

3 European Closed Wall Systems and Technologies

3.1 European Closed Wall Panel Design

European closed wall panel designs and specifications vary from region-to-region and from company-to-company. However, as German and Austrian closed wall panels appear to set the standard, they are the primary focus of this analysis. Also, as manufacturers in both countries offer wall panels with similar design features and specifications, we will throughout this section use the term “German closed wall panel” to refer to closed wall panels manufactured in either country. A cursory look at closed wall panel systems in the United Kingdom provides the basis for comparison in the European context. One caveat, however, the closed wall panels under consideration are framed with dimensional lumber or timber, as defined by European standards.

3.1.1 German Closed Wall Panel

As mentioned before, closed wall panel systems offered by German companies differ from manufacturer to manufacturer. However, there are typical features that can distinguish German closed wall panel systems from other European closed wall panel systems.

German Exterior Closed Wall Panel - Typical Core Features	
Bottom and top plates	<ul style="list-style-type: none"> Timbers 120x180 mm or larger are typical
Wall studs	<ul style="list-style-type: none"> Timbers 50x180 mm or larger are typical Finger-joint wall studs are common
Sheathing	<ul style="list-style-type: none"> Sheathing is usually fixed to both the inside and outside of the frame
Insulation	<ul style="list-style-type: none"> In addition to wall cavity insulation between the studs, rigid insulation is normally fitted to both the inside and outside of the framed wall Many types of insulation are used but consumers are demanding "green" alternatives such as mineral wool and cellulose fiber
Vapor Barrier	<ul style="list-style-type: none"> Usually applied on the interior side but some manufacturers omit the vapor barrier to create a "breathable wall"
Service Void	<ul style="list-style-type: none"> Sometimes a void is left between the structural frame and the interior plasterboard to run electrical, pre-wire and other services to lessen the need to breach the vapor barrier
Plasterboard	<ul style="list-style-type: none"> Usually applied to the interior side
Breathable Waterproof Membrane	<ul style="list-style-type: none"> Usually building paper or house wrap is applied to the exterior
Rain Screen Void	<ul style="list-style-type: none"> A void between the structural frame and the exterior finish is sometimes specified to allow moisture to drain away from the structural frame
Exterior Finish	<ul style="list-style-type: none"> Varies according to local codes and customer preference
Windows	<ul style="list-style-type: none"> European style with triple glazing is typical

Notes

- The total width of exterior walls from interior plaster board to finished exterior typically ranges from 180 mm to over 380 mm
- The width of double wall systems can exceed 600 mm
- Electric wiring, roughed-in plumbing, roughed-in gas fittings and pre-wiring are typically installed in closed panels as required

Table 6: Core Features of German Exterior Closed Wall Panels

From a Canadian perspective, the most prominent features are the larger studs and plates, the application of sheathing on both the inside and outside of the frame, and the high values of insulation.

The reasons for using larger studs and plates can be attributed to cultural, marketing and structural reasons. Sheathing on both sides of the framed wall increases the structural integrity and strength, which is beneficial during transit from the factory and handling at the building site. It also serves as a substrate for the rigid insulation.

From a competitive standpoint, German wood wall manufacturers compete with the entrenched brick and block home building sector. German customers historically prefer the “massive” look and feel of a solid wall so manufacturers try to emulate similar qualities in wood framed walls.



Features of closed wall panels

Photos: PDA

The images above illustrate some of the common features in a German closed wall panel, the large studs and plates and increased levels of insulation. Note the fiberboard insulation on the interior side with the service chases that function as conduits for wiring and other services.

Upon closer examination, some German closed wall panels feature details not commonly found in Canadian wall panel systems. In the typical Canadian factory-built wall, framing nails, metal straps, truss plates and other metal connectors are used to attach plates to studs and panels to panels; and to reinforce the framing around window and door openings. Some German

manufacturers use mortise-and-tenon joinery to attach top and bottom plates to studs, and wall panel to wall panel. German factory-built housing manufacturers sometimes use metal connectors, which are somewhat unique to the European factory-built housing industry.

3.1.2 Dovetail Mortise and Tenon Joinery

In the timber frame tradition it is common practice for many German manufacturers to use mortise and tenon joinery to couple panels together at the building site. Also note the thickness of the top plate or top boom as it is sometimes called. The black straps (similar to seatbelt material) attached to the top plate allow for the panel to be lifted in the factory and at the job site.



Dovetail Mortise (left) and Tenon (right)

Photos: PDA

Small shops use common timber framing tools to shape timbers. In larger manufacturing plants, automated saws like the Hundegger timber framing machines are used to mortise and tenon, and cut other joinery profiles.

3.1.3 Metal Connectors

Closed wall panel manufacturers in the European Union use a variety of engineered fasteners.



Sherpa Connectors



Placing a panel

Photos: Sherpa

Sherpa Connectors is one of several companies that manufacturer specialized fasteners for the timber frame and factory-built housing industry; see Appendix 6.11.



Walco 40 slide-in wall connector system



Photos: Knapp GmbH

The Walco 40 by Knapp GmbH is another type of panel-to-panel connector used by closed wall panel manufacturers in Europe. For contact information, see Appendix 6.11.

3.2 UK Closed Wall Panel

According to the UK Timber Frame Association (UKTFA), consumers have accepted wood frame housing as a viable alternative to conventional brick and block homes. The negative perceptions associated with wood homes are gone. And building authorities, mortgage lenders and homeowner insurance carriers no longer hold prejudices against wood frame homes.

The UK has become a leader in developing building codes, creating design guidelines and instituting product and construction standards for wood homes. The factory-built housing industry has experienced considerable growth in the last decade. The Republic of Ireland has also been successful in establishing a viable factory-built wood housing industry as well. Irish manufacturers supply domestic markets, and markets in the UK and other parts of the EU.

Although German closed wall panel systems are well known and distributed widely in the UK, other imported wall systems (primarily from Scandinavian countries), compete with domestically produced factory-built wall systems. At the risk of being overly simplistic, positioning the German, UK and Canadian walls could be as follows:

- The typical German wall panel features oversized framing members sheathed on each side with generous levels of insulation to create a “massive” super-insulated wood frame wall that ranges from 180 mm to more than 380 mm in width
- The typical Canadian 2x6 wall is considered light in comparison to the German solution
- UK factory-built manufacturers offer variations of the lighter Canadian wall as well as the massive German version.

3.3 European House Design

The emphasis up to this point has been exclusively on German closed wall systems. It is necessary to put closed wall systems in proper context. The exterior wall is an integral structural component but just one part in building the frame of a house to meet code requirements and the demands of the market. Let's briefly look at the German post and beam home and the integration of framing systems used to build the structural shell.



German Post and Beam Style - Construction Center Poing, Munich Germany



Photos: Eigenheim

The quintessential German designs above are found throughout the model home villages in Germany and Austria and can be classified as post and beam variants. The German post and beam home usually features structural ridge beams and purlins that support prefabricated roof panels. The floor systems are typically panelized in a factory as well. Together the post and beam, wall, roof and floor systems are engineered to work in unison.

Linwood Custom Homes and other pre-engineered and prefabricated home manufacturers home offer a Canadian equivalent of the German post and beam across Canada. Although the home styles and product specifications differ to reflect local building codes and customer requirements, the building systems share similar characteristics.



