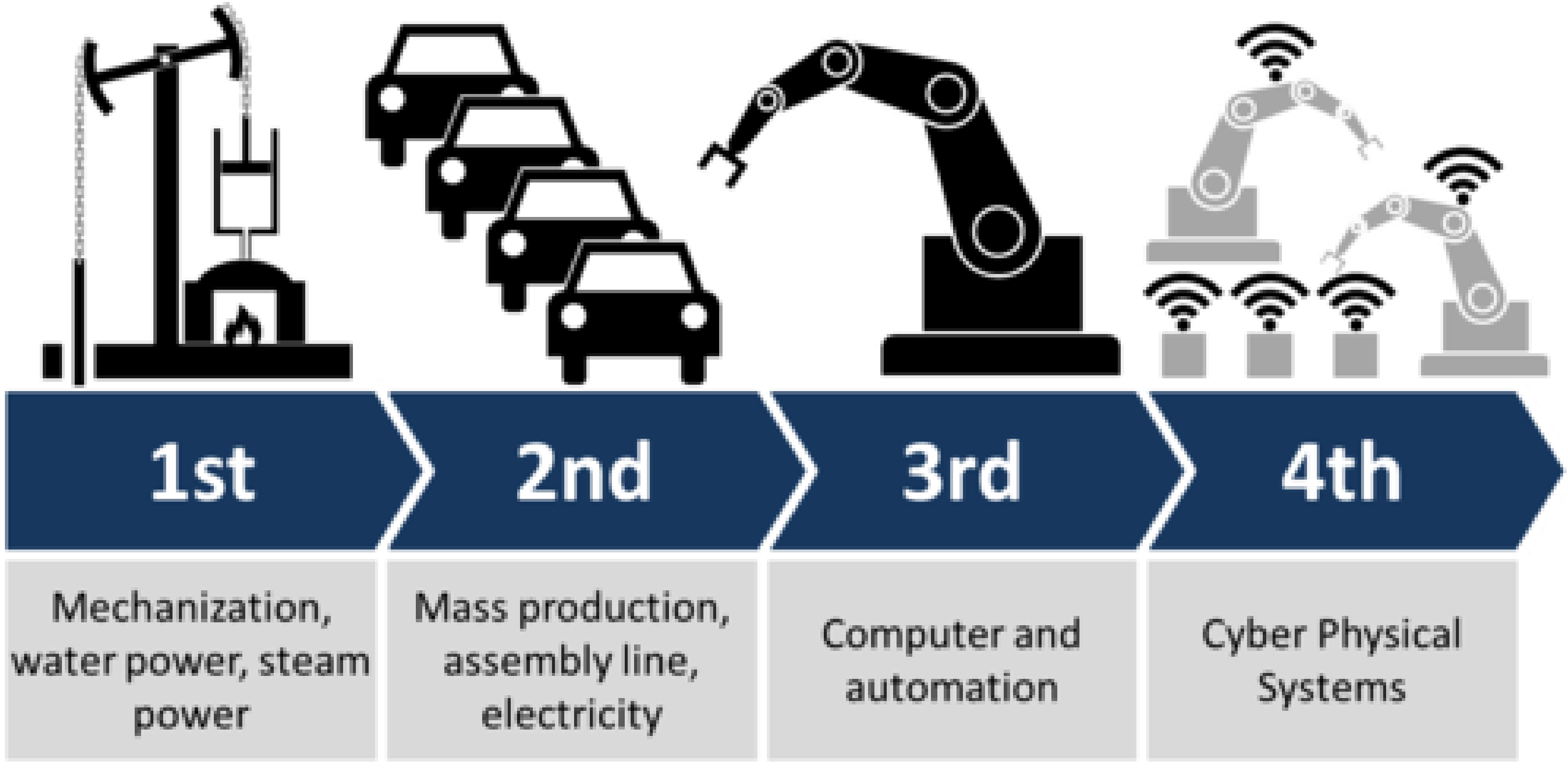
Industry Agenda

Shaping the Future of Construction
A Breakthrough in Mindset and Technology

Prepared in collaboration with The Boston Consulting Group

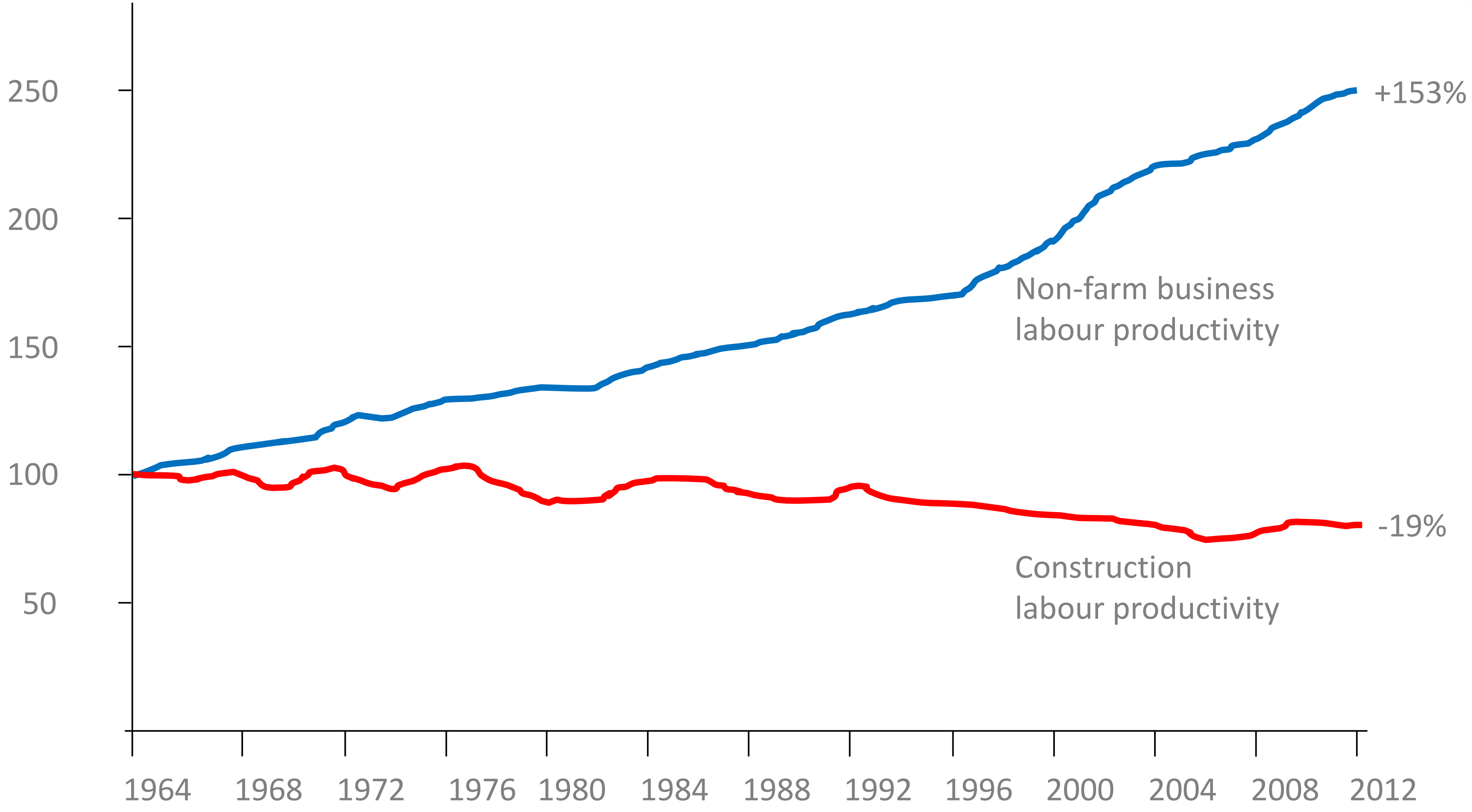
May 2016

Industry 4.0



Graphic: Wikipedia

Construction Labor Productivity (USA)



Graphic: Wimmers, based on report

Peer set based on US companies with engineering, construction and service-related standard industrial classification codes. Financials are inflation-adjusted and indexed to 1964; output per working hours. Source: Global Vantage; Compustat; Bloomberg; www.aecbytes.com/viewpoint/2013/issue_67.html; www.nber.org/papers/w1555.pdf; S&P Capital IQ; BCG ValueScience Center; World Economic Forum

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Why is the Construction Industry Performing so Poorly?

- Lack of innovation and delayed adoption
- Informal processes or insufficient rigor and consistency in process execution
- Insufficient knowledge transfers from project to project
- Weak project monitoring
- Little cross functional cooperation
- Little collaboration with suppliers
- Conservative company culture
- Shortage of young talent and people development

Source: World Economic Forum

Productivity

Photos: William Henry Jackson, Habitat for Humanity, Wimmers

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New Driving Factors for Prefabrication in Canada

In recent years two major building code changes have started to transform the construction industry and will continue to increase their influence:

- **Tall wood buildings**
- **Energy efficiency of buildings**

Tall Wood Buildings

Since 2020 the BCBC allows for 12 floor wood construction and the upcoming NBC goes in the same direction.

Without prefabrication, no wooden high-rise!

Energy Efficiency

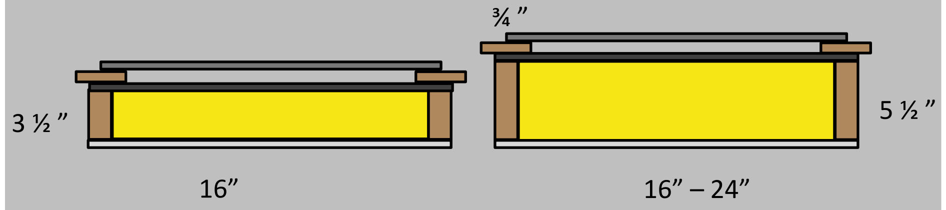
The BC Energy Step Code has introduced a 5 tier system for the energy efficiency of BC's buildings, leading to the highest step at latest in 2032.

Step 5 is typically called "net-zero ready", not to be confused with Passive House. Passive House is still a level up and is occasionally referred to as "Step 6".

Without prefabrication, no cost efficient construction of thermally higher performing envelopes.

Energy Efficient = Thicker Envelope

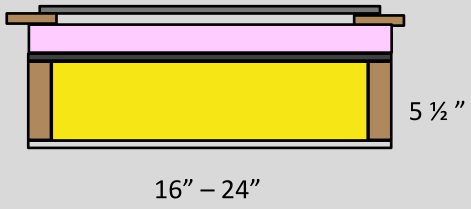
Past



Traditional framing from ~1950’ to ~2005

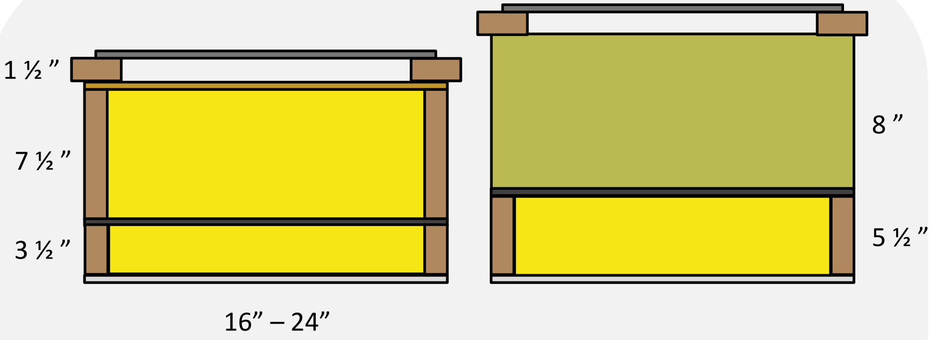
Slightly better framing from ~2005 to ~2020

Intermediate



Intermediate step, risky with EPS/XPS! ~2015 to ~2025

Future



Well preforming and well proven envelopes for energy efficient buildings, such as Passive House ~2010 and into the future

Graphic, Author: Wimmers

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Classification

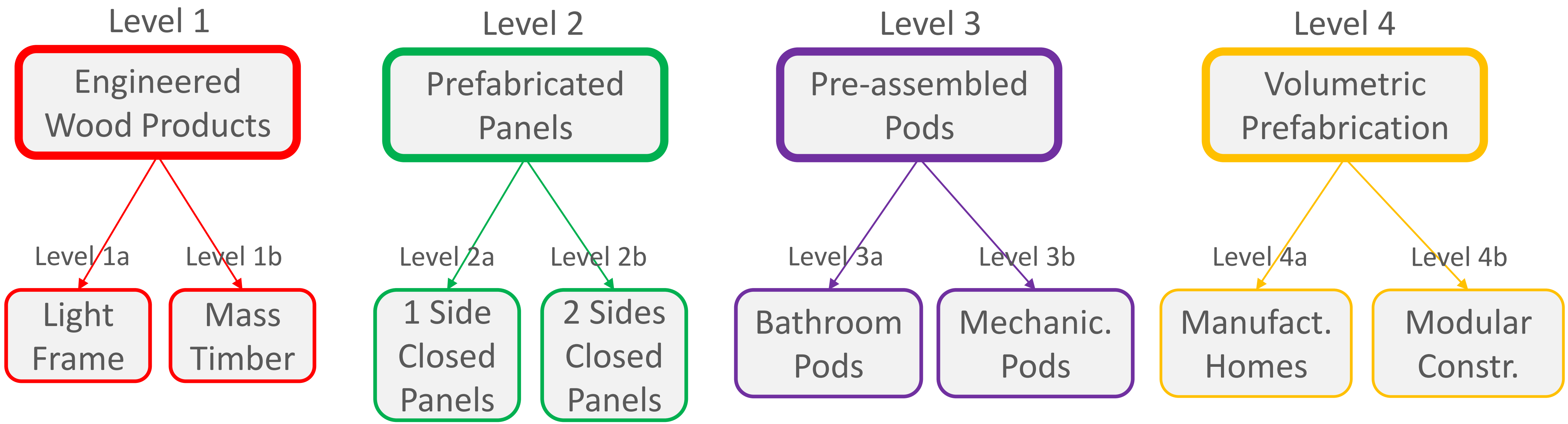
- ***Objectives:***
  - Define the general levels of prefabrication
  - Summarize the basics and the principles of each level
  - Identify all relevant labour steps included in each level
  - Discuss the necessity of multi trade collaboration in the advanced levels
  - Estimate the financial and spatial dimensions of each level
  - Investigate the advantages and disadvantages of each prefabrication level

Definitions

- 1D, 2D, 3D
- Non-volumetric, Volumetric, Modular
- Prefabricated housing involves the manufacturing and pre-assembly of components, elements or modules off-site, before their final installation at a chosen location (Goodier & Gibb, 2007).
- Construction components are produced in a manufacturing factory, transporting complete or semi complete components to the construction site for final assembly to create building structures (Tam, Tam, Zeng & Ng, 2007).

Author: Wimmers

Levels of Prefabrication

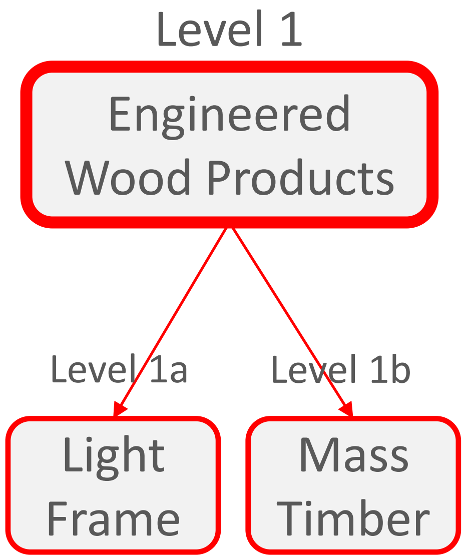


Sources: Goodier C., Gibb A.: Future opportunities for offsite in the UK. Construction Management and Economics, 25(6), 585–595., 2007.
Goodland H., Lam A., Taylor M., Zadeh P.: Cost Implications of Accelerated Construction Schedules. Vancouver: FP Innovations, 2019.
Wimmers G: Wood Technology Solutions Report, Quesnel: City of Quesnel, 2020.

Graphic, Author: Wimmers

Level 1

pre-cut and/or pre-assembled to size and specification



Framing Packages or Trusses

Incl. studs or joists, top and base plates, headers , nailing plates or nails or staples and sheathing

- Trades: one
- Limited expertise in manufacturing, transportation and installation required
- Some engineering involved
- Moderate investment required

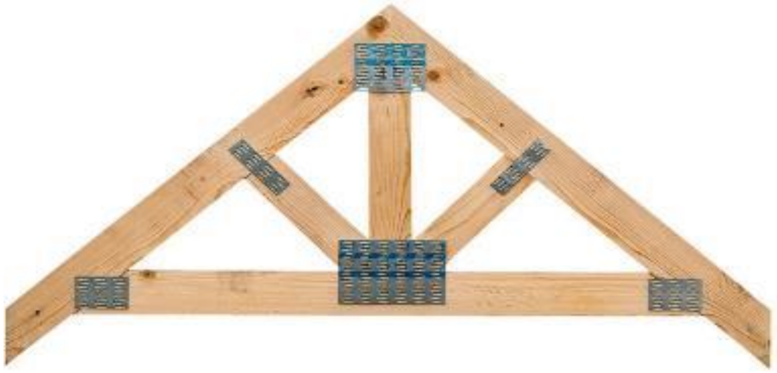
Glulam, CLT, NLT, DLT, …

Precut and predrilled panels or posts and beams, incl. connectors and cut-outs

- Trades: one
- Expertise in manufacturing, transportation and installation required
- Engineering involved, connections usually included
- Manufacturing company may play a more central role in the design and construction process through the preparation of shop drawings
- Higher investment required

Graphic, Author: Wimmers

Level 1a: Trusses and Framing Packages



- Moderate overall Investment required
- Relatively small space required
- Relatively small investment in equipment required

Photos: Homeadvisor, North East Remodeling Group

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Level 1b: Glulam, NLT, DLT, CLT, …








- For DLT and NLT moderate investment in equipment required
- For Glulam larger investment in space and equipment required
- For CLT very large overall investment required

Photo: upper Dataholz, Structurecraft, lower Wimmers

Level 2

Prefabricated Panels

Level 2a – 1 Side Closed Panels

- **1 side closed**
  Incl. level 1 plus weather barrier on outside; can include insulation, services and windows
- **1 side closed and finished**
  As above plus completely finished exterior and windows

Level 2b – 2 Sides Closed Panels

- **2 sides closed**
  Incl. all necessary layers to close the panel for air, vapour diffusion and weather; final layer on the inside and the outside not included; can include services and windows
- **2 sides closed and finished**
  As above plus completely finished exterior, services, windows and interior

- Trades: several (e.g. carpenters, insulators, window installers, etc.)
- High expertise in manufacturing, transportation and installation required
- Engineering involved, connections and weather barrier included
- Prefabrication company plays a central role in the design and construction process through the preparation of shop drawings, coordination of sequencing, provision of specialized equipment, etc.

- Trades: many (e.g. carpenters, insulators, window installers and potentially electricians, plumbers, installers of mechanical systems, etc.)
- Very high expertise in manufacturing, transportation and installation required
- Engineering involved, connections, weather barrier, airtightness and vapour retarder included
- The prefabrication company plays now a vital role in the design and construction of the project and beside the multiple trades also an interdisciplinary design team is included.

Graphic, Author: Wimmers

Level 2a: Outside Closed, Inside Open

- Higher overall investment than for 1a required
- More space and more work stations than for 1a required
- Investment in more equipment recommended but not necessary

Photo: UBC Brock Commons*, WoodWorks BC

Level 2b: Panel Closed (or finished) on both Sides

- Higher overall investment than for 2a required
- In addition to 2a more space and more work stations required for electrical, plumbing, air barrier, drywall and flooring
- Investment in more equipment recommended, typically more automation
- More storage space required

Photo: FAZ.net, Wimmers

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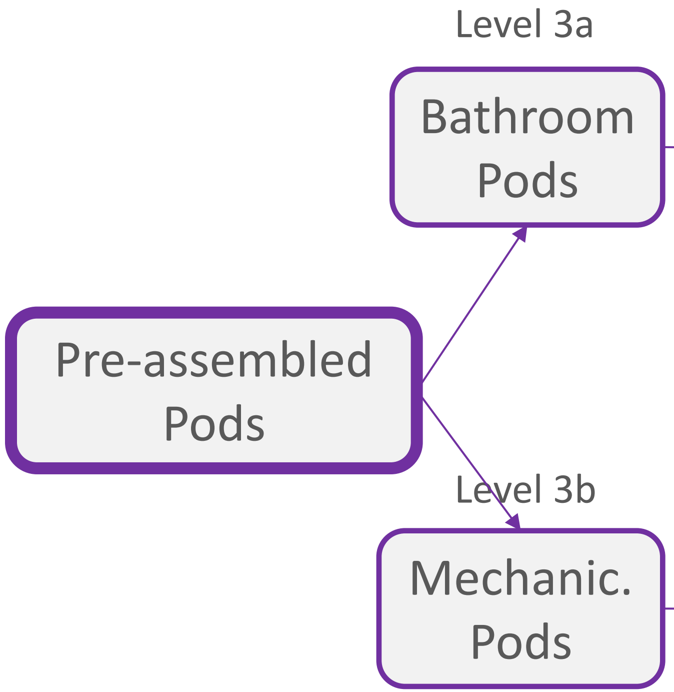
Level 3



Complete installation of all plumbing and bathroom fixtures, including finishes such as tiles. Occasionally combined with kitchen fixtures preinstalled on one of the wall's opposite sides.
For structural system wood or steel studs can be used.

Similar to bathroom pods, mechanical pods entail all relevant mechanical system preinstalled and prepared for "plug and play". Mechanical pods are typically used in larger buildings and are not mass produced as bathroom pods as typically only one is needed per building

- Trades: many (e.g. carpenters, tile setters, electricians, plumbers, installers of mechanical systems, etc.)
- Highly specialized three-dimensional elements have been fabricated by multiple trades (focus is on electrical, mechanical) and are shipped fully finished from a factory to integration on-site or off-site
- The specialized company works closely with the project team to customize, assemble, transport and install the units.
- Examples include fully equipped mechanical rooms, most common are so called bathroom and/or kitchen "pods".
- Off-site those pods are integrated into modular construction
- On-site those pods are then typically connected to either prefabricated panels according to level 2a or 2b or off-side integrated into modules as described in level 4.

Graphic, Author: Wimmers

Level 3: In a Manufacturing Plant and Integration in Modules

- Less investment in large machines required as pods are usually smaller
- More investment in workstations for electrical and plumbing required
- Storage space for many different types of material required

Photos: Tjiko, Wimmers

Level 4

Volumetric Prefabrication

Level 4a

Manufactured Homes

Constructed and completed in a factory and shipped in one piece to the final place. Customization is limited to structural and size constrains. These buildings are also occasionally referred to as mobile homes or trailer homes.

Level 4b

Modular Construction

Constructed and ideally completed in a factory and shipped in several modules to the building site. Customization is possible. Large buildings are possible. Combinations of modular, panelised and pods are more common for very large buildings.

- Trades: many (e.g. carpenters, insulators, window installers, tile setters, electricians, plumbers, installers of mechanical systems, etc.)
- 3 dimensional elements are shipped to site and put into position (manufactured home) or assembled to a larger building (modules)
- The specialized company works closely with the project team to customize, assemble, transport and install the units.
- The range of this category goes from mobile homes to tall residential wood buildings such as 14 floor Treet in Bergen (Norway)

Graphic, Author: Wimmers

Level 4: Manufactured and modular Buildings

Photos: Rune Abrahamsen, Homes Direct

What Influences the Transition to Prefabrication?

1. How will current or future building codes potentially influence the prefabrication industry?
2. How large do you estimate the savings potential for more efficient manufacturing?
3. How does Canada’s prefabrication industry fit into the different prefabrication levels?

Lesson 2: Prefabrication Process

- Influence on design process
- Influence on product
- Production process panelized prefabrication

Influence on Design Process

- ***Objectives:***
  - Define and compare the different approaches of conventional and Integrated Project Delivery (IPD)
  - Discuss the elementary changes in the design and delivery process
  - Discuss the necessity of Building Information Modelling (BIM) in prefabrication

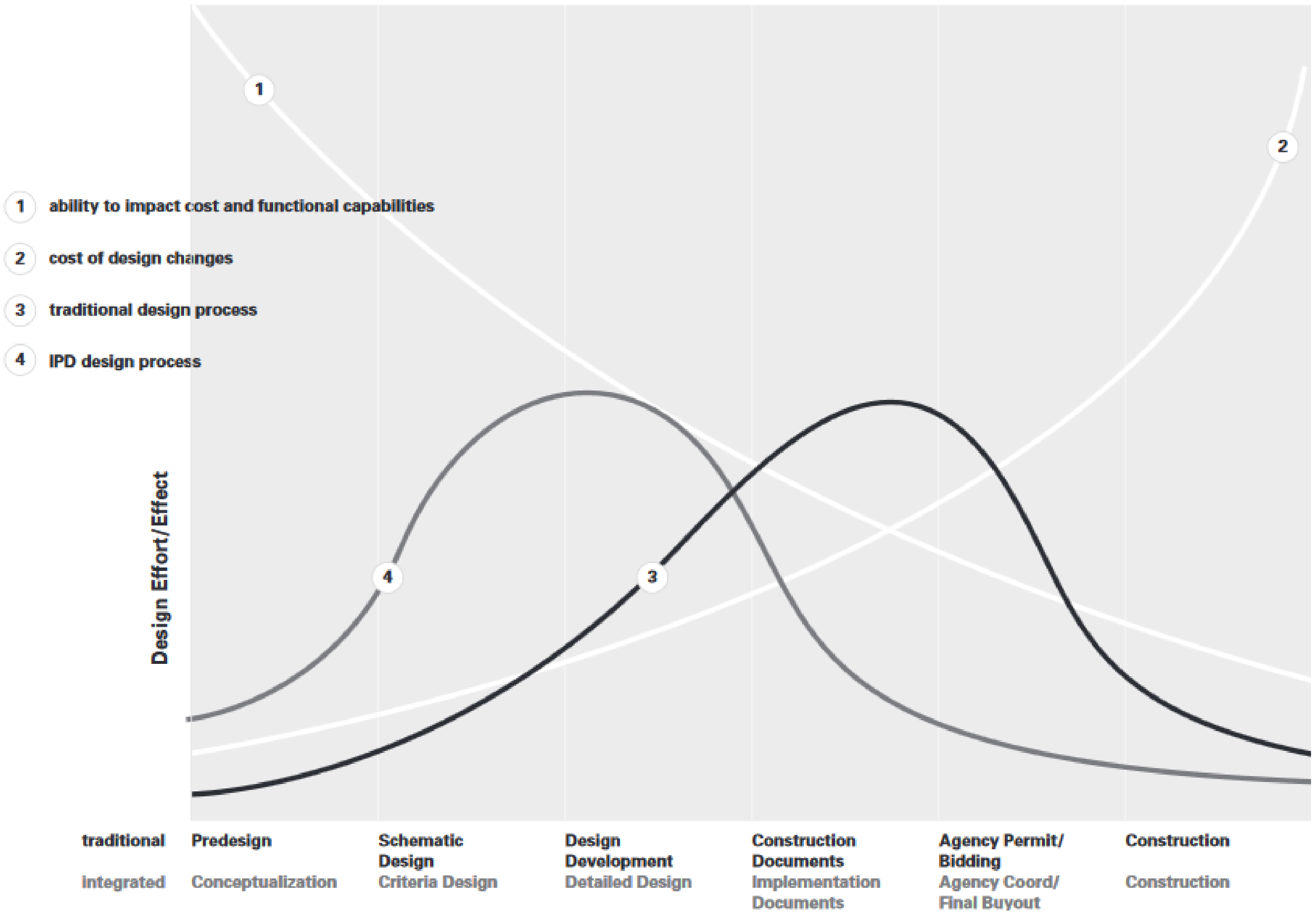
Unique Design Process Requirements

- Architectural Design and Engineering (Integrated Design & Delivery Process)
- Early engagement of entire team
- Conceptual design becomes important and more detailed
- Understand available systems
- BIM highly advised (1st BIM tool ArchiCAD 3.0 introduced in 1987)
- Very detailed Shop Drawings
- Vertical integration of builder/contractor is very helpful
- Transition from 3D Drawings to Machine readable Information
- Transportation and Installation Plan
- Assembly and Connections different than in typical "On-site" Construction

Author: Wimmers

Integrated Project Delivery

Macleamy Curve

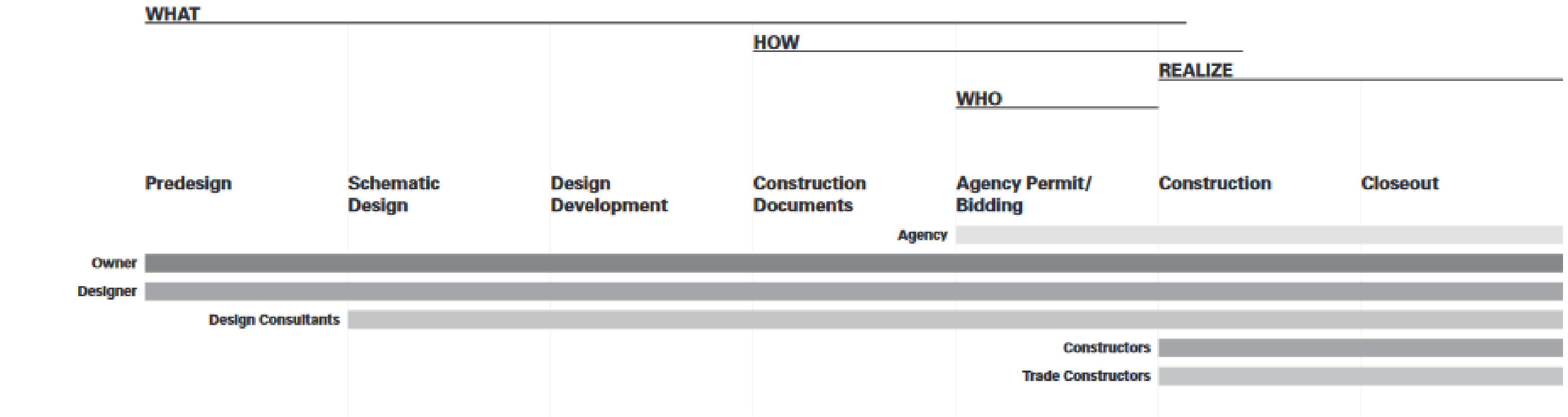


Introduced in the Construction Users Roundtable's "Collaboration, Integrated Information, and the Project Lifecycle in Building Design and Construction and Operation" (WP-1202, August, 2004)", the "MacLeamy Curve" illustrates the concept of making design decisions earlier in the project when opportunity to influence positive outcomes is maximized and the cost of changes minimized, especially as regards the designer and design consultant roles.