Post and Beam Style Homes



Photos: Linwood Custom Homes

Readers are encouraged to compare and contrast Germany and Canadian manufacturers in terms of: home designs, building systems and product specifications; factory-built (offsite construction) methodologies; and the integration of onsite construction activities.

German and Austrian factory-built manufacturers can be easily located in model home villages throughout Europe. Visits to the Poing model home village near Munich Germany and the Blue Lagoon model home village near Vienna Austria would be beneficial.

3.4 European Home Design Trends

3.4.1 Whole House Design

Whole house design is fundamental and its importance cannot be overstated. Legislation and market drivers make it absolutely necessary for architects and factory-built home manufacturers to give due consideration to the design of all systems and features in the home. Of paramount concern to manufacturers, building officials and consumers is the overall performance of the home and its impact on the environment. The ultimate goal is to design and build a home with a healthy living environment, a net-zero energy requirement and zero carbon footprint.

Reviewing the guidelines for Passive Homes (EU) and the Code for Sustainable Homes (UK) illustrates the performance weighting criteria and hence the most important factors that concern European architects and factory-built home manufacturers:

- **Energy and CO2 Emissions:** Energy efficiency and CO2 saving measures
- **Water:** Internal and external water savings measures
- **Materials:** The sourcing and environmental impact of materials used to build the house
- **Surface Water Run-off:** Measures to reduce the risk of flooding and surface water run-off, which can pollute rivers and streams
- **Waste:** The storage for recyclable waste and compost and care taken to reduce, reuse and recycle construction materials
- **Pollution:** The use of insulation materials and heating systems that do not add to global warming
- **Health and Well-Being:** Provision of good daylight quality, sound insulation, private space, accessibility and adaptability
- **Management:** Supply occupant with a home user guide, ensure the house is physically secure and the builder made a commitment to reduce the impact of construction
- **Ecology:** Protection and enhancement of the ecology of the area and efficient use of the building site.

With respect to wall systems, green legislation and consumer preferences will continue to determine the composition of exterior walls in the EU. The scoring criteria for the above-mentioned ECO schemes also position the importance of building materials, which does undeniably influence designers and specifiers.

It is true that green legislation benefits manufacturers that build walls with certified wood products from sustainable forests. However, there appears to be no appreciable distinction between natural lumber and engineered wood in regards to the scoring criteria.

The entrenched brick and block producers have green building products in the marketplace; some offer factory-built brick and block wall panels. Even steel-studs with an acceptable amount of recycled steel (perhaps from junked Renaults, Fiats and Volkswagens) are considered green.

The bottom line is, products used to construct walls are on a fairly level playing field. Architects and specifiers can equally choose natural wood, engineered wood, brick, block, steel-stud and other products such as structural insulated panels (SIPs) and solid wood to build walls that meet the scoring criteria and performance expectations. Or mix various products and systems to design a hybrid wall. Creativity in wall design is quite evident in the European Union at this time.

3.5 Closed Wall Panel Trends

Acceptance of the Kyoto Accord and the legislated environmental schemes are key drivers in regards to the composition of closed wall panels. The trend to construct factory-built walls with certified environmental friendly products from local sustainable sources has already been established. German and Austrian factory-built home manufacturers prefer using local mills for lumber and timber. Natural products are preferred and customers are asking about the origins and even demanding chain-of-custody evidence for products. Insulation levels have increased significantly as well. Here again, insulation made from natural and sustainable sources is favored. The trends support the whole house design concept, as the ultimate goal is to create a healthy living home environment with a zero carbon footprint and a net-zero energy requirement.

Information and communication technologies (ICT) and smart home systems are commonly being offered in new homes. Because closed wall panels can be built to an almost finished state in a factory, a great deal of planning must be done to ensure the integration of these various systems. It is common for closed wall panels to contain electrical wiring, perhaps gas fittings and roughed-in plumbing. Allowances need to be made in closed wall panels for air extraction, ventilation and other systems that pass through walls. Closed wall panel designers and manufacturers also consider and carefully plan routes in and through walls for telephone, Internet, security, television, voice and smart home technologies. Logically, the integration of specialized tradesmen to connect and test the above-mentioned systems at the building site requires rigorous coordination, especially when the tradesmen are independent contractors.

In summary, European closed wall panels are engineered systems that must be considered in the larger context of whole house design. Design and drafting work is more intensive in closed wall systems in comparison to the open wall system where services are installed at the building site. Special attention in regards to the integration of specialized trades to connect and test the systems adds a degree of complexity to the closed wall panel system.

3.6 European Closed Wall Panel Manufacturing

3.6.1 Overview of European Closed Wall Panel Manufacturing

Closed wall panel manufacturing operations run the gamut from the simplest workshop to the sophisticated automated factory and everything in between. When you think about it, the concept is quite simple. Factory-built home manufacturing is the process of moving part or most of the construction process from the job-site to a factory or offsite location.

3.6.1.1 So, what is needed to start manufacturing closed wall panels?

The basic closed wall panel shop can conceivably operate with the same carpentry tools a site-builder or framer would use. Many shops also have a framing table or framing jigs, and a method of lifting and turning the wall panels. This is the genesis of closed wall manufacturing in Germany and for that matter in Canada as well.

Although there are small builders with simple offsite construction programs in Germany and elsewhere in Europe, the Germans are known for their expertise in industrializing closed wall panel manufacturing. Companies like Weinmann and Hundegger have led the way. The Swedish home building solutions equipment manufacturer Randek BauTech has been successful in this regard as well.

3.6.2 Small Closed Wall Panel Assembly Plant

The process in a small closed wall panel shop begins at the cutting and pre-assembly stage. The lumber or timbers are cut with manual or automated saws. Sub-components such as window and door rough openings may also be prepared beforehand. The wall parts are laid-out on the assembly table, framed and sheathed.

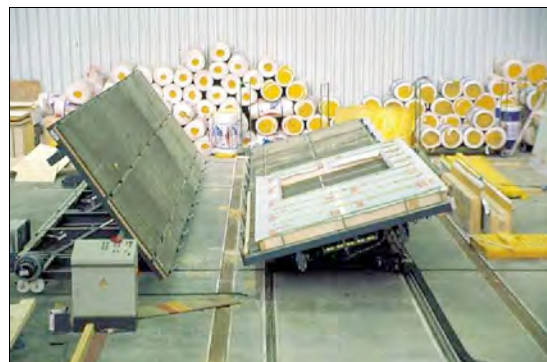
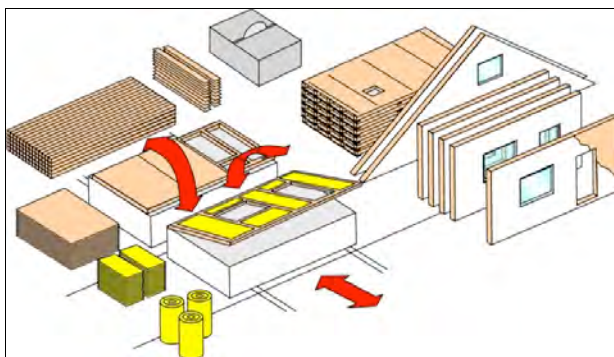


Figure 6: Weinmann Butterfly Assembly Table (Illustration: Courtesy Weinmann)

Photo: PDA

The wall panel is then flipped on the butterfly turning table (above illustration) to expose the underside for further processing. Insulation and perhaps roughed-in electrical, plumbing and other components are fitted between the studs. The plasterboard is attached and the panel is then lifted and placed in an upright position where the windows are installed.