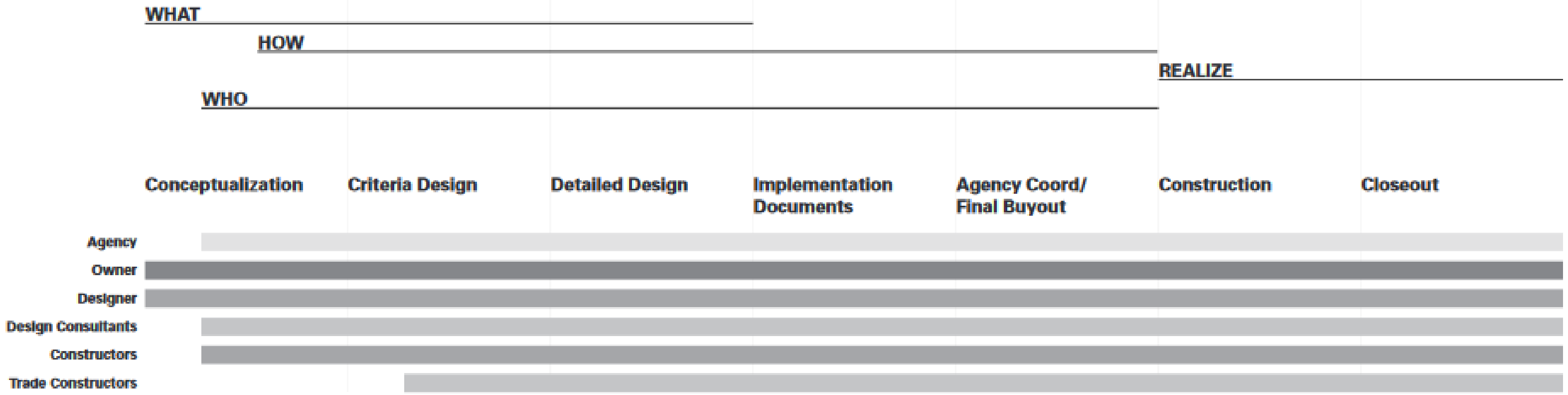
Source: Integrated Project Delivery: A Guide 2007 AIA

Integrated Project Delivery

Traditional Design Process

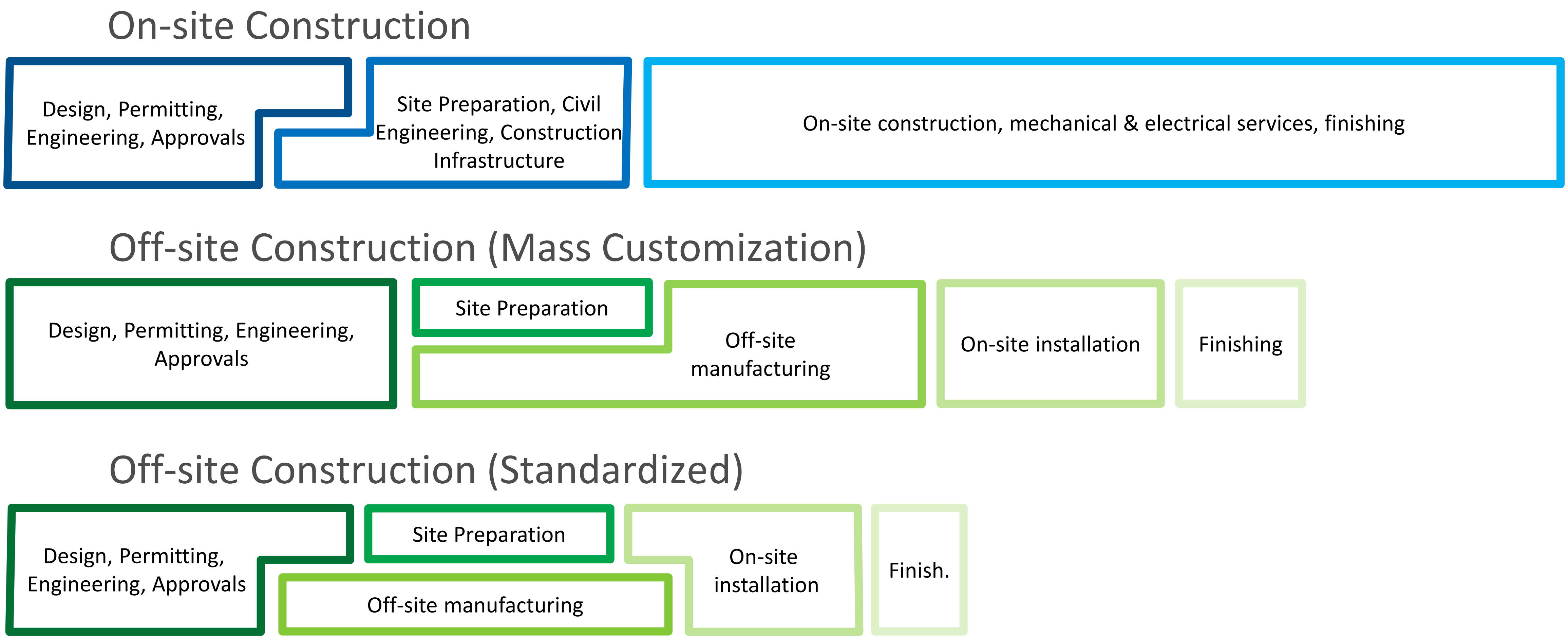


Integrated Project Delivery



Source: Integrated Project Delivery: A Guide 2007 AIA

Schematic Timelines



Graphic, Author: Wimmers

Definition of BIM

- A Building Information Model is a "shared digital representation of physical and functional characteristics of any built objects (including buildings) which forms a reliable basis for decisions."
  ISO 29481

- In addition:

  The model can and should be maintained over the lifetime of the building to support maintenance, future renovations, extensions and other activities to generate the full potential over the lifetime of the building.

Author: ISO, Wimmers

The BIM issue

- The output of the design are not drawings!
- It is the information presented on or imbedded into the drawings.

The “drawings” are simply a tool to carry multiple layers of information models that support the design, the construction process, the commissioning and the operation, including potential alterations at any given time over the life time of the building.

BIM is not an absolute necessity for successful prefabrication, but it is very beneficial and saves costs!

Digital Project Delivery and Integrated Project Delivery

Photos: ICD University of Stuttgart, Jakob+MacFarlane

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Influence on Product

- ***Objectives:***
  - Analyze qualitatively how off-site manufacturing leads to building science related assembly changes
  - Discuss the changes in the procurement process and material flow

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Changes in Assemblies

The plywood issue:

a) Light frame construction needs something to handle lateral forces. Traditionally this is done with a sheet of plywood (or OSB)

b) 12,7mm (1/2”) plywood is rated as a vapour retarder

c) Vapour retarders should always be on the inside (warm side) and are usually the same material as the airtight layer.

d) Because of the assembly sequence in on-site construction, plywood was traditionally installed on the outside of the insulated building envelope

e) Installed on the outside (cold side, layer e. on next slide) plywood triggers increased vapour pressure, potentially above saturation pressure and consequently condensation

Author: Wimmers

Changes in Assemblies

The plywood issue (continue):

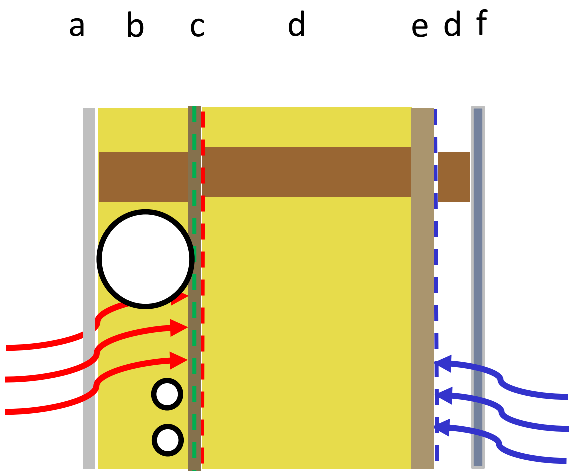
f) This, combined with a lack of airtightness on the inside, became over time (decades) an added risk to common construction

g) Off-site construction opens up a more science based decision, where the plywood (vapour retarder) should be located

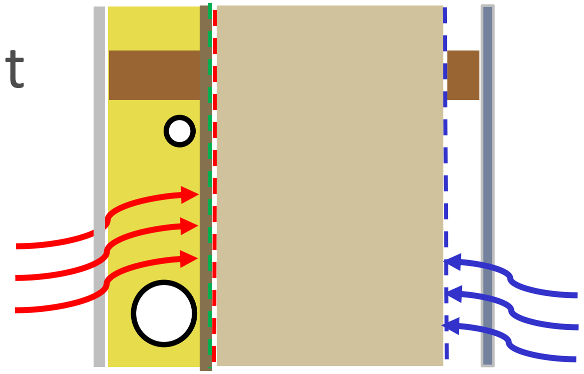
h) Plywood (or OSB) can take lateral forces but is also excellent as air barrier (needs to be taped) and vapour retarder

i) Using plywood on the warm side (layer c.) is much safer

j) Assuming an installation layer is introduced (layer b.) and special grommets are used to achieve airtightness, plywood can now fulfill 3 different functions at once



Assembly 1)

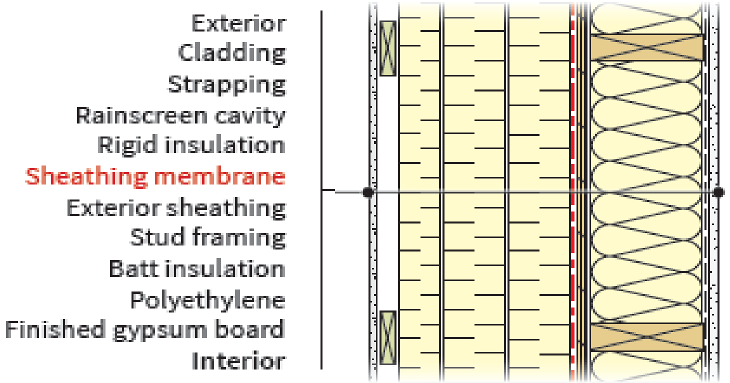


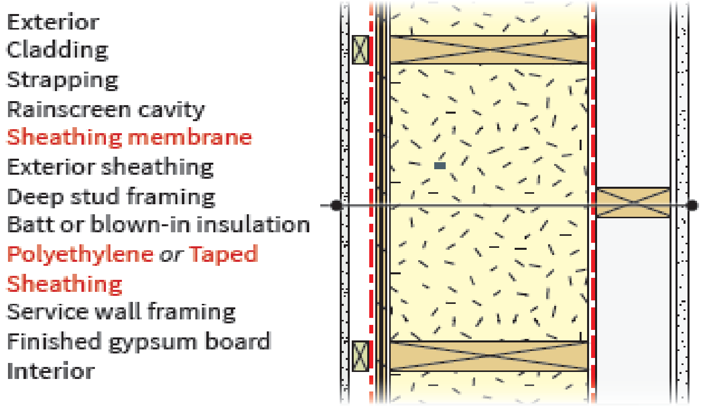
Assembly 2)

Graphic, Author: Wimmers

Prefab is a **necessity because…**

Envelope will get 42 – 77% heavier and will have 87 – 100% more volume!





Source: MOC 2019 Conference Paper: Conroy, Wimmers, Consequences of the BC Energy Step Code on Offsite Construction

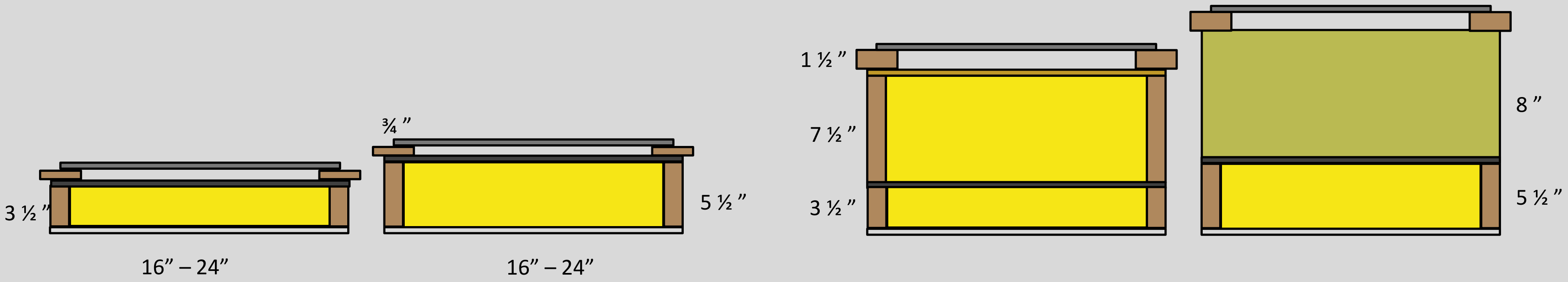
Changes in Planning and Design of Services

Photo: Tjiko

Photo: TECEsystem

- The implementation of several trades in the prefabrication process requires a more detailed involvement of those trades/planners in the design phase

Changes in Process



- Estimate additional labour steps needed
- Estimate additional expenses on site
- Compare to off-site construction

Graphic, Author: Wimmers

Production Process

for panelized prefabrication

- ***Objectives:***
  - Develop the generic outline of a prefabrication production line and evaluate the workflow
  - Differentiate the requirements in production process depending on the level of prefabrication
  - Outline the setup and ergonomics of different workstations in the production process
  - Estimate the financial impact of different machinery and level of automation and their space requirements

Procurement and storage

- Prefabrication and the level of standardization changes the procurement processes. Depending on the size of the factory, larger amounts have to be delivered to the same address, allowing for bulk purchases, but require storage space.
- The storage space is further increased if more mass customization is used.
- For windows and other larger and more valuable components typically “just in time” delivery is preferred.

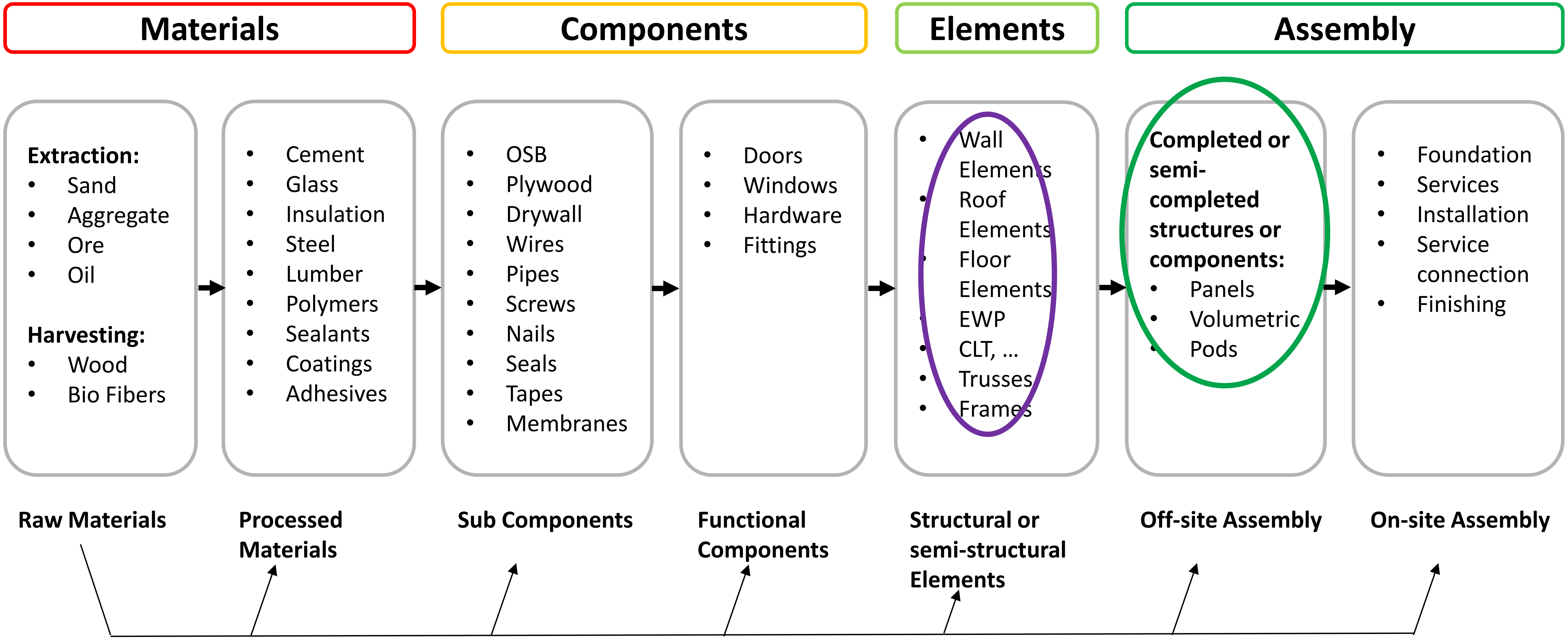
What prefabrication should be

Clarifying what Prefabrication should be:

- Prefabrication is **not** the continuation of the traditional process sequence in an controlled environment.
- Prefabrication includes the optimization of all processes in an controlled environment, optimizing ergonomics and productivity and eliminating high noise levels, dust, heavy lifting and other health and efficiency reducing factors.
- Optimized prefabrication processes have a balanced work flow, eliminating bottle necks!
- Every company will have different limitations. Optimizing the process means always getting the highest “quality to effort ratio” for each aspects of the process.

Author: Wimmers

Material flow of wooden prefabrication of buildings



Graphic, Author: Wimmers

woodSMART Canadian Wood Council Conseil canadien du bois

Material flow

- To minimize the need for storage space a different procurement process has to be applied than traditional construction
- On-time delivery can be practiced to some degree
- Standard design allows for faster flow and less storage space
- Custom design requires more on-time delivery (e.g. windows)
- Material should flow from storage to the stations with as limited as possible interference of production process

Smaller Prefabrication Company…

Photos: BC PASSIVE HOUSE, Wimmers

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Large Prefabrication Company

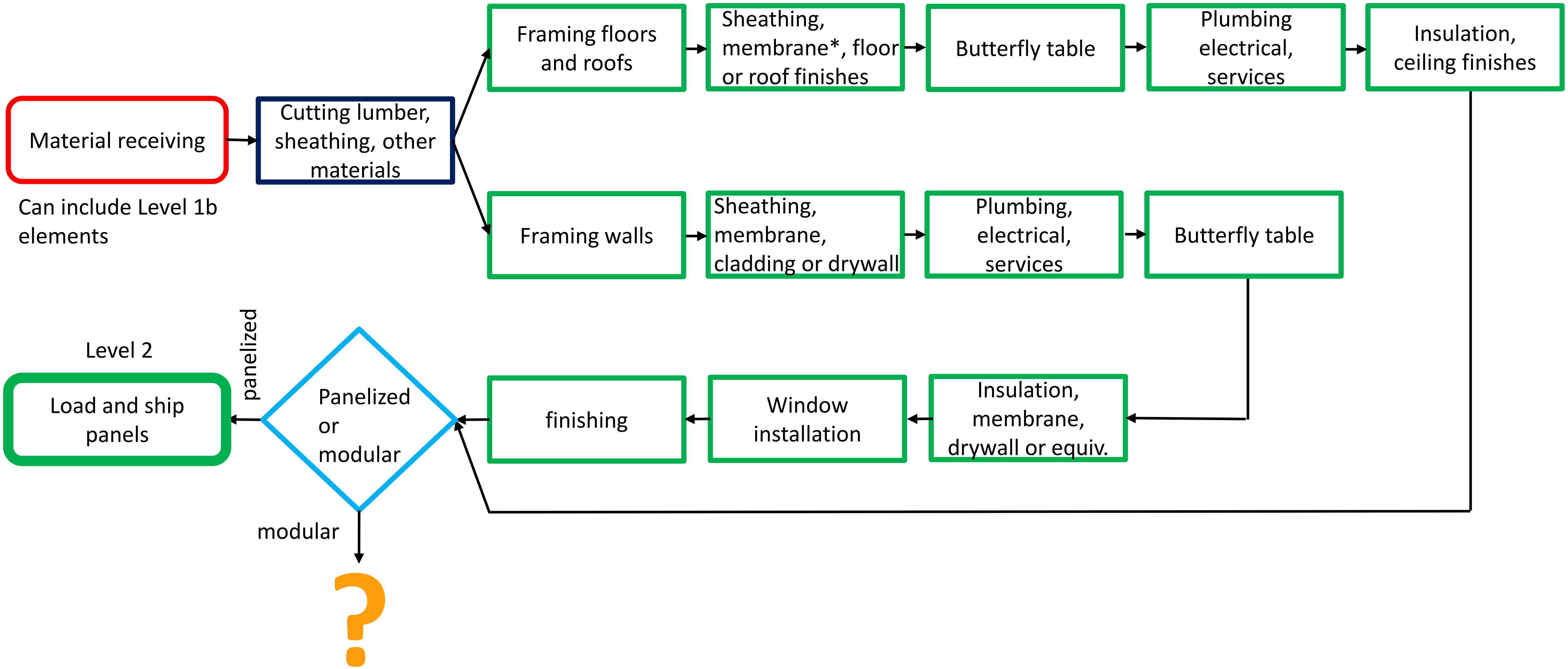
Photos: EXJÖHUS, Wimmers

woodSMART Canadian Wood Council Conseil canadien du bois

General Production Steps

- Cutting of materials
- Building structural system of panels
- Installing membranes and windows
- Installing electrical and plumbing services
- Installing insulation
- Preparing/finishing interior and exterior

Schematic Prefabrication Plant Layout



Graphic, Author: Wimmers

*if needed

Cutting lumber: Saw with Stop

BC PASSIVE HOUSE, Pemberton, BC

Photos: Wimmers

Cutting timber: Turbo Drive, Speed Cut or Robot Solo…

UNBC Prince George

HUNDEGGER Germany

Photos: Wimmers

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Mass Timber Panel Saws

RUBNER, Italy

HUNDEGGER, Germany

Photos: Wimmers

Stationary Framing Tables

SCHAFFERER Austria

HORIZON NORTH, Kamloops BC

Photos: Wimmers

Table moves panels

SCHLOSSER Germany

Photos: Wimmers

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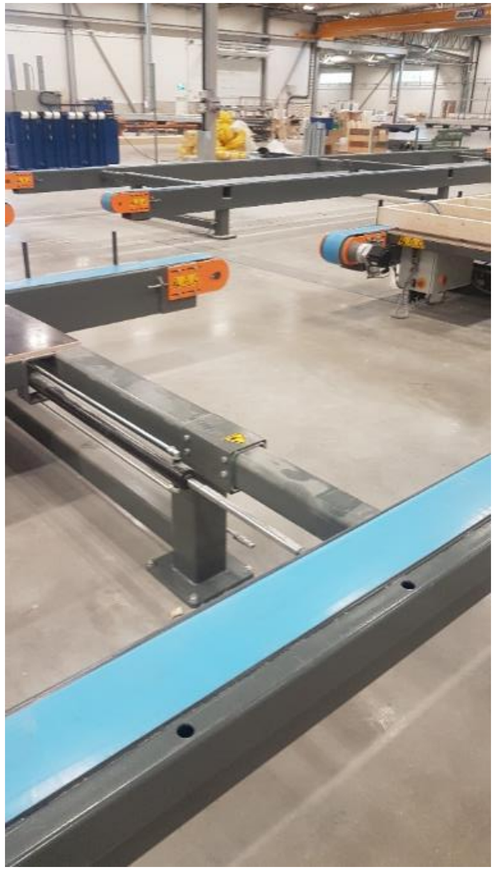
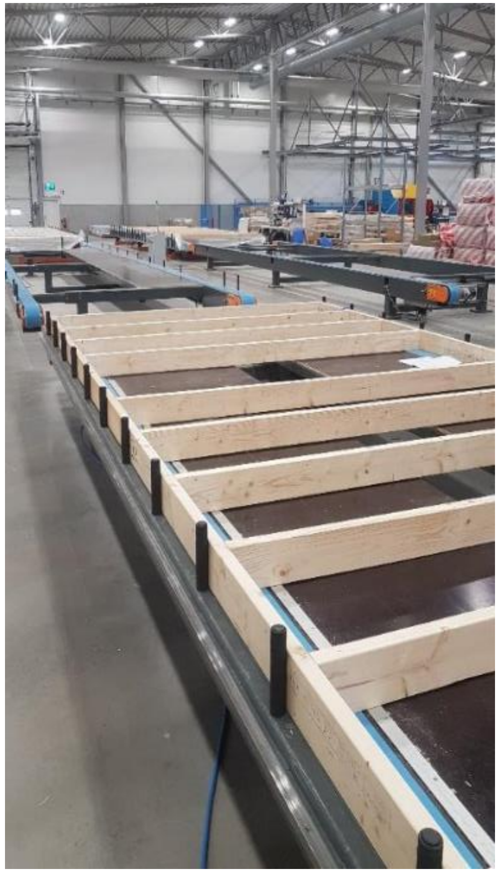
Adjustable tables with conveyer belt

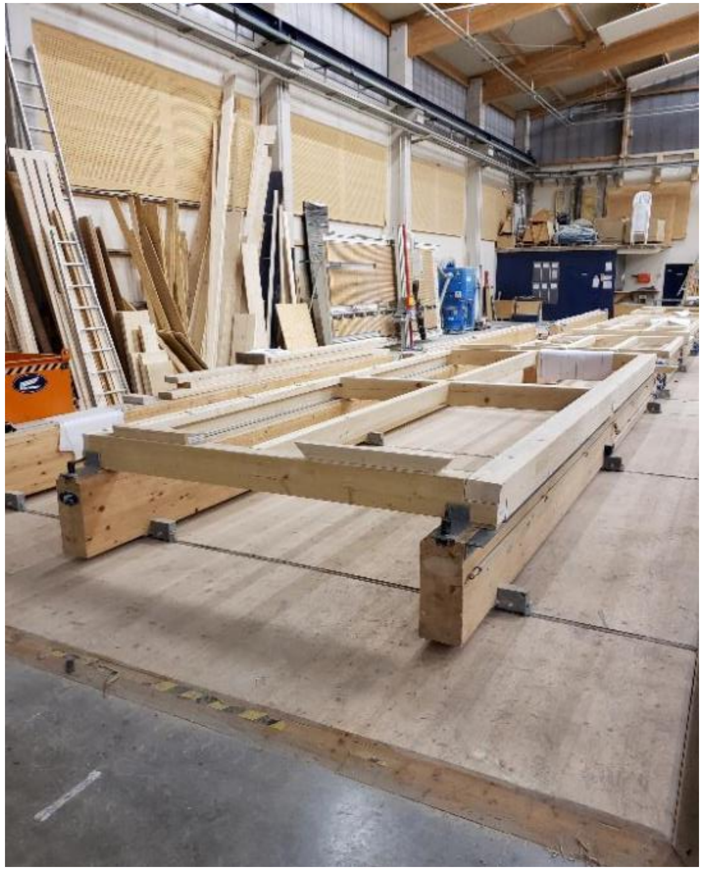




EXJÖHUS Sweden

Photo: Wimmers

Table moves with panel



SCHLOSSER Germany

Photos: Wimmers

Butterfly Tables

BoKlok Sweden

HOMAG Germany

Photos: Wimmers, HOMAG

BoKlug Sweden, HOMAG Germany
Photos: Wimmers, HOMAG

Nailing Bridge

EXJÖHUS Sweden

Photo: Wimmers

Automated production line

EXJÖHUS Sweden

MYRESJÖHUS Sweden

Photos: Wimmers

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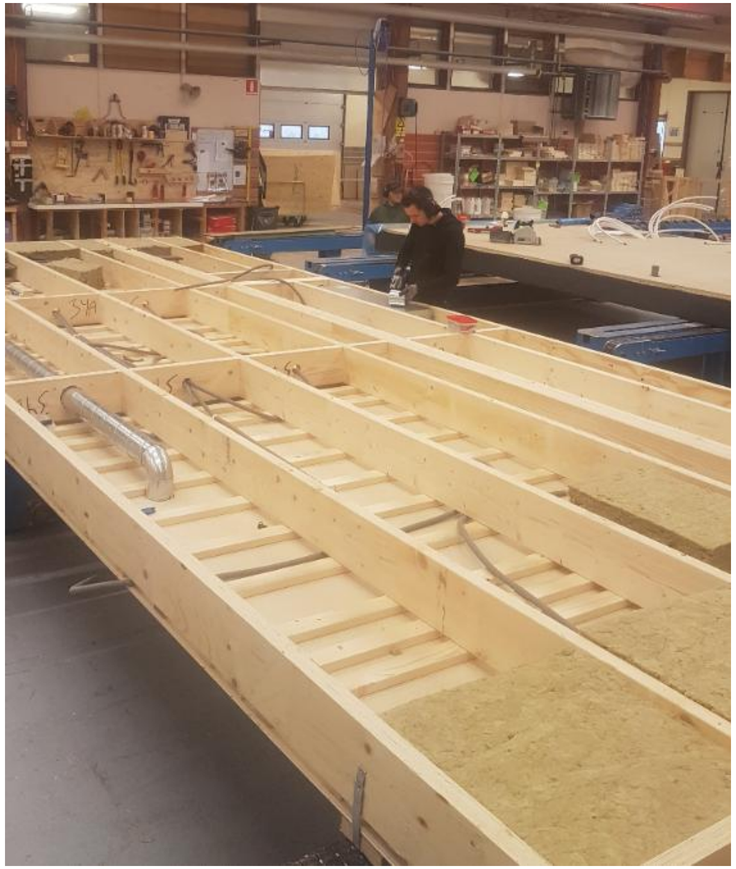
Robots