The workflow outlined above is only intended to give the reader a very general idea of the fabrication process. There are many ways to manufacture closed wall panels and systems differ from company to company. Equipment suppliers like Weinmann can provide information on setting up a small factory-built program that is capable of producing 20 to 200 homes annually.

3.6.3 Industrial Scale Closed Wall Panel Assembly Plant

Weinmann and other factory-built housing experts offer industrial scale solutions that enable companies to produce 200 to 800 or even thousands of homes annually. This type of facility usually features specialized workstations, of which many are advanced with semi-automated or fully automated equipment.

3.6.3.1 Cutting Stage

The process begins at the cutting stage. An industrial closed wall panel plant is likely to have several manual and automated saws to cut and shape lumber, timber, engineered wood products and sheet goods like OSB and plasterboard. The Hundegger timber milling machine and the Weinmann linear saw are just two examples of automated CNC saws used in Europe.



Linear CNC Saw

Photo: Weinmann



Timber Milling Machine

Photo: Hundegger

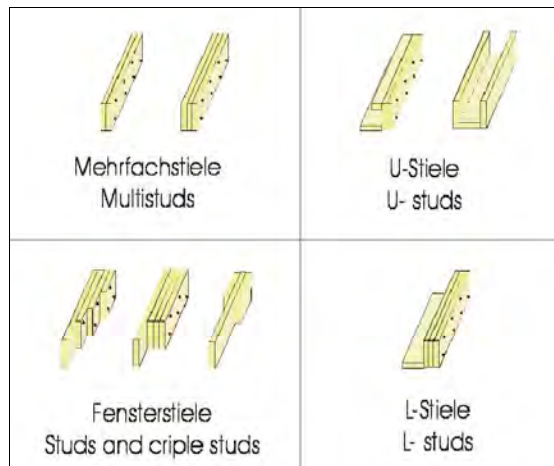
3.6.3.2 Pre-Assembly Stage

One or more component nailers are usually found in industrial scale closed panel plants. The component nailer laminates (nails) lumber together to make sub-components for window and door openings; and for other sub-components like built-up posts, headers, corners and intersections in wall panels.



Component Nailer

Photo: Weinmann



Sub-components

Illustration: Weimann

A dedicated workstation to pre-build window and door openings from the sub-components is commonly found in many industrial wall fabrication lines as well.

3.6.3.3 Wall Panel Assembly Stage

The wall panel assembly stage consists of a number of linear workstations beginning with the framing station.

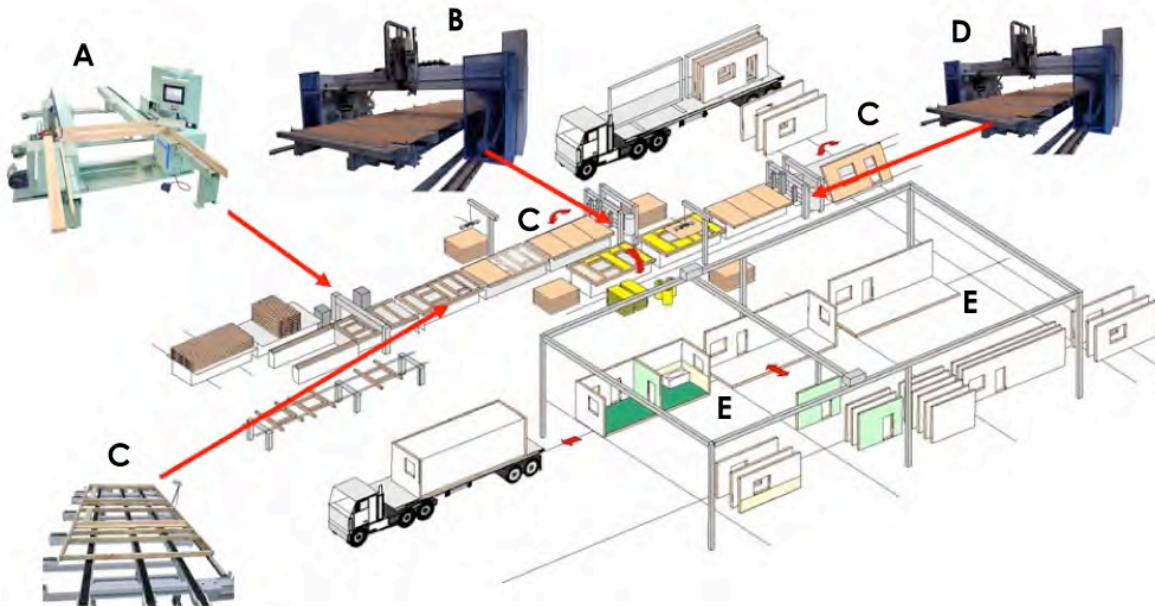


Figure 7: Industrial Scale Closed Panel and Modular Assembly Line

Courtesy: Weinmann

Bunks of pre-cut studs and lumber or timber (top and bottom plate material) are positioned within reach of the framing station operator. Pre-built sub-components and pre-built window and door openings are placed on conveyors in sequence to be dropped into the panels at the framing station. The framing station (**A in figure 7**) is a Weinmann extruded wall framer with semi-automated features. The computer driven framing station uses automation to layout and nail studs to the bottom and top plates. Once the wall panel is framed, saws in the framing station trim off the top and bottom plates. The wall panel moves down the line where the panel is sheathed.

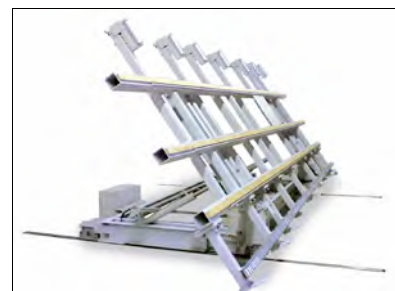
Next, a computer driven multi-function bridge moves over the wall panel; automatically nails or staples the sheathing to the frame and then routers-out the window and door openings. The computer driven multi-function bridge (**B in figure 7**) is a very versatile machine that can be fitted with a number of tools to process sheathing, plasterboard and other panel elements.



Framing Station (A)



Multi-Function Bridge (B&D)



Butterfly Assembly Table (C)

Photos: Weinmann

Once the multi-function bridge has finished, the panel is flipped on a butterfly turning table (**C in figure 7**) to expose the underside for further processing. In addition to insulation, perhaps electrical wiring and other components are installed between the studs. The insulated wall panel moves down the line to the next table where another layer of sheathing is placed. In German factories, wall panels are usually sheathed on both sides of the wood frame.

A second computer-driven multi-function bridge (**D in figure 7**) moves over the panel and automatically nails or staples the sheathing to the frame and then routers-out the window and door openings.

It is also common in German factory-built operations to apply rigid insulation and plasterboard to the wall panels. The multi-function bridge can be programmed to process these elements as well.



Preinstalled plumbing components



Precut cutouts in plasterboard

Photos: PDA

Pre-installed plumbing components are featured in the first image above. The second image shows the roughed-in plumbing components that were pre-installed behind the plasterboard. The cutouts in the plasterboard were pre-cut by the multi-function bridge on the panel assembly line.