RANDEK Sweden

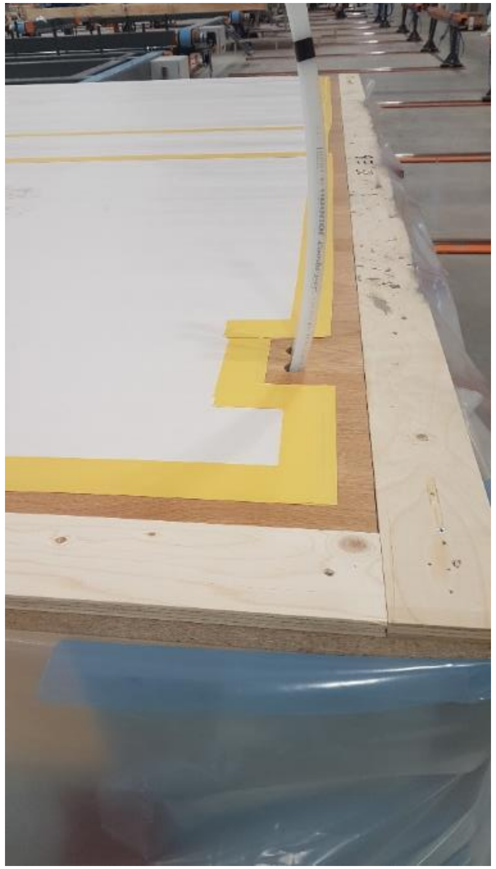
Photo: Butler

Roof and Ceiling Panels



BoKlok, Sweden

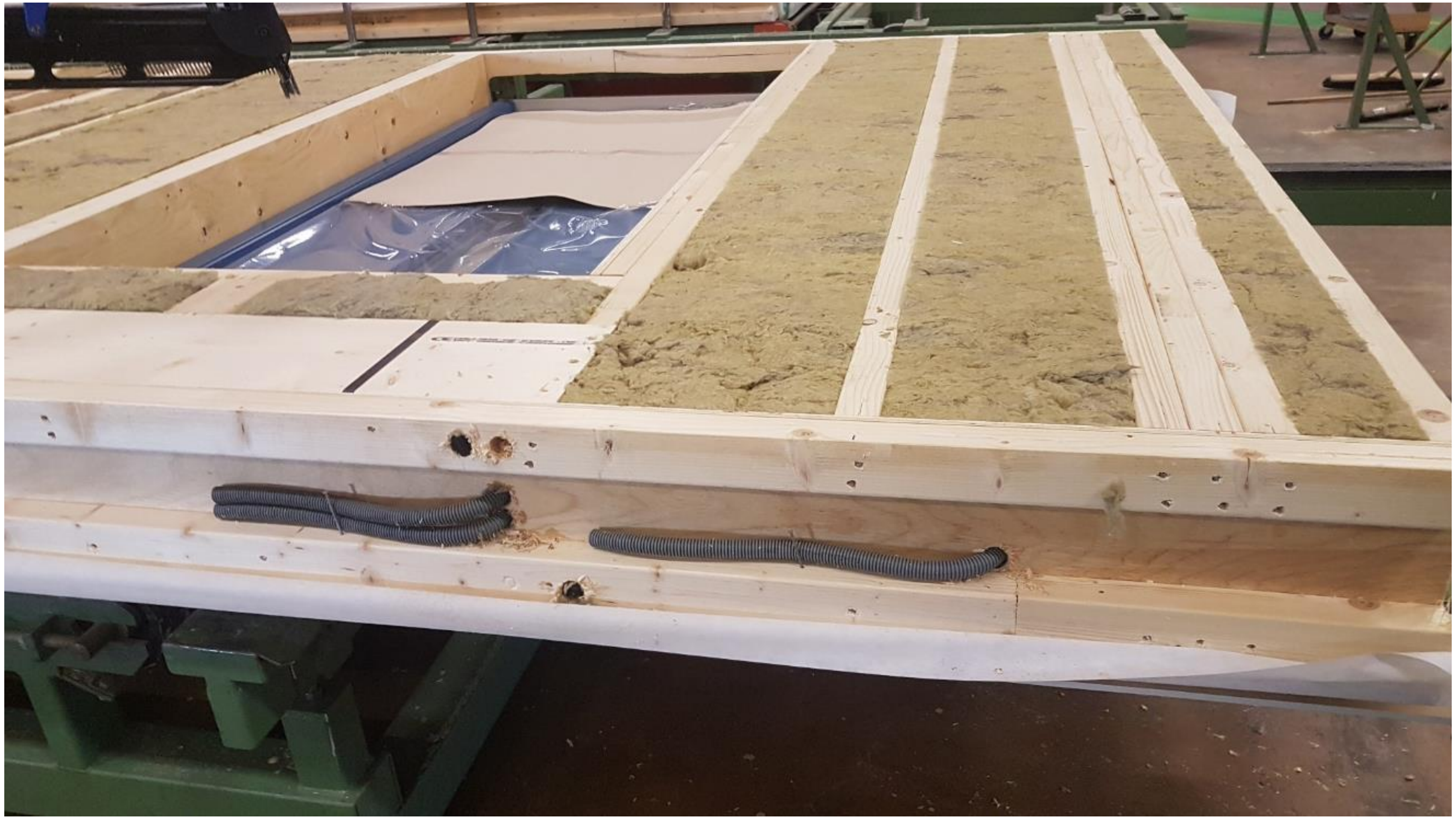
EXJÖHUS Sweden



EXJÖHUS Sweden

Photos: Wimmers

Wall Panel



MYRESJÖHUS Sweden

Photo: Wimmers

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Cellulose Application

SCHLOSSER Germany

Photo: Wimmers

Cellulose Application

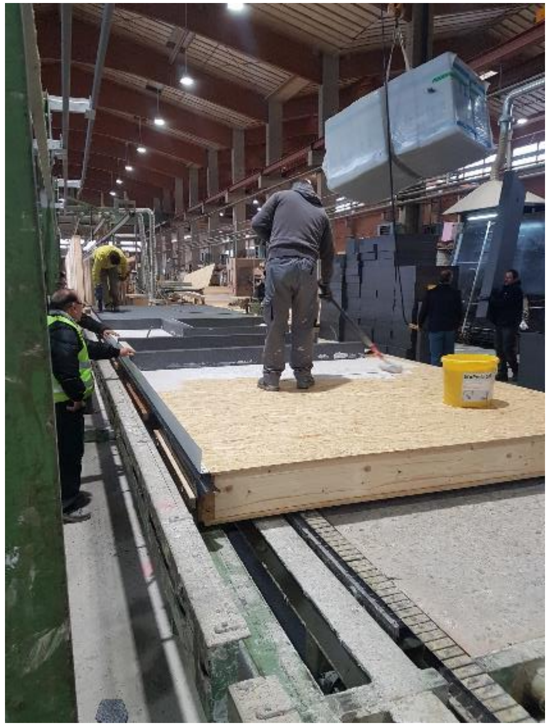
SCHLOSSER Germany

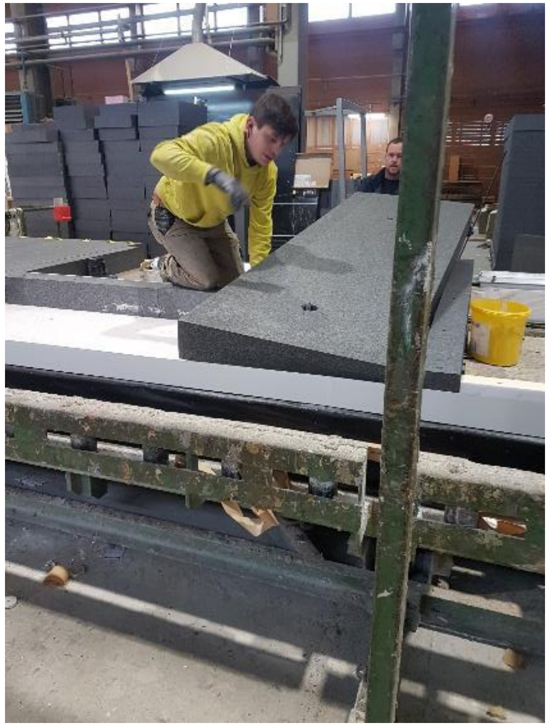
Photo: Wimmers

Canadian Wood Council
Conseil canadien du bois

Photos: Wimmers

Exterior insulation






ELK HAUS, Austria

Photo: Wimmers

Plaster (Stucco) and Wall Storage




ELK HAUS, Austria

Photo: Wimmers

Videos of production lines

Tibeco Wood House, simple production line (2min)

https://youtu.be/pDPVNkFeiQM

Elk Haus, more advanced production line (2:40min)

https://www.youtube.com/watch?v=V8OByy4GGdU

Weinmann, fully automated (3min)

https://www.youtube.com/watch?v=P1uvwwI29Qg

BoKluk production [IKEA] (6min)

https://www.youtube.com/watch?v=wgu7ZK894gs

BC Passive House Extension 2020 (1:20min)

https://www.youtube.com/watch?v=U7E3xxMSGPo

What could prefabrication look like?

1. So what are the changes in the design and engineering phase?
2. What is important to have for a well working production line?
3. What equipment is necessary and what is optional?

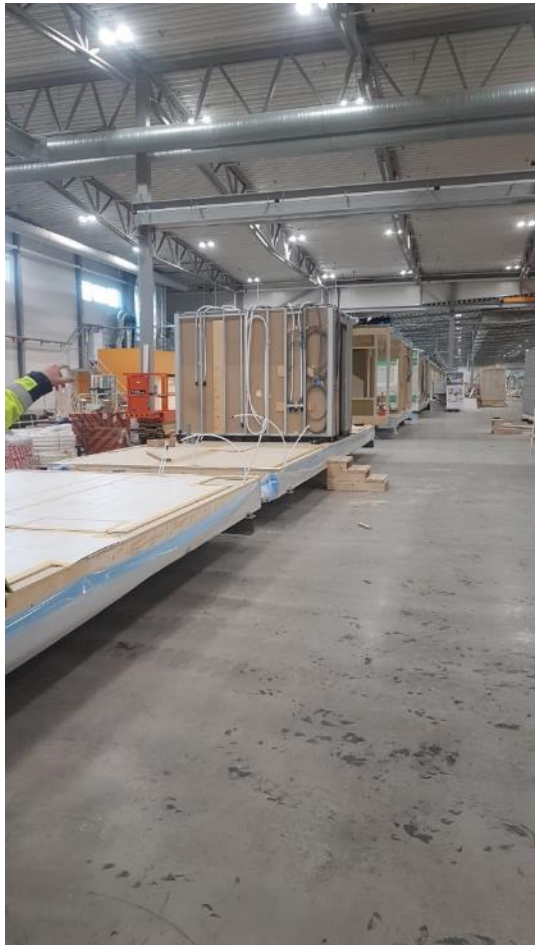
Lesson 3: Modular and Materials

- Production Process Pods
- Modular Production EU
- Modular Production CAN
- Materials

Pods Production

- ***Objectives:***
- structural system
- Installing all services
- Installing surfaces and finishes

Steel Pods



EXJÖHUS Sweden

Photos: Wimmers

Wood Pods

Video

Photos: Tjiko, Germany

Shipping and lifting

Photos: Tjiko, Germany

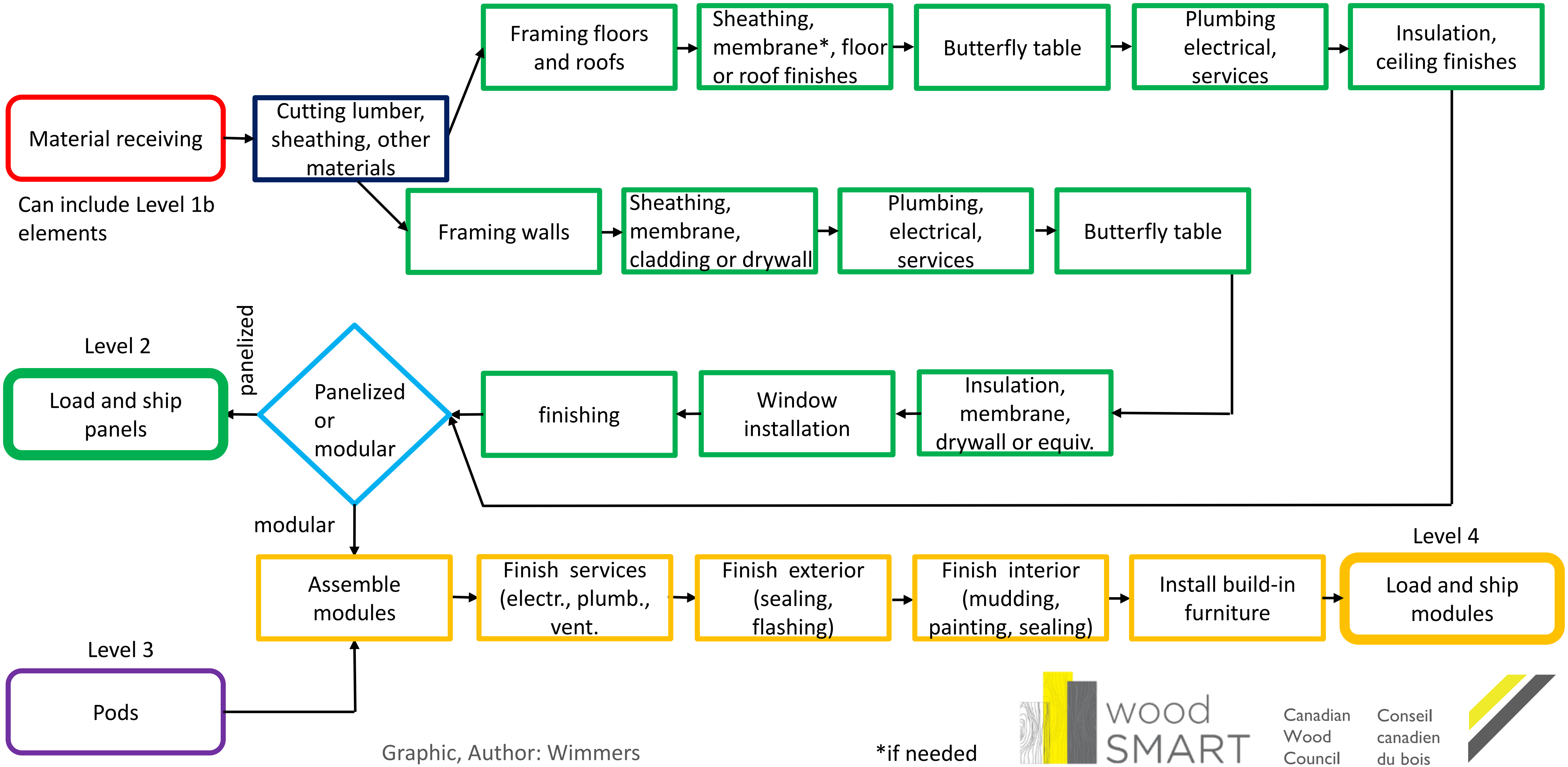
Pods installed

Photos: Tjiko, Germany, Wimmers

Modular Production EU

- ***Objectives:***
- Panel production
- Installation of all services
- Installation of panels to 3D structure
- Finishing surfaces as far as possible

Schematic Prefabrication Plant Layout



Graphic, Author: Wimmers

*if needed

wood SMART Canadian Wood Council Conseil canadien du bois

Installation of services

Photo: HOMAG

Modular as simple add-on to panel production

ELK HAUS, Austria

Photo: Wimmers

Services installed

ELK HAUS, Austria

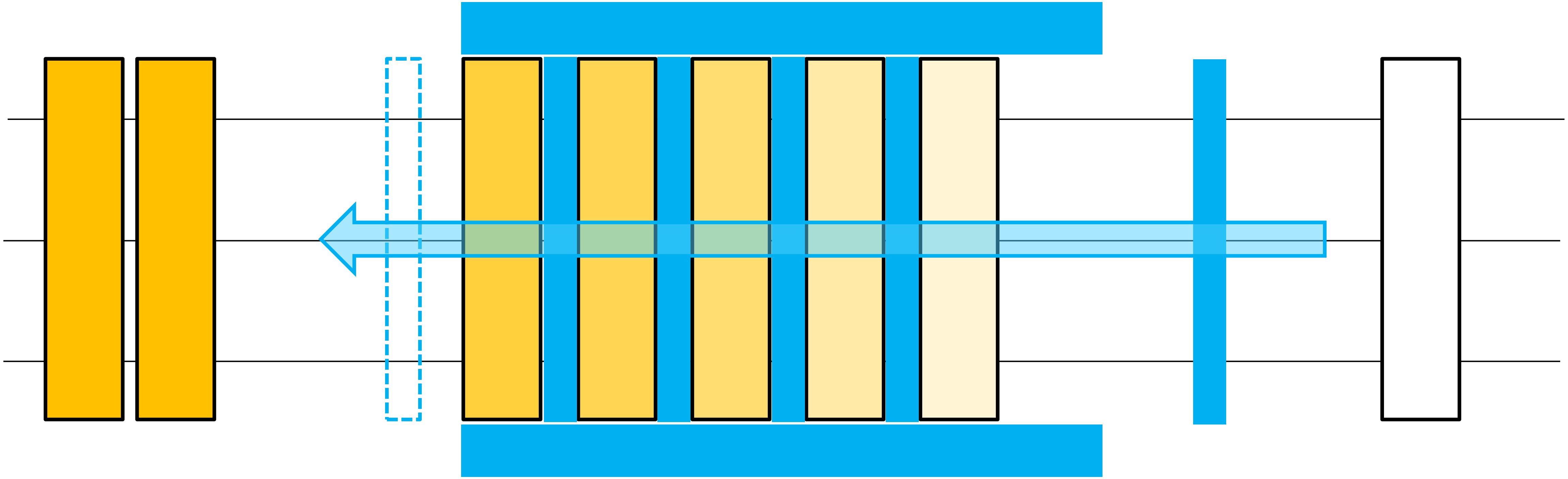
Photo: Wimmers

Hardwood floor installed

ELK HAUS, Austria

Photo: Wimmers

Modular finishing line perpendicular to the flow



Short term storage for finished modules

Multi stage finishing line, orientation of modules is perpendicular to the flow

First stage, assembly of prefabricated floor, walls and ceiling

Lifted traffic area (walkways and bridges)