When the panel exits the line it is placed in the wall panel magazine (**E in figure 7**) for further processing or readied for delivery. Windows and doors are generally installed when the panel is in a vertical position but some manufacturers prefer to install windows while the panel is on the assembly table. The plasterboard is typically taped, mud applied, sanded and primed while hanging in a finishing station in the panel magazine.



Panel storage magazine



Applying a finish coat

Photos: PDA

The factory worker in the left image above (look closely) is pushing the wall panel out of the wall panel transporter into the panel storage magazine. Also note the degree of completion in the foreground panel that includes mechanical components installed above the window with a roll-up metal shutter. In the second image a tradesman is applying a finish coat to the panel.

Closed wall panel home packages are very common in Germany and elsewhere in the European Union, but this is not the only solution offered. Most factory-built home manufacturers are also capable of producing three-dimensional modular boxes. The industrial plant layout also features a modular assembly area. The German factory-built system allows flexibility to supply both modular and closed wall panel solutions.

For further information on closed wall panel manufacturing operations browse through the list of German and Austrian factory-built manufacturers listed in the Appendix. Many have links to videos of manufacturing operations on their websites.

The process flow outlined in the above section is only intended to provide a general example of an industrial scale factory-built closed wall panel plant. European factory-built solutions providers like Weinmann can provide detailed information on setting up an industrial program that is capable of producing hundreds or thousands of homes annually.

3.6.3.4 Transporting and Erecting Closed Wall Panels

Transporting wall panels begins on the factory floor. Once wall panels exit the assembly line they are lifted by the straps and suspended from an overhead steel I-beam. In other factories the panel is placed vertically in a panel transporter and delivered to a panel storage magazine (see figure 7).



Panels suspended from rail by straps



Wall panel storage magazine

Photos: PDA

The first image shows a panel suspended by its straps. In the second image a group is walking through a wall panel storage magazine. The suspended panels can be easily pushed, like a drape on a wheeled drapery track.

Transporting closed wall panels to the job site requires special handling and consideration. Height restrictions on roads may be a concern for tall walls. And care must be taken not to damage the panels during loading, unloading and in transit. Factory-built manufacturers in the

European Union have for the most part implemented their own innovative ways to deal with closed wall panel handling and transportation issues.



Panels ready to be placed on steel decks for transportation



Photos: PDA

In the images above, closed wall panels are lifted via crane on what can best be described as a custom made steel deck without sides, top and chassis. Metal posts help to keep the load on the deck. The panels are lashed together by straps or other means, and covered to protect them from the weather. A lorry with wheeled chassis slides under the loaded deck and then transports the closed wall package to the job site.

This method allows the factory-built manufacturer to own a number of trailer decks and outsource transportation to specialized trucking companies.



Panel hoisted from

Photo: Dan-Wood

The above image shows the Polish factory-built home manufacturer Dan-Wood's custom-made trailers used to transport closed wall panels to the building site. Site coordination of equipment and labour is an important factor in closed wall panel construction. Cranes are used to carefully lift the panels from the trailer.



Day 1: ground floor panels are placed



Day 3: Waiting for roof panels

Photos: Dan-Wood

Panels are placed according to plan and quickly connected to complete the ground floor. Floor panels arrive next, followed by the upper floor wall panels, gable wall panels, roof beams and roof panels. The image on the right was taken on the third day before the roof panels were installed.

3.6.4 Leading European Equipment Supplier

Leading factory-built equipment suppliers include equipment providers include:

-  <http://www.hundegger.de/>
-  <http://www.randek-bautech.com/home/>
-  <http://www.weinmann-partner.de/cms/en/>

3.7 Summary

German home designs are classified as post and beam variants. The major structural components include prefabricated wall, floor and roof panels. In addition to dimensional lumber and timbers, engineered wood products are commonly used. The Canadian post and beam equivalent is offer by Linwood Custom Homes and other pre-engineered and prefabricated home manufacturers.

Although European closed wall panel designs vary from company-to-company and from region-to-region, the German system has emerged as a leading industry standard. Typical key

features include: studs that are 50x180 mm and plates that measure 120x180 mm; sheathing applied to both sides of the framed wall; generous amounts of insulation that push the total width of walls to 380 mm or more; and triple glazed windows. The typical Canadian 2x6 wall with double glazed windows is considered light in comparison to the German version.

Granted, the wall specifications are important in Germany and throughout the EU but must be considered in the context of "whole house design". ECO legislation and consumer demands require homebuilders to design and supply homes with a healthy living environment, a net-zero energy requirement and zero-carbon footprint. Walls are just one part of the total solution.

With respect to industrial housing production, German factory-built systems have become world renown. German closed wall panel manufacturing operations run the gamut from the simplest workshop to the sophisticated automated factory and everything in between. The technologies and building systems are proven in Germany and in other parts of Europe. The question remains: Is there a market for European style closed wall panels and building systems in Canada?

4 The Market for European Closed Wall Panels

4.1 Is there a market for European closed wall panel systems in Canada?

In formulating a response, the following analysis compares and contrasts:

- The evolution and structure of the home building industry in Canada to selected regions in the European Union
- Consumer attitudes toward wood frame homes and the relative importance of “selling” the structural wall elements
- The typical German exterior wall specifications to the standard Canadian 2x6 wall
- The impact of ECO legislation on German exterior wall specifications and its relevance
- The Passive House and the “Code for Sustainable Homes” schemes to the equivalent but voluntary CMHC Equilibrium™ scheme.

4.2 Home Building Industry Differences

The wood home building industry in the Germany-Austria region is inherently different from the wood home building industry in Canada in terms of its evolution and structure. The industrialized German home building industry is organized around the closed panel-operating model. The Canadian home building industry is overwhelmingly stick and onsite-framing using manufactured components, particularly roof trusses. The UK and Irish wood home building industries have evolved by incorporated German and Scandinavian home building technologies, as well as adopting and modifying North American systems. Although the UK and Irish home building industries include closed panel systems and stick framing, trends favor the open panel system where open wall, floor and roof panels are utilized. Engineered wood components and trusses (roof and floor) are increasing in popularity as well.

Another way to interpret the industry differences is in terms of qualified framing carpenters. The Canadian mainstream method of stick and onsite framing with components is foremost because framing carpenters are available in most housing markets. However, a continued decline in the number of experienced framing carpenters may lead to an inevitable change in the way homes are built in the future.

Offsite manufacturing of closed wall panels to substantial completion has evolved as the prevalent building system in Germany. The industrialization of home building with emphasis on automation, quality control and volume production relies less on qualified onsite framing carpenters. Factory workers and onsite house erectors are easier to find and train from the general labour pool.

Qualified framers (joiners) exist in England, Scotland, Wales and Ireland but can be hard to find. The strong growth of the prefabricated components sector has helped to establish panelizing with trusses and open wall, floor and roof panels as the leading method of wood home building in the British Isles. Like the German experience, factory workers and house erectors are drawn from general labour and other building trades.

What we take away from this summarization is that the wood home building industries in each of the regions mentioned evolved in their own unique ways to effectively serve their own unique

markets. Stick framing and onsite framing with components works when there are trained and experienced framing carpenters. Panelizing offsite to varying degrees of completion can utilize more general labour and lower the need for qualified framing carpenters.

4.3 Consumer Acceptance of Wood Homes

The emergence of the post-war European wood frame home building industry was less than ideal with ramifications that continue to this day. Immediately after the Second World War, many parts of Europe were rebuilt with simple prefabricated wood homes. These nondescript homes were labeled as cheap, undesirable temporary structures. Although attitudes have changed somewhat, the unfavorable reputation attached to prefabricated wood homes lingers on. Brick and block continues to be the most popular method of home construction in Europe.

Factory-built home manufacturers are focused on winning market acceptance and are therefore attentive to customer wants and concerns. The cheaply constructed 100 mm walls in post-war prefabricated wood homes cannot be compared to the bespoke super-insulated wood homes of today with wall systems that range from 180 mm to over 380 mm in width. Despite the exceptional product quality, European factory-built wood home manufacturers routinely "sell" the wood frame features and precision offsite manufacturing in order to compete effectively against the brick and block sector.

In contrast, the wood home building industry in Canada is firmly entrenched. Although other building systems are offered, wood is the unequaled market leader. The industry is mature with prescribed home building best practices, established codes, product standards and third-party inspection requirements. This provides homebuyers with reasonable assurances that wood homes are built to an acceptable and proven standard.

Homebuyers in Canada have a long history and an affinity to wood frame homes. Many wood homebuyers in Europe require convincing. Because of this unfamiliarity and/or concerns about wood homes, European wood homebuyers are more likely to study the framing elements when making a purchasing decision. The opposite is the case in Canada. Conversations with marketers of new home developments in greater Vancouver suggest that "selling" the structural elements in a wood frame home (as is commonly done in Europe) is not usually necessary. Most homebuyers assume and accept 2x6 construction with OSB and roof trusses as typical. Having said this, many builders do offer framing upgrades like I-joist floor systems. Some custom homebuilders offer a "code-plus" scheme, which essentially means the specifications of the built frame are "one-better" than the stated code requirements. For example, a 2x10 floor system is required by code; the builder upgrades to a 2x12 floor system to fulfill the "code-plus" scheme. One structural frame related concern asked about often by homebuyers is the rain-screen and mitigation of mold as this issue has been a problem in coastal British Columbia for a number of years.

Vancouver region marketers of new housing developments, for example, seem to agree that homebuyers are more interested in the reputation of the home builder or developer than the framing specifications. The perceived quality of the house and its structural frame is closely associated with the reputation of the builder or developer. Marketers "sell" the company brand

and the benefits of the home and surrounding community to homebuyers. Successful builders and developers truly understand the importance of branding and proactively manage their company's brand identity and market positioning reverently. Builders and developers also associate their companies with established brand-name products used in the construction of new homes. Typical branded products include: finished roofing, siding, windows, doors, flooring, plumbing fixtures, lighting, cabinets, counters and others. ECO brands such as EnergyStar®, FSC (Forest Stewardship Council) and other are becoming increasingly desirable as well.

The current customer attitudes mentioned above in the mainstream new housing market are generally found in the high-end custom home market as well. In this market, niche homes are more likely to be designed by architects. The main reason is that unlike in many jurisdictions in Western Europe, a single-family home in Canada does not have to be designed by an architect. Canadian factory-built manufacturers, custom homebuilders and production builders routinely use architectural technicians or technologists to design homes. The elite homebuyers who hire architects are, however, more likely to consider alternative building systems and framing specifications; thus presenting a possible niche market for European closed wall panel systems.

The bottom line is that many European homebuyers are not familiar with or have concerns about wood frame homes. Coupled with this is the variety of wood home framing systems currently available in the European market. In addition, there is movement to standardize wood frame construction methodologies and codes throughout the European Union; however, this is progressing slowly. In comparison, the Canadian 2x6 wood frame building system is well established, standardized, widely understood and accepted by consumers, the home building industry and building authorities. European wood home marketers are therefore more likely to educate, showcase and sell on structural framing details than Canadian wood home marketers. Both European and Canadian marketers of wood frame homes understand that creating, positioning and maintaining the company's brand in the marketplace is the primary objective.

4.4 Framing Specifications

Determining the fit of European closed wall panel systems to selected Canadian markets requires a closer look at the principal elements in a typical European exterior wall. Contrasting the specifications to the typical 2x6 Canadian wall will provide a frame of reference. As the German closed wall is regarded as a leading industry standard, its core features are the basis for this comparison.

Although it is possible to design and build exterior walls with German-sized 50x180 mm studs and 120x180 mm plates instead of using Canadian 38x140 mm (2x6) dimensional lumber, there are factors that warrant consideration, as illustrated in table 8.

The National Building Code of Canada, Provincial building codes, and organizations such as the Canada Wood Council have standardized code, design guidelines and performance requirements for 2x6 wall systems. Designers, engineers, homebuilders and building authorities are familiar with the existing codes, guidelines and standards. Manufacturers of building materials used in framed wall systems like friction-fit insulation have also sized product lines

specifically for the 2x6 wall. Changing the framing specs will likely result in additional engineering and approvals, and have cost implications.

Exterior Wall Framing Features	Typical German Exterior Wall Specifications	Typical Canadian Exterior Wall Specifications
Top wall plate size	<ul style="list-style-type: none"> 120 mm x 180 mm + (typical top plate size) 	<ul style="list-style-type: none"> 38 mm x 140 mm (standard 2x6 single top plate) 76 mm x 140 mm (standard 2x6 double top plate)
Bottom wall plate size	<ul style="list-style-type: none"> 120 mm x 180 mm + (typical bottom plate size) 	<ul style="list-style-type: none"> 38 mm x 140 mm (standard 2x6 single bottom plate)
Wall stud size	<ul style="list-style-type: none"> 50 mm x 180 mm + (typical stud size) 	<ul style="list-style-type: none"> 38 mm x 140 mm (standard 2x6 wall stud)
Structural sheathing	<ul style="list-style-type: none"> Applied to both the inside and outside of the frame 	<ul style="list-style-type: none"> Applied to one side of the frame
Wall cavity insulation	<ul style="list-style-type: none"> 180 mm + thickness (typical frame thickness) 	<ul style="list-style-type: none"> 140 mm thickness (standard 2x6 wall size)
Rain screen void between frame and cladding	<ul style="list-style-type: none"> May be required by local building authorities 	<ul style="list-style-type: none"> May be required by local building authorities
Rigid insulation - exterior side of frame wall	<ul style="list-style-type: none"> Up to 100 mm thickness typical 	<ul style="list-style-type: none"> Optional
Rigid insulation - interior side of frame wall	<ul style="list-style-type: none"> Up to 100 mm thickness typical 	<ul style="list-style-type: none"> Optional
Windows	<ul style="list-style-type: none"> Triple glazing with double argon filled typical 	<ul style="list-style-type: none"> Double glazing argon filled typical
<p>Summary</p> <ul style="list-style-type: none"> German walls use more board-feet of lumber and twice as much structural sheathing Wall cavity insulation in German walls is at least 40 mm thicker than in Canadian walls because of the larger dimensioned wall studs Rigid insulation is typically applied to both the inside and outside of the German framed wall Triple glazed double argon filled windows are standard in a German wall; double glazing is standard in Canada. 		

Table 8: Comparison of German vs. Canadian exterior wall framing specifications

The lumber used to build 2x6 walls is graded and stamped to ensure performance standards. Common dimensional lumber is also readily available in distribution channels and competitively priced. Canadian mills and distributors selling European sized lumber likely do so for export reasons only as there is no apparent demand for European sized lumber in Canadian domestic markets.