Graphic: Wimmers

Wall panels added to floor

BoKlok, Sweden

Photos: Wimmers

Finishing line, perpendicular




BoKlok, Sweden

Photos: Wimmers

Modular finishing line linear to the flow

Short term storage for
finished modules

Multi stage finishing line, orientation of modules is perpendicular to the flow

First stage, assembly of prefabricated floor, walls and ceiling

Lifted traffic area (walkway)

Graphic: Wimmers

Finishing line, linear

EXJÖHUS Sweden

Photos: Wimmers

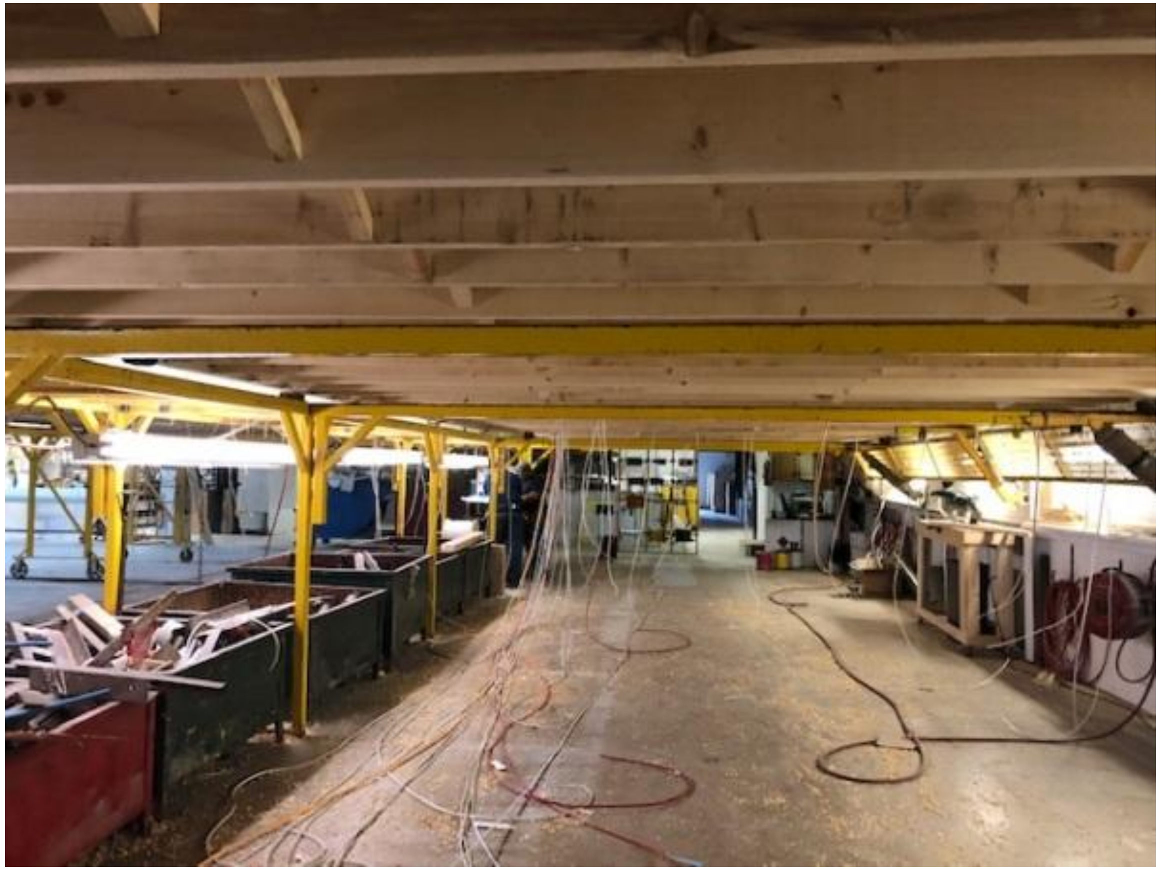
Modular Production CAN

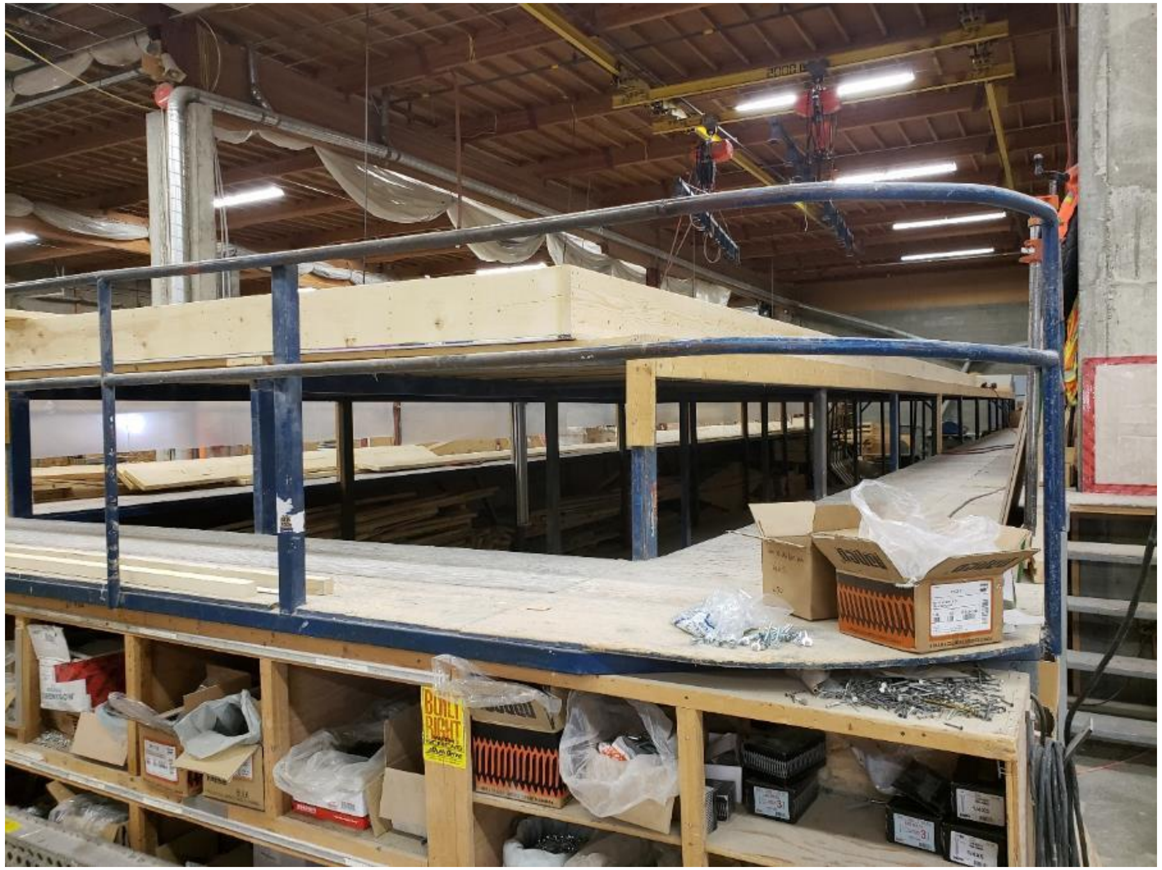
- ***Objectives:***
- Building structural system of panels
- Installation of raw framing to 3D structure
- Installing membranes, occasionally windows and potentially installing insulation
- Preparing/finishing exterior

Modular Construction

Photos: Koo, Wimmers

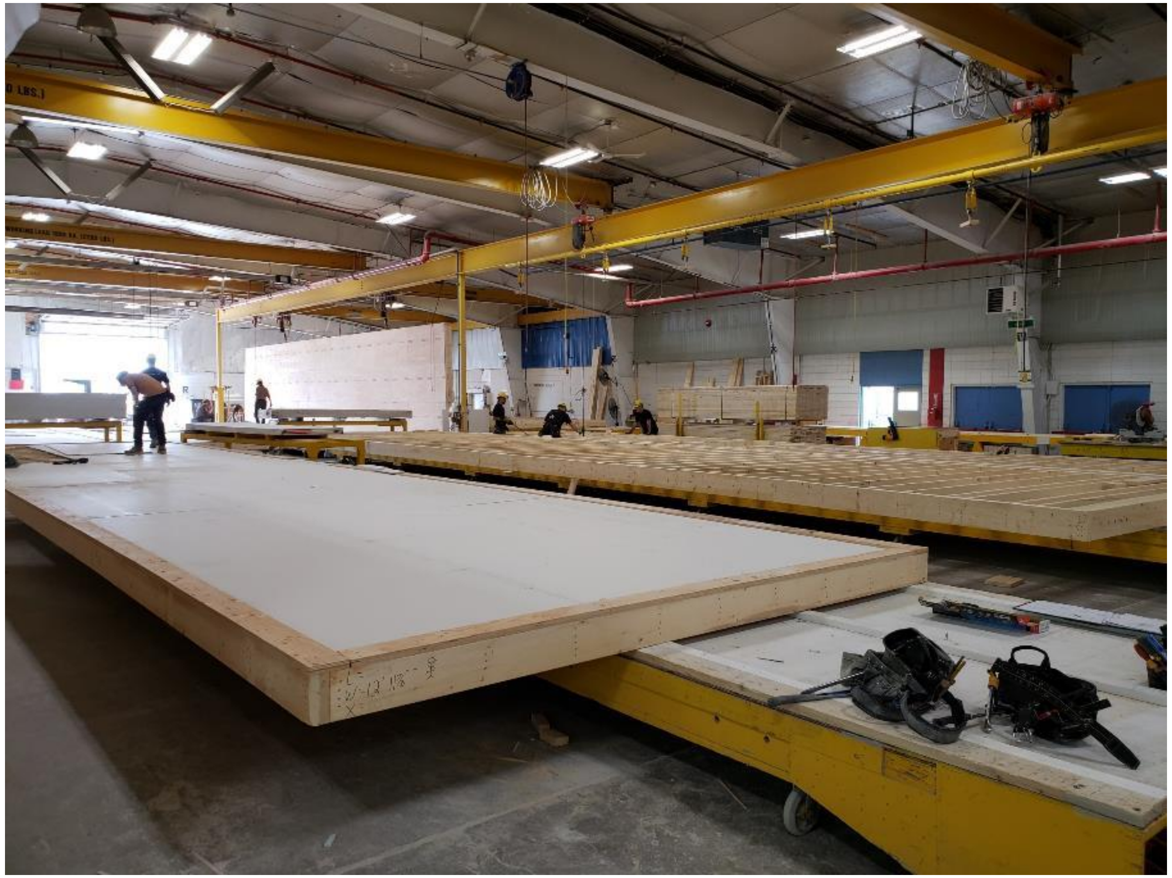
The Ceiling Rig, a typical North American method





Photos: Koo, Wimmers

Crane to flip panels



Photos: Wimmers

Construction as usual

Photos: Koo

Construction as usual




Photos: Koo

Automated production line

Photos: Koo

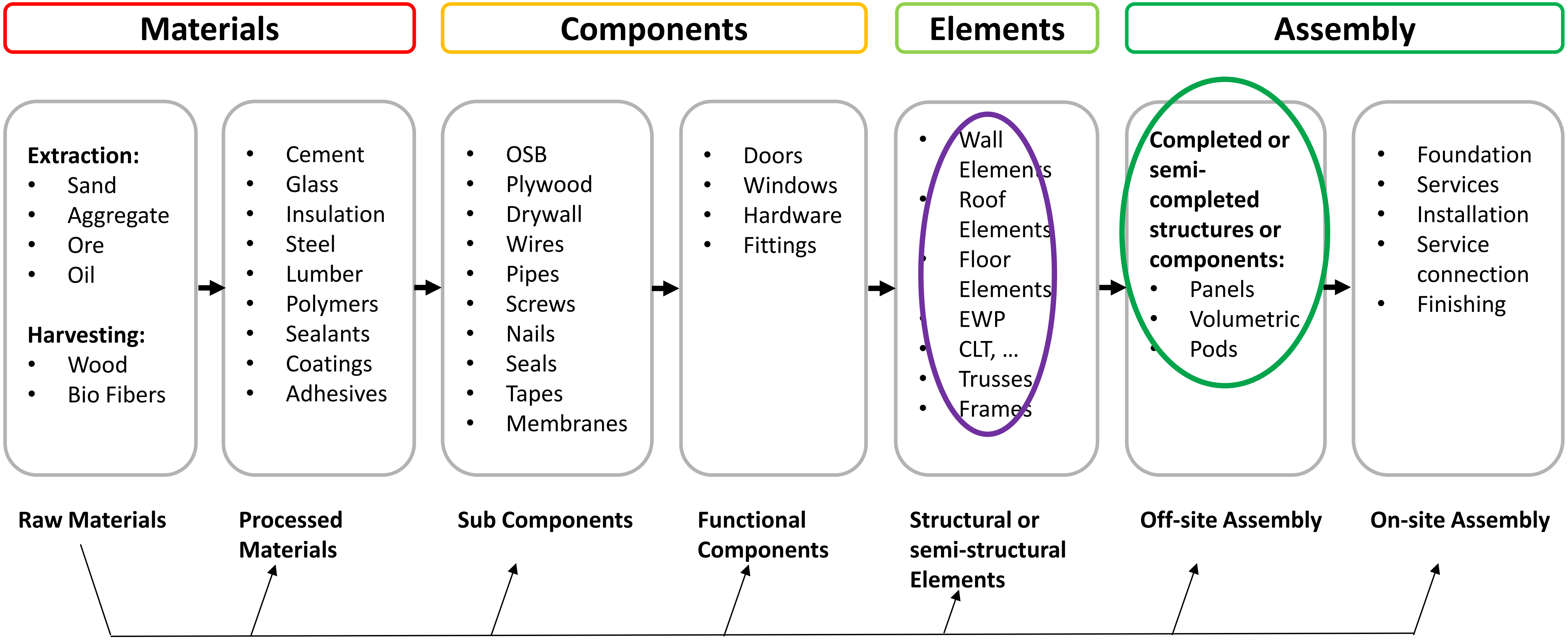
What are the next steps?

1) Where can the Canadian prefab industry increase their productivity?
2) What will be the consequences of an efficient prefabrication industry? (positive and negative)
3) What will happen to traditional builders?

Materials (45min + 5min Q&A)

- ***Objectives:***
  - Analyze the principal changes in material choices of envelope assemblies for prefabrication
  - Compare and rank airtight materials, membranes and tapes for suitability in prefabrication
  - Discuss building science related consequences of material choices in optimized prefabrication
  - Discuss the potential problems resulting of the lack of dimensional stability of dimensional lumber in automated production lines
  - Explore suitability of engineered wood products (EWP)
  - Summarize of plausible material changes in prefabrication

Material flow of wooden prefabrication of buildings



Graphic, Author: Wimmers

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Materials

- Several materials, depending on the level of prefabrication, have to be ordered, stored, and installed in the facility:
  - Lumber and sheathing
  - EWPs
  - Fasteners and connectors
  - Membranes (ext. and interior) and tapes
  - Windows
  - Insulation
  - Cladding
  - Electrical material
  - Plumbing material
  - …

Lumber Requirements

- The requirements for lumber used in prefabrication vary with the level of automation introduced to the process.
- For best results humidity of lumber should be always close to the equilibrium humidity of the final project's location, typically <12% at the core (not surface!).
- Keep in mind that the equilibrium humidity in dry or cold climates can be very different (e.g. Prince George ~5-6%).
- Dimensional stability and precision is crucial and gains importance the more automation is introduced into the project.