A noticeable difference to the Canadian wall is that more board feet of lumber and twice as much sheathing is specified in the German version. German wood homebuilders are focused on quality, perhaps at the risk of over-engineering wall systems from the Canadian viewpoint.

Having said this it must be noted that German builders are competing against other German builders offering a similar product mix.

Canadian builders are intently focused on balancing quality with costs. Competition forces home building companies in mainstream markets to drive framing costs down; the quality benchmark in Canada is the building code. Many homebuilders also employ optimum value engineering (OVE) techniques to reduce material and labour costs. Profitable homebuilders are very astute at managing direct costs, especially materials and labour. Because direct costs can typically reach 70% of the total cost of construction, cost management is vital.

Several Vancouver area framers, home builders, developers and factory-built home manufacturers were asked in an informal telephone survey to comment on framing walls to European specs, sheathed on both sides. Typical responses include: "Why..." "We only build what customers will pay for..." and "There is no reason to change the way we do things..."

A review of the wall framing specifications used by several leading factory-built home manufacturers, builder-developers and custom home builders in British Columbia indicates that the vast majority of homes in the greater Vancouver area are framed with conventional wall studs in accordance with the British Columbia Building Code.

The impression given is that it would be highly unlikely for homebuilders to deviate from proven and accepted home building practices without a compelling reason to do so. Homebuilders are customer-focused by nature and construct only what customers are willing to pay for. Homebuyer demands for alternative framing systems or code changes are the likely instruments that would redefine the way walls are constructed.

The other unique elements in the German closed wall for analysis include: high levels of rigid insulation fixed to the inside and outside of the frame; and triple glazed double argon filled windows. These elements are addressed in the next section.

4.5 ECO Market Drivers

European super-insulated walls up to 380 mm thick (up to 100 mm rigid insulation on the outside of the frame + 180 mm frame + up to 100 mm rigid insulation on the inside of the frame) are commonplace. Moreover, as discussed in the foregoing, triple glazing with double argon filled windows is usually standard. These specifications have been influenced in large part by ECO legislation, ECO performance targets and other drivers; see also p.

- Acceptance of the Kyoto Accord to reduce greenhouse gas emissions
- ECO legislated schemes such as the Code for Sustainable Homes (UK) and the Passive House (EU) with measurable targets to reduce energy consumption and the carbon footprint on the built environment
- "Green" consumer attitudes in purchasing environmentally friendly products from local sustainable sources if possible
- ECO initiatives in the way of grants, loans and subsidies to help mitigate additional costs to the homebuyer and builder.

These interrelated ECO market drivers have profoundly changed the entire home building industry in the European Union. The wood home building sector has embraced the ECO wave (or perhaps tsunami) and is well positioned to realize the benefits. The ultimate goal is to design and build homes with a healthy living environment, net-zero energy requirement and a zero-carbon footprint. The super-insulated German style walls are one important step in the "whole house design" process to create a livable home that meets or exceeds consumer expectations and ECO performance targets.

In comparison to the European Union, Canada lags behind in ECO legislation and measurable performance targets to reduce energy requirements and the carbon footprint of new homes.

Issue	European Union	Canada
Acceptance of the Kyoto Accord to reduce greenhouse gas emissions	Yes	No
Legislated environmental home building schemes to reduce energy consumption and the carbon footprint of new home construction	Code for Sustainable Homes (UK) Passive House (EU)	No
Legislated net-zero energy target for new home construction	<15 kWh/m ² of floor area	No
Legislated zero-carbon target for new home construction	Yes	No
Legislated performance and sustainability rating system for new home construction	Yes	No
<p>Notes</p> <ul style="list-style-type: none"> ▪ The EU has established and legislated measurable performance targets to reduce energy requirements and carbon emission levels for new home construction. ▪ In Canada, there are various programs such as the newly formed LEED® for Home Building and CMHC Equilibrium™, but no government initiatives or meaningful legislated performance targets have been implemented as yet. 		

Table 9: Comparison of ECO Legislation between the European Union and Canada

It is worth reiterating that since 1979, CMHC has made innovative contributions in regards to energy efficiency. Refer to the R-2000, Super-E and Equilibrium™ programs in the appendix. It should also be noted again that the Equilibrium™ program is similar in scope to the Code for Sustainable Homes and Passive House schemes; see section 2.

In determining the appropriate insulation levels for a net-zero energy home in Canada, CMHC provides the following guidelines, shown as RSI (R) values in Table 10 on the next page.

City	Ceiling	Main walls	Exposed floors	Below-grade walls	Slab
Vancouver	8.8 (50)	4.6 (26)	4.6 (26)	4.6 (26)	1.8 (10)
Calgary	14.4 (80)	10.6 (60)	10.6 (60)	7 (40)	1.8 (10)
Toronto	10.6 (60)	7.0 (40)	7.0 (40)	7 (40)	1.8 (10)
Montreal	14.4 (80)	10.6 (60)	10.6 (60)	7 (40)	1.8 (10)
Halifax	10.6 (60)	7.0 (40)	7.0 (40)	7 (40)	1.8 (10)
Whitehorse	14.4 (80)	10.6 (60)	10.6 (60)	7 (40)	1.8 (10)

Table 10: Exterior wall ratings

From: CMHC Technical Series 08-104, June 2008

In the above chart for the Vancouver region, an exterior wall rating of R-26 is sufficient for a net-zero home. This rating can be achieved easily by adding roughly 25 mm of rigid insulation to the existing insulated 2x6 frame. With respect to the European norm for triple glazed double argon filled windows, double-glazing is the norm in British Columbia and throughout Canada.

In summary, the ECO drivers in Europe are not relevant in Canada. In addition, the high levels of insulation and triple glazed windows specified in the typical German wall are not deemed necessary for the Vancouver region and many other areas of Canada. Yet, CMHC recommended net-zero insulation ratings for Calgary, Whitehorse and Montreal are more in line with the levels of insulation commonly specified in a German style wall. Regardless, the CMHC recommendations are not mandatory.

The criteria advocated under the CMHC Equilibrium™ stratagem is suitable for the design of efficient homes in Canada to the net-zero energy standard; i.e., if levels of government, the home building industry and consumers want it! The European Union is committed to building net-zero energy and zero-carbon homes. In all likelihood, Canadian homes will continue to be built according to the prevailing building codes. At best, the Equilibrium™ scheme will remain a demonstration project as governments, the home building industry and homebuyers debate the issue.

4.6 Building Systems

There are two general approaches to building wood homes in Canada: the “onsite” or “site-built” method, and the “offsite” or “factory-built” method. This section compares and positions the closed panel system in relation to the other building methods considered.

Onsite Construction or Site-Built	Offsite Construction or Factory-Built
Stick-Framing	Closed Panel System
Open Panel System	Modular System

Table 11: Closed wall panel system in site-built vs. factory-built

Notes (Table 11)

- **Onsite construction** implies that framing inspections occur at the job site as required by building codes
- **Offsite construction** implies that framing inspections occur onsite at the job site as required by building codes; and offsite in the factory as regulated by CSA Standard A277
- **Stick-Framing:** onsite construction using dimensional lumber
- **Open Panel:** onsite construction with prefabricated components: trusses (roof and floor); panels (wall, floor and roof); engineered wood components
- **Closed Panel:** wall, roof and floor panels substantially completed offsite
- **Modular:** modules (boxes) are substantially completed offsite.

4.6.1 Characteristics and Advantages

The four building systems featured all have individual characteristics and unique advantages. The following factors are useful in determining the positioning of the building systems in the Canadian context:

- Labour
- Cost to Build
- Time to Build
- Quality
- Customer Perceptions

4.6.1.1 Labour

Employed labour and subcontracted labour is a substantial direct cost in home building. Professional Builder surveyed the top 350 homebuilders in the USA. According to the 2008 study (Professional Builder, May 2009), construction labour represents 23.12% of the price of a single-family home. Labour can be further categorized into framing labour and specialized trades such as electricians and plumbers. Each framing system has its own labour requirements.

Stick framing requires qualified and experienced carpenters. The same applies to open panel or onsite framing with prefabricated components. Though the open panel system does reduce the number of job-site framing hours, it does not eliminate the need for qualified framing carpenters.

Modular and closed panel operations can benefit by using qualified framing carpenters if available but most plants employ general labour. Unlike onsite framing carpenters who are specialists in framing the entire house, factory labourers are proficient at various workstation tasks on the production line. The factory-built operating model requires specialized house erection crews to join the large panels and modules to quickly close-in the structure.

Hiring or subcontracting specialized trades such as certified electricians, plumbers, gas fitters and others is similar to both onsite and offsite construction methodologies. The coordination of specialized trades is critical to the modular and closed panel systems as components are usually roughed-in offsite in the factory then finished-out at the site. A seamless build without delays requires a high degree of coordination and planning. In stick framing and open panel systems specialized tradesmen are generally not a concern as they are typically brought-in after the house is framed.

With respect to the labour factors, closed panel and modular systems have a clear advantage in markets where there is a shortage of qualified framing carpenters and specialized building trades. Prefabricating to substantial completion offsite and then “flying” the modules and panels in by crane to quickly erect the structure is ideally suited for areas where qualified and experienced building trades are not readily available. The challenge for the closed panel - modular builder is managing all the specialized building trades needed, and integrating offsite and onsite construction activities to create a seamless build.

4.6.1.2 Cost to Build

In addition to the finished building lot, the primary direct costs associated with home building are materials and construction labour. Home building is unlike other forms of manufacturing because almost every home is a prototype with its own cost structure. This makes it difficult to compare build costs in absolute terms. Benchmarking is the recommended course of action to determine competitiveness. For new builders or builders new to a market, cost books from RS Means and other companies can be helpful. Industry studies such as the National Association of Home Builders (NAHB) construction cost survey of the average single-family home can provide useful insights as well; see below.

Chart 1: Construction Costs for Single-Family Unit: National Results, March 10, 2007
 Lot Size: 11,968 sq ft Finished Area: 3,340 sq ft

I. Sale Price Breakdown	Average (\$)	% of Total
1. Finished Lot Cost (including financing cost)	111,476	24.5%
2. Total Construction Cost	219,015	48.1%
3. Financing Cost	10,718	2.4%
4. Overhead and General Expenses	31,969	7.0%
5. Marketing Cost	11,258	2.5%
6. Sales Commission	19,499	4.3%
7. Profit	50,971	11.2%
8. Total Sales Price	454,906	100%
II. Lot Cost	Average (\$)	% of Lot Cost
A. Raw Lot Cost	45,507	40.8%
B. Development Costs:		
a. Cost of processing approvals	2,091	1.9%
b. Site preparation	9,947	8.9%
c. Site improvement	25,785	23.1%
- Paving	9,511	8.5%
- Water and sewer	15,130	13.6%
- Erosion and sediment	1,144	1.0%
d. Impact analysis	5,160	4.6%
e. Water/electric hook-up	3,435	3.1%
f. Land dedication or fee in lieu	2,076	1.9%
g. Bonding/escrow fee	1,183	1.1%

Continued next page →

II. Lot Cost. Cont'd	Average (\$)	% of Lot Cost
h. Financing cost	9,182	8.2%
i. Tree preservation and planting	504	0.5%
j. Wetland preservation and planting	1,283	1.2%
- Value of unbuilt land	823	0.7%
- Cost of mitigation	460	0.4%
k. Value of land left unbuilt as green space or park	1,328	1.2%
l. Other costs	3,996	3.6%
Total B - Development Costs (a. to l. incl.)	65,969	59.2%
Total Finished Lot A + B	111,476	100.0%
III. Construction Cost Breakdown	Average	% of Construction Cost
Building Permit Fees	3,708	1.7%
Impact Fee	3,175	1.4%
Water and Sewer Inspection	3,535	1.6%
Excavation, Foundation, and Backfill	15,249	7.0%
Steel	1,852	0.8%
Framing and Trusses	34,600	15.8%
Sheathing	3,494	1.6%
Windows	6,322	2.9%
Exterior Doors	2,080	0.9%
Interior Doors and Hardware	3,348	1.5%
Stairs	1,674	0.8%
Roof Shingles	7,070	3.2%
Siding	12,476	5.7%
Gutters and Downspouts	965	0.4%
Plumbing	11,753	5.4%
Electrical Wiring	8,457	3.9%
Lighting Fixtures	2,284	1.0%
HVAC	8,641	3.9%
Insulation	3,471	1.6%
Drywall	11,185	5.1%
Painting	7,425	3.4%
Cabinets and Countertops	12,477	5.7%
Appliances	3,826	1.7%
Tiles and Carpet	11,058	5.0%
Trim Material	6,831	3.1%
Landscaping and Sodding	6,148	2.8%
Wood Deck or Patio	1,450	0.7%
Asphalt Driveway	3,157	1.4%
Other	21,305	9.7%
Total	219,015	100.0%

Chart 1: Construction Costs for Single-Family Unit; National Results 2007 Source: NAHB

The NAHB survey clearly illustrates the variable cost nature of the home building industry. The direct cost of construction (48.1%) and the finished building lot (24.5%) represent 72.6% of the sale price for a single-family home.

The hard costs of construction (materials and construction labour) typically range as follows: construction labour represents 20-24% of the single-family home sales price; materials account for 27-31% of the single-family home sales price. A 2008 study of the top 350 home builders in the USA for the Professional Builder trade magazine pegs construction labour at 23.12% of the sales price; materials at 28.93% (Professional Builder, May 2009 issue).

In a comparative cost analysis, the materials specified for the same architectural design are essentially similar for all building systems; modular / closed panel, stick-framed and onsite framing with components. The labour is the key factor that determines cost competitiveness. The ability of the modular / closed panel manufacturer to integrate and control both offsite factory and onsite construction labour is critical to success.

The Wood Truss Council of America (WTCA) and Solutions for Wood initiated relevant comparative studies of the hard costs (materials and labour) associated with stick and onsite framing using pre-manufactured components. Additional information is in the Comparative Studies section.

4.6.1.3 Time to Build

There are several ways to analyze the onsite time to build:

- Time to frame the structure
- Time to build to the weather-tight lock-up stage
- Time to build to the ready-to-decorate stage
- Time to build turnkey

The closed panel and modular systems have the clear advantage when it comes to building to substantial completion (ready-to-decorate stage) or turnkey. Onsite construction can range from one day to usually less than one week for a typical structure.

4.6.1.4 Quality

Quality is defined by building code requirements and by customer knowledge and perceptions. With respect to the building code requirements, all methods of framing are deemed as satisfactory.