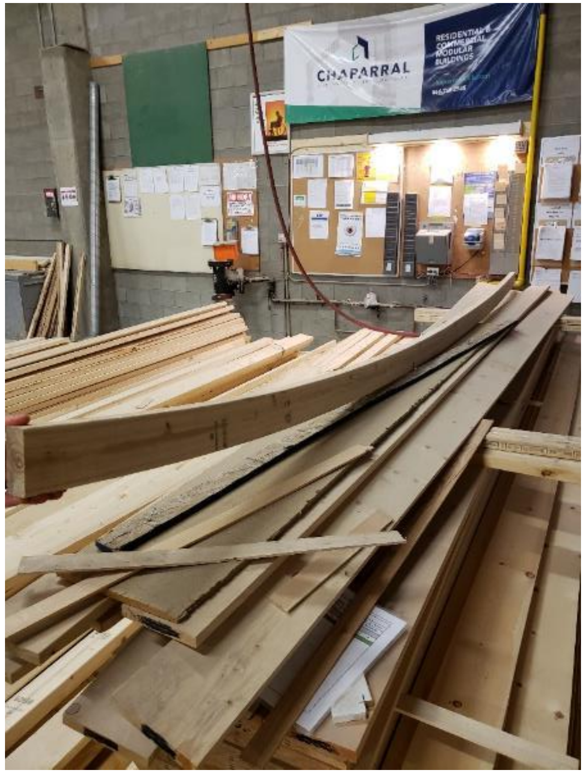
“Dimensional” Lumber

- **Advantages:**
- Availability of lower grades
- Very cost efficient*, minimal knowledge and skill level necessary
- **Disadvantages:**
- Small width of 38 mm results in small distances between studs and only very small screw sizes can be used
- Potentially very low dimensional stability (grade #2), lots of warping, twisting and bending
- Low dimensional consistency and stability, therefore limited use for automation
- Inconsistent and occasionally relatively high humidity levels

* Until summer 2020, future remains to be seen

The Lumber Issue

- Dimensional lumber can be used for prefabrication if it is not perfectly straight!
- Slight inaccuracies can be tolerated as long as the process is mainly manual and not much automation is integrated.
- Inaccuracies of dimensional lumber can cause lower quality and higher labour costs (to force material into position).
- Dimensional lumber #2 will usually have a relative high percentage of rejects (increasing handling, storage and shipping costs)
- So-called dimensional lumber #2 is to a large extend not dimensionally stable and can only be used very limited for prefabrication (the quality of locally available lumber might vary significantly)



Author: Wimmers

Need for Engineered Wood Products

- EWPs have the advantage of superior precision and low humidity compared to dimensional lumber
- EWPs can be ordered and used for much larger spans
- EWPs can handle much higher structural loads
- Mixing EWPs with dimensional lumber can create challenges as the standard dimensions in North America are different for both products (e.g. 2x10 is 38mm x 235mm [1 ½ x 9 ¼], an equivalent LVL is 44.4mm x 241.3mm [1 ¾ x 9 ½])

Post & Beams (1D)

- Glulam
- I-beam
- Laminated Strand Lumber
- Oriented Strand Lumber
- Parallel Strand Lumber
- …

Glulam

- **Advantages:**
- High structural strength and dimensional very stability
- More efficient use of forest resource
- Product can be mass produced
- Consistent pricing over volume for variable dimensions
- Many wood species can be used
- Various structural and architectural qualities can be produced
- Suitable for automation

Author: Wimmers

Glulam (continue)

- **Disadvantages:**
- Relatively expensive manufacturing process, even if highly automated
- Significant financial investments needed to produce in large volumes including automated sorting machine, finger jointer, glue applicator, high frequency kiln, press and planer

Author: Wimmers

I-Beam (I-Joist)

- **Advantages:**
- Very cost-efficient product,
- Structurally extremely efficient
- Light and easy to handle on site
- Dimensionally stable
- **Disadvantages:**
- Very low fire resistance
- Sensitive to moisture damage
- High glue content

Author: Wimmers

Laminated Strand Lumber (LSL)

- **Advantages:**
- Very cost-efficient product
- Dimensionally stable
- Uniform material
- Only small diameter trees needed
- Uses several different species
- **Disadvantages:**
- Lower structural strength than LVL
- High glue content
- Very sensitive to moisture

Author: Wimmers

wood SMART

Canadian Wood Council

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Oriented Strand Lumber (OSL)

- **Advantages:**
- Very cost-efficient product
- Only small diameter trees needed
- Uses several different species
- **Disadvantages:**
- Lower structural strength than LSL
- Very sensitive to moisture,
- High glue content

Parallel Strand Lumber (PSL)

- **Advantages:**
- Very high structural strength (strongest EWP)
- Homogenous performance
- Visually appealing
- Only small diameter trees needed
- Relatively low sensitivity for moisture
- Very good for pressure treatment
- **Disadvantages:**
- Relatively high glue content (lower than OSB and LSL)
- Sensitive to liquid water

Author: Wimmers

Panels and Boards (2D)

- 3-Ply
- Plywood
- Oriented Strand Board
- Laminated Veneer Lumber
- Nail Laminated Timber
- Cross Laminated Timber
- Nail Cross Laminated Timber
- Dowel Laminated Timber
- Dowel Cross Laminated Timber
- …

3-Ply

- **Advantages:**
- Dimensional stable, shrinkage is effectively eliminated
- Structurally strong
- Number (always odd) and thickness of layers is flexible
- Low glue content and excellent air tightness if joints are properly sealed
- **Disadvantages:**
- Manufacturing less efficient than plywood as lamellae are sawn and not peeled
- Currently not produced in Canada

Photo: DATAHOLZ

Plywood

- **Advantages:**
- Dimensionally stable, shrinkage effectively eliminated
- Structurally strong
- Number of layers (always odd) and thickness of layers (<7mm) is flexible
- Medium glue content and good air tightness if joints are properly sealed
- Can be used as airtight layer and vapour retarder
- **Disadvantages:**
- Relatively high price
- Deciduous boards even higher price

Photo: HOME DEPOT

Author: Wimmers

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Oriented Strand Board (OSB)

- **Advantages:**
- Very low price
- Lightweight
- Fasteners holding strength is high close to the edge
- Excellent air tightness if joints are properly sealed
- Only small diameter trees needed
- Uses several different species
- **Disadvantages:**
- Slightly less strong than plywood
- Sensitive to liquid water
- High glue content

Photo: DATAHOLZ

Author: Wimmers

Laminated Veneer Lumber (LVL)

- **Advantages:**
- Cost efficient
- High structural strength
- Can be visually very appealing
- Less sensitive to moisture
- Versatile application
- Can be used as board or as beam
- **Disadvantages:**
- Slightly more difficult to cut, hard on blades

Photo: CWC

Photo: POLLMEIER

Author: Wimmers

Nail Laminated Timber (NLT)

- **Advantages:**
- Very simple production process
- Relatively high fire rating possible, charring used as protective layer
- One of the most cost efficient option of mass timber panels
- Suitable for automation
- Boards can be profiled before nailing to create acoustic ceiling
- **Disadvantages:**
- Spans only one directional, potentially needs additional sheathing for lateral loads
- Very moisture sensitive, panel can swell perpendicular to the span
- Cutting limited due to nails

Photo: STRUCTURECRAFT

Author: Wimmers

Nail Cross Laminated Timber

- **Advantages:**
- Very simple production process
- Low quality lumber can be used in the mid layers
- Dimensionally exceptionally stable and relatively moisture resistance
- Can be machined with CNC (if aluminum or wood nails are used)
- Performs well and predictable in case of fire due to charring layer
- **Disadvantages:**
- Only used for walls
- Limited lateral stiffness

Photo: HUNDEGGER

Cross Laminated Timber (CLT)

Photo: DATAHOLZ

- **Advantages:**
- Low grade lumber can be used in the middle layers
- Spanning (to some degree) in two directions possible
- Offers significant lateral stiffness and carries high loads
- Dimensionally exceptionally stable and relatively moisture resistance
- Can be machined with CNC
- Performs well and predictable in case of fire due to charring layer
- **Disadvantages:**
- Higher production costs compared to NLT and DLT
- Lumber shall have consistent m.c. of ~12%
- Less strong in main axis compared to NLT, DLT or glulam on flat when used as floor

Author: Wimmers

Dowel Laminated Timber (DLT)

Photo: SOHM

- **Advantages:**
- Simple production process
- Suitable for automation, can be fully CNC machined
- Boards can be profiled before dowelling to create acoustic ceiling
- Best environmentally performing mass timber product as no glue or metal is required
- Performs well and predictable in case of fire due to charring layer
- **Disadvantages:**
- Spans only one directional and might need additional sheathing for lateral loads
- Panel width limited by dowelling technology (currently up to 1.2m)
- Very moisture sensitive due to swelling perpendicular to span, better if diagonally doweled

Author: Wimmers

Cross Dowel Laminated Timber

- **Advantages:**
- Simple production process
- Suitable for automation, can be fully CNC machined
- Best environmentally performing mass timber product as no glue or metal is required
- Performs well and predictable in case of fire due to charring layer
- **Disadvantages:**
- Only used for walls
- Limited lateral stiffness

Photo: HOLZ 100

Other EWPs

- Wood Trusses and Nailing Trusses
- Box Beams
- Kielsteg

Wood Trusses, Nailing Trusses

- **Advantages:**
- Very simple production
- Structurally very efficient, light
- Can be assembled manually or with a high level of automation in a truss plant
- **Disadvantages:**
- Nailing Trusses are very poor performance in case of fire if not further protected as nailing plates become soft very quickly. Wood Trusses are slightly better
- For larger trusses additional bracing necessary during lifting and throughout installation

Photo: HOMEADVISOR

Photo: TRIFORCE

Author: Wimmers

Box Beam

- **Advantages:**
- Relatively simple and cost-efficient manufacturing process
- Flexible system with multiuse of cavity, small and light segments possible
- Predictable in case of fire, thickness of boards can be increased to increase fire safety by adding additional charring layer
- **Disadvantages:**
- Limited level of prefabrication possible, still several labor steps on site necessary
- Width of beams is limited by maximum width of boards available, hence relatively small size and large number necessary to build floor

Photo: LIGNOTREND

Author: Wimmers

wood SMART

Canadian Wood Council

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Kielsteg

- **Advantages:**
- Excellent strength to weight ratio
- Very large spans possible (up to 27m or even 35m)
- Very light and efficient system
- Relatively simple production process
- **Disadvantages:**
- Medium fire performance without further protection
- When used as floor, vibrations and serviceability might become a concern due to very light weight
- Proprietary system

Photo: KIELSTEG

Materials

1. What are the upcoming challenges regarding the manufacturing and use of EWPs?
2. Is the Canadian industry well prepared for this shift?
3. Besides higher quality, why is switching from resource extraction to value added manufacturing beneficial for the Canadian forest industry?
4. Why did it not or only very seldom happen over the last 25 years?

Lesson 4: Pros & Cons and Case Studies

- Construction Site
- Pros & Cons
- Case Studies

Construction Site

- ***Objectives:***
  - Identify elementary steps of construction site preparation
  - Generate strategies for transportation
  - Discuss basic rules for installation process
  - Identify size, type, access and location of crane
  - Compare several structural connection systems for prefabrication
  - Develop strategies to protect building during construction from unfavourable weather
  - Discuss the durable implementation of weather, vapour and air barriers

Installation

Video

How to build successfully a house in 8 hours:

- Production in prefab facility to high level of accuracy including preparation of all structural and service connection
- Preparation of foundation to the same specs and dimensions of the prefab package
- Position the right size of crane (reach and load capacity) in the best possible position
- Experienced and well trained (in prefab install) crane operator
- Accessibility for delivery truck
- Experienced and well trained (in prefab install) installation crew
- Some luck with weather (rain and wind)

Author: Wimmers

Site preparation

- Foundation and/or basement to be installed during prefabrication time
- High 3D accuracy necessary for proper transition between materials
- Preparation for installation simultaneous to prefabrication to ensure readiness when panels or modules are finished
- Area for delivery trucks for unloading required
- Area for crane (if not mounted to delivery truck) required
- Crane has to get close enough to installation site
- If necessary install tower crane including power line

Shipping horizontally loaded

Photo: Koo, QUALITY HOMES, Canada

Shipping

Photo: NASS TRANSPORTE, Germany

- Load must be secured against movement, wind and moisture
- Panels allow much higher shipping density then volumetric
- Generally, all panels are loaded upright
- Load and deliver according to installation sequence

Installation with crane



Photos: Fertighau.com, ZIMMEREI OCAK, Germany

- Telescopic mobile crane or truck mounted cranes can be used for small and medium size projects, depending on weight of panels. The installation of a tower crane is preferred if a large or tall building has to be installed.

Author: Wimmers

Special lifting equipment

- Crane type, reach and capacity
- Additional equipment such as spreader bar and lifting clamps
- Staging area for trucks to stop and crane to lift
- Just-in-time delivery (assuming storage and space requirements)
- Sequencing of lift
- Temporary bracing if needed
- Awareness of wind
- Protection against rain

Photo: PITZL panel lifting device, Germany

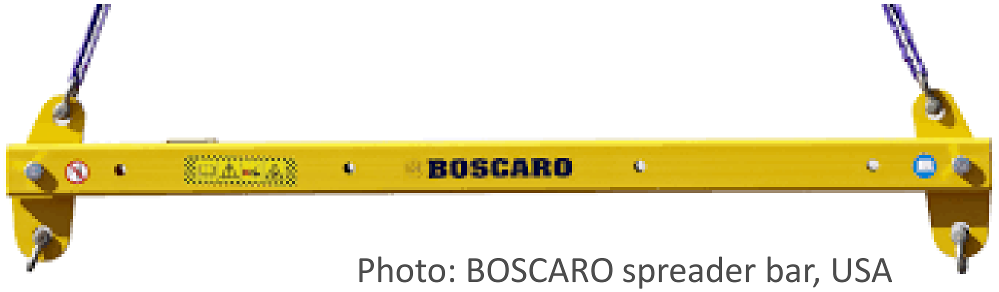

Photo: BOSCARO spreader bar, USA

Panel to panel connection systems

- Structural wood screws
- Hex bolts
- Specialty connectors such as Knapp or Pitzl

Photo: GRK screws, Germany

Hex bolts

Photos: Wimmers

Small and medium steel connectors

Photos: Wimmers and KNAPP Germany

Heavy duty connectors

Photos: Wimmers

High strength aluminum connectors

Photo: PITZL Germany and HERMANN FRAME Ottawa

Protection of prefabricated panels or modules

- Prefabricated panels or modules have to be handled very carefully and should not experience any larger mechanical force, other than transportation and lifting
- If finished surfaces (e.g. drywall or visible wood surface) are installed, be extra careful to not allow mechanical (forklift, hammer, drill), moisture (rain) or chemical (glue, solvent, paint) damage
- Any cutting or grinding of metal in proximity of prefabricated panels is to be avoided
- Floors, facades and walls can/should be secured with protective layer during installation
- Preinstalled glazing has to be handled extra carefully

Author: Wimmers

Weather protection

- During the installation, the structure should be protected from moisture as well as possible
- Small buildings usually wait for a day without rain
- Large buildings might have to temporarily protect the structure from rain
- A short shower on glulam or CLT is not necessarily a big concern
- Wet insulation is a concern as the drying out time is usually longer
- If rain cannot be avoided, the installation of insulation, services and finishes might have to be moved to the building site or the panels have to be well enough protected to avoid penetrating humidity
- If water has penetrated the insulated wall cavities, drying out should be accelerated by ventilation and potentially heat as much as possible
- Generally, wood can get wet. It can't stay wet.

Weather tight Facade

- After the envelope panel is installed and structurally secured, the most important step is to seal the weather barrier on the outside to avoid the penetration of liquid water and to secure the insulation layer.
- The transition from panel to panel, horizontally and vertically have to be sealed.
- This can be done by accessing the panel from the outside, or by design, if appropriate gaskets have been designed and installed so that no access from the outside is required. This solution is certainly preferred for mid- and high-rises.

Airtightness

- After the envelope panel is installed, structurally secured, the weather barrier is sealed and all services are connected, the next important step for the envelope is to seal the airtight barrier*, typically in conjunction with the vapour barrier.

**The airtight barrier should always be on the warm side to avoid long-term damages. Please see CWC module on building science for wood structures.*

Pros and Cons

- ***Objectives:***
  - Summarize the general advantages and disadvantages of traditional construction and prefabrication
  - Compare panelized and modular prefabrication
  - Qualitatively assess the improvement potential in modular construction in Canada
  - Evaluate cost implications of accelerated construction processes.
  - Estimate the general economic opportunities of prefabrication companies
  - Evaluate the specific economic opportunities of prefabrication companies located in rural areas

Advantages of off-site

Video

- Prefabrication offers a variety of advantages, some of them are explained in the video (click upper left corner) by John Boys of Nicola Logworks in BC. John and his team were in charge of the installation of several larger mass timber buildings, such as the Wood Innovation Design Center in Prince George or the Earth Science Building at UBC.

Preconditions for successful adaptation of prefabrication in the Market…

The Market has to:

- Overcome prejudices
- Be educated and demand quality
- Follow a rigorous Building Code
- Be ready for energy efficient buildings (step code 4-5 and PH)
- Request cost certainty
- …

Author: Wimmers

Advantages of Prefabrication

- Better cost control
- Better quality control
- Faster on site – and overall
- Less impact on environment/traffic
- Climate independent
- More efficient use of labor
- Healthier, safer workplace
- More efficient use of materials -> less waste, less transportation costs
- …

Vandalism and theft

- Construction period and therefore exposure to potential criminal activity is much shorter than traditional construction
- If seen necessary, security guards can be hired for a much shorter period
- Closing building against access is potentially already possible on the first evening
- As less work steps are done on site, much less material is stored on site
- As less work steps are done on site, fewer tools are needed on site

Fire safety

- Panels are potentially already cladded with fire resistant layers, e.g. drywall, minimizing the risk of fire on site drastically.
- During construction on site one side open wall structures are exposed for a much shorter time span, minimizing the risk of fire.
- Mass timber panels, post and beams can already be pretreated if necessary.
- Be careful regarding fire spread in modular construction as potentially cavities between modules (horizontally and vertically) allow hot gasses to travel if not sealed properly. If structure is built with modules each wall has two layers and each horizontal layer has typically a floor and a ceiling.

Airtightness

- Further advanced designing of details allows for more precise solutions
- Pre-manufacturing process allows for smaller tolerances
- Materials to seal can be easier applied and taped to each other
- Installation of gaskets around panels possible on tables

Workers health and safety

- Ergonomically optimized workspace (tables)
- Mechanical help for lifting (cranes)
- Less tripping hazard (no materials and less cables on floor)
- Fewer falling items (no one works above)
- Better sound protection possible (machines can be muffled)
- Better dust and fumes control (dust and fume extraction)
- Climate optimized for good working conditions (temperature, humidity, draft)

Productivity

- Ergonomically optimized workspace
- Mechanical help for lifting
- Overall good working environment
- Optimized work stations with appropriate machinery
- Spare parts always available
- Optimized material flow and storage
- Short distances to retrieve parts or materials
- Materials always available

Author: Wimmers

Optimized use of materials

- Optimized planning allows for more efficient use of materials
- Cut offs are reused for other parts, resulting in very small waste production
- Waste can be sorted and recycled or reused for other applications
- Very little remaining waste production on site
- Modular construction uses double walls and floors/ceilings. Generally there is a risk that this reduces the efficiency of material usage

Specifically the first statement became much more important in recent time.

The price of lumber increased from spring 2020 to spring 2021, depending on where you are located by 300-400%. One 8ft 2x4 rose from ~2.5 CAD to 8-10 CAD.

Reducing waste in the production/construction process becomes a crucial factor and can help to balance price increases to some degree.

Author: Wimmers

Shipping

- As there is very little remaining waste production on site, less material has to be shipped to the site and less waste has to be removed from the site
- The materials necessary for the production are shipped in larger amounts to the production facility
- Both effects together are resulting in a reduction in trucking, generally prefabrication reduces shipping costs
- A potential exemption are modular constructions as the shipping from the factory to the construction site is very inefficient and can only be justified in specific situations

Author: Wimmers

Impact on the surroundings

- Shorter construction period
- Less noise
- Less dust
- Less traffic infringement
- Potentially short term road closure due to large crane

Author: Wimmers

Pros and Cons

Advantages

- Higher quality control
- Cost control
- Productivity increased
- Systematic approach (potentially shorter lead time)

Challenges

- Historical and probably justified negative perception of quality (clients and architects)
- Costs of land for facility (capital costs)
- Investment in equipment (capital costs)
- Highly detailed design required (BIM highly advisable)
- In transition period potentially longer lead time
- Higher upfront costs

Author: Wimmers

Pros and Cons

Advantages

- Productivity
- Consistent labour force
- Automation possible
- Healthy and ergonomically optimized production
- Waste reduction

Challenges

- Labour and skills shortage
- Trade schools have not educated in this field over the last 20 years
- Finding educated /skilled/trained labor
- Architects and Engineers only limited educated in this field
- No local equipment available

Author: Wimmers

Pros and Cons

Advantages

- Seldom change orders due to advanced planning, BIM and virtual models
- More efficient transportation
- Less noise, dust and traffic on site
- Far shorter construction time on site
- Smaller risk for fire and theft

Challenges

- Change orders are usually very expensive
- Potentially large shipping distances
- Crane needed
- Site Inspections
- Highly detailed design required (BIM highly advisable)
- Perceived quality

Author: Wimmers

Discussion volumetric

inherent disadvantage of volumetric construction:

- all walls and floors/ceiling are double
- potential gap between the walls and floor to ceiling can increase the risks of hidden channels allowing fire and smoke to travel

volumetric construction has an advantage if:

- large number of similar or identical modules are requested
- installation speed on site has to be extraordinary high (> 1 floor per day).
- well engineered the potential gap and separation between the walls and floor to ceiling can increase the acoustic performance of the finished building.

Current fundamental differences in modular construction

Warning: Simplification

North America

- 2D components are connected into a 3D structure as soon as possible (Level 1a). Many ergonomic advantages to optimize productivity and quality are not utilized.
- Modular construction often used as default, not always questioning if this is the most efficient method

Central Europe

- 2D components have been fabricated and finished as far as possible (Level 2a or 2b)
- Modular construction only used if it truly makes sense (e.g. large number of repetition, extreme fast construction period on site necessary), 2D panels will be connected to 3D structure and then shipped to site.

Photos, Author: Wimmers

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Current fundamental differences in modular construction

Warning: Simplification

North America

- Membranes, insulation, electrical, plumbing and other services, drywall, cladding etc. are often either installed off-site in 3D structure or installed on-site.
- Three-dimensional elements can be shipped relatively “raw” or fully finished from a factory to a project site for integration into a permanent or semi-permanent building.

Central Europe

- Typically all services (electrical, plumbing, ventilation etc.) are preinstalled, using “plug & play” on site. Modules are fully finished including final surface of walls, ceiling and floor and built-in furniture are installed as well.

Photo: HOMAG

Author: Wimmers

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Canadian Wood Council

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Current fundamental differences in modular construction

Warning: Simplification

North America

- Modular prefabrication is often very obviously visible after the building is finished. Architects are challenged to create good architecture.

Photo: METRIC MODULAR

Central Europe

- To be more architecturally appealing, ideally the level of prefabrication is not obviously visible after the building is finished.

Photo: KAUFMANN BAUSYSTEME

Author: Wimmers

Prefab may not make sense if:

- Low thermal performance is requested
- Lesser quality is sufficient
- Long construction periods acceptable
- **The same methods and sequence of on-site construction are used and are just moved in a controlled environment**

Prefab is challenging if:

- Industry is not sufficiently trained
- Prefabrication has historically a suboptimal reputation in North America
- Building Inspection system is not prepared for advanced construction methods

Author: Wimmers

Prefab makes sense if:

- The required thermal performance of the envelope is higher (> 6 inch insulation)
- High overall quality level is requested
- Prefab companies are capable of delivering high quality
- A large part of the optimization potential is utilized
- Lots of precipitation or cold temperatures are expected
- It is difficult to get skilled trades on site

Author: Wimmers

Processes Included in Prefab in Canada

Warning: Simplification

1. Planning and Design — **Depends…**
2. Structure and Envelope — **Only partially**
3. Services (Electrical, Plumbing, HVAC, etc…) — **Not included!**
4. Finishes (Floor, Fixtures, Furniture, Equipment, etc…) — **Not included!**

Only a fraction of the optimization potential is currently utilized!

Author: Wimmers

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Case Studies and Discussion

- ***Objectives:***

  Discuss following aspects by utilizing case studies of your choice

  - Recall process sequence of design, manufacturing and installation
  - Discuss the obstacles during the transition from current status to prefabrication
  - Evaluate potential obstacles in the regularity system such as current set-up of building code and building inspections
  - Discuss potential obstacles in the financial system

- ***Examples:***

1. Austria House, 2009 Whistler, a milestone in Canada's construction industry. 1st CLT and DLT application and 1st Passive House in Canada.
2. Passive House, 2011 Langley, conservative architecture, high level of prefabrication
3. Rainbow House, 2011 Whistler, duplex, high level of prefabrication
4. LCT 1, 2012 Austria, 27m, 8 floors in 8 days, very advanced hybrid prefabrication
5. Forte, 2012 Melbourne, 32m, world's tallest **timber** building at the time, direct comparison to concrete building next door
6. Wood Innovation Design Center, 2014 Prince George, 29.5m, tallest **timber** building in North America at the time
7. Treet, 2015 Bergen Norway, 44m, world's tallest **timber** building at the time
8. Brock Commons, 2016 Vancouver, 53m, world's tallest **hybrid** building at the time
9. Origine, 2017 Quebec City, 41m, tallest **timber** building in North America at the time
10. WIRL, 2018 Prince George, first industrial PH building
11. Mjøstårnet, 2019 Norway, 85.4m, currently the world's tallest **timber** building
12. HoHo, 2020 Vienna, 84m, currently the world's tallest **hybrid** building

Austria House in Whistler 2009-2010

Video

The Austria House (build in 2009) stands for a new generation of energy efficient, thermally comfortable and innovative prefabricated wood buildings.

Photos: Wimmers

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Milestone in BC’s construction

The entire building, including the interior was delivered prefabricated and shipped in containers

Photos: Wimmers

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1st Building in Canada using DLT

Photos: Wimmers

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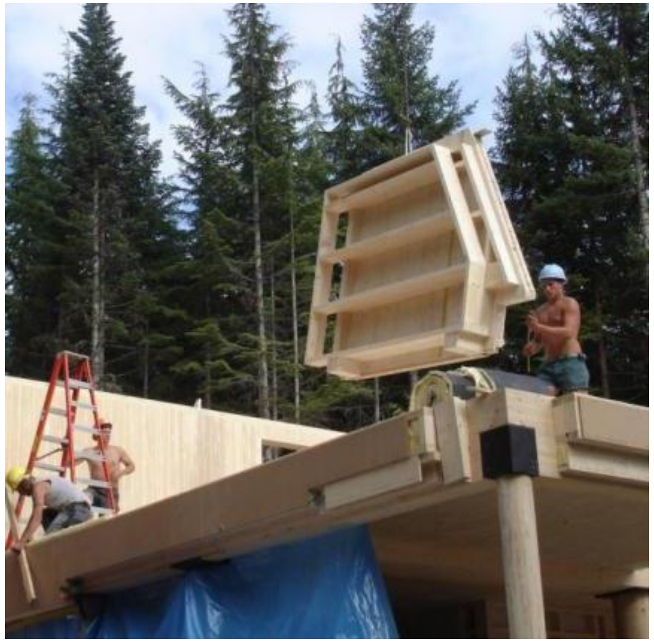
Diagonally Doweled Timber

Photos: SOHM HOLZBAU

1st Building in Canada using CLT



Photos: Wimmers

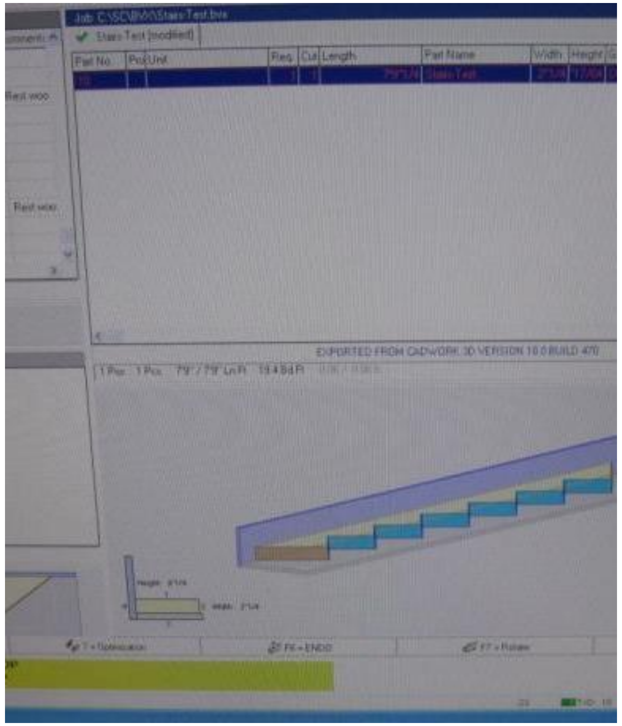
1st Passive House in Canada

Photos: Wimmers

Langley Passive House, 2011 Langley

Graphics: Wimmers

Cutting and waste minimization



Photos: CUT MY TIMBER

Labelling and prefabrication

Photos: CUT MY TIMBER

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Insulation and taping of airtight interior plywood

Photos: CUT MY TIMBER

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Loading and securing against rain

Photos: CUT MY TIMBER

Installation on site

Photos: Wimmers

Installation cavity

Photos: CUT MY TIMBER

Pre-drywall airtightness test

Rainbow House, 2011 Whistler

Video

Photo: MARKEN DESIGN

LCT 1, 2012 Dornbirn, Austria

Video

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Forte, 2012 Melbourne, Australia

Video

Wood Innovation Design Center, 2014 Prince George

Video

Photo: Ema Peter

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TREET, 2015 Bergen, Norway

Video

Photo: Wimmers, Abrahamsen

Brock Commons, 2016 Vancouver

Video

Photo: UBC

Photo: UBC

Photo: Urban One

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Origine, 2017 Quebec City

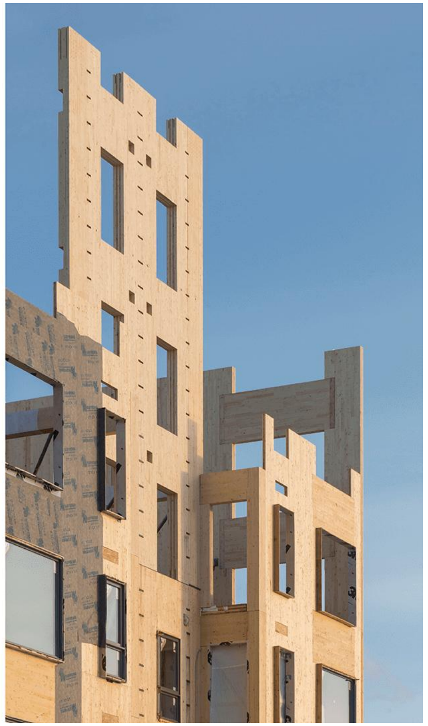

Photo: NORDIC

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Wood Innovation Research Laboratory, 2018 Prince George

Video

Photo: UNBC

Mjøstårnet, 2019 Brumunddal, Norway

Video

Photo: MOELVEN

HoHo, 2020 Vienna

Video

Photo: Baudevelopment GMBH