Industry experts tend to agree however that the modular method of construction produces homes that are structurally superior. Customer quality perceptions are intrinsic and more complicated to measure. Customers generally equate quality perceptions to what they know.

Stick-framing, panelizing and modular construction all have an established presence in the Canadian marketplace. As closed wall panel systems are not well known in Canada, positive customer perceptions of quality remain to be seen.

4.6.2 Customer Perceptions & Choice

Does it really matter if homes are stick-built, framed onsite with open panels, built with closed panels or erected with modules? Several factors that favor the modular and/or closed panel systems include:

- The market or location of the building site is not adequately served by custom homebuilders and production homebuilders
- Framing carpenters and specialized building trades are not available or hard to find
- A quick onsite build time is required by the customer
- The project calls for multiple homes or units to be constructed over a short time period
- Favorable customer perceptions of closed wall panel and/or modular systems

Stick and onsite framing with prefabricated components is the dominant method of home building in Canada. In fact, 92.7% of single-family residential homes are site-built. Modular construction accounts for the remaining 7.3% of homes constructed. There are no statistics or information to suggest that homes are built with closed wall panel systems in Canada.

4.7 Comparative Studies

The following two studies illustrate the focus of the home building industry and the trend to use more prefabricated components in onsite construction.

4.7.1 Framing the American Dream®

Information about “Framing the American Dream®,” a project sponsored by SBCA (formerly WTCA), individual component manufacturers, supplier companies, and the Building Systems Council of NAHB, featured two 2,600 square-foot homes built simultaneously.

<http://www.sbcindustry.com/fad.php>



WTCA Demonstration Project

4.7.2 Solutions for Wood

Prefabricated versus stick frame; side by side home building comparison

<http://www.solutionsforwood.ca/prefabvideo.html>

The above comparative studies illustrate the industry trend toward onsite framing with prefabricated components. Overwhelmingly accepted by homebuyers, stick framing and onsite framing with prefabricated components remains very competitive in terms of the cost to build, time to build and quality. Modular / closed panel and other systems are forced to compete head-on in most housing markets in Canada.

4.8 Conclusions

4.8.1 Is there a market for European closed wall panels and systems in Canada?

Though the Canadian home building industry has evolved, it must be acknowledged that it is deeply entrenched in stick framing and onsite construction using manufactured components. As long as there are sufficient framing carpenters to meet demand, the industry's "status quo" will likely continue.

In contrast, the European housing market has evolved very differently. Faced with a changing market and a shortage of skilled framing carpenters, industry visionaries developed innovative technologies to industrialize home building. The resulting closed wall panel systems have become mainstream in Germany, Austria and in other European countries. The demand for these technologies from outside the European Union is steadily increasing.

With respect to consumer attitudes toward wood homes and the importance of the "selling" structural wall elements, Europeans are more concerned and interested than Canadian homebuyers. Europeans in general are not as familiar with wood homes and usually have questions and/or concerns. Europeans also have a number of choices as manufacturers offer various wood framing systems.

Canadians have a long history and an affinity to wood homes. The 2x6 wood frame building system is well established, standardized, widely understood and accepted by consumers and building industry professionals. Canadian consumers are more interested in the reputation of the builder or developer than the structural wall elements as this tends to be a better indicator of the home's structural quality.

In comparing key exterior wall specifications, German walls contain more board feet of lumber, double the sheathing, significantly higher levels of insulation and better performing windows than the typical Canadian wall. The trend in mainstream Canadian housing markets is to maintain quality and drive framing costs down. Many builders employ optimum value engineering (OVE) techniques to reduce material and labour costs. The competitive reality is home builders usually build to the same base standard, the National Building Code of Canada or the applicable Provincial and municipal codes. Builders are not likely to upgrade the framing specifications unless the customer is willing to pay more; according to marketers of new homes, most are not.

The implications of ECO legislation have profoundly changed how homes are designed and constructed in the European Union. European walls are super-insulated and can be more than 380 mm thick. Triple glazed double argon filled windows are a standard specification. However, the massive walls are only one part of the "whole house design" process to meet homebuyer

and ECO mandated performance targets. The ultimate goal in the European Union is to design and build a home with a livable environment that has a net-zero energy requirement and a zero-carbon footprint.

The legislated ECO performance targets of net-zero energy and zero-carbon do not exist in Canada. The CMHC Equilibrium™ scheme is equivalent in scope to the prevailing schemes in the EU; however, the CMHC recommendations are not requirements. As a result, Canadian homes will in all probability continue to be built to code.

With respect to the question: Does it really matter to the Canadian homebuyer if the home is stick-built, framed onsite with components, built with closed panels or erected with modules? Modular and closed panel systems do have the advantage in markets where framing carpenters and building trades are not readily available or when the home must be erected and finished-out quickly. The fact the matter is over 90% of all single-family homes in Canada is stick-built or framed onsite with components.

The bottom line is the dynamics that have and continue to shape the European wood home building industry and markets are unique to Europe. The industry and market dynamics in Canada are fundamentally different from the European experience. ECO legislation is driving and redefining the home building industry in the European Union. Canada lags behind in this regard but there is a latent market emerging.

Transferring European closed panel building systems to serve selected Canadian markets was the general focus of this research initiative. Although there is no compelling information to suggest a viable market exists for European closed panel systems; the certification requirements under CSA Standard A277 allow a closed panel manufacturer to offer modular, open panel and pre-engineered solutions. And, considering the latent ECO market in Canada, focusing on “whole house design” specifications to an environmental standard such as LEED® for Homes and/or Equilibrium™ using CSA certified building products and existing 2x6 framing standards would seem a better fit for the Canadian housing market.

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6 Appendices

6.1 Building Regulations & Codes

BREEAM: The Environmental Assessment Method for Buildings around the World

BREEAM (BRE Environmental Assessment Method) is the leading and most widely used environmental assessment method for buildings. It sets the standard for best practice in sustainable design and has become the de facto measure used to describe a building's environmental performance.

<http://www.breeam.org/>

BRE Building Research Establishment Ltd

BRE Trust Companies, BRE and BRE Global, are world leading research, consultancy, training, testing and certification organizations delivering sustainability and innovation across the built environment and beyond.

<http://www.bre.co.uk/>

CCC (The Canadian Codes Centre)s

The National Research Council of Canada's Codes Centre plays a vital role in ensuring that the latest innovations and applications are applied safely by the construction industry; providing technical and administrative support to the Canadian Commission on Building and Fire Codes (CCBFC) and its related committees, which are responsible for the development of the national model construction codes of Canada. http://irc.nrc-cnrc.gc.ca/codes/home_E.shtml

CSA (Canadian Standards Association, The)

The CSA functions as a neutral third party, to provide a structure and a forum for developing standards.

<http://www.csa.ca/Default.asp?language=english>

CHS (The Code for Sustainable Homes)

Setting the standard in sustainability for new homes, this document sets out the UK's assessment process and the performance standards required for the Code. <http://tiny.cc/85fD7>

FSC Certification

FSC certification is a voluntary and market-based mechanism for ensuring that our forests are healthy. Consumer demand for FSC-certified products encourages forest managers and owners to become FSC-certified. Independent third-party auditors conduct all FSC certification audits.

<http://www.fscCanada.org/certification.htm>

ISO (The International Organization for Standardization)

ISO is a network of the national standards institutes of 159 countries, one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. It is the world's largest developer and publisher of International Standards that forms a bridge between the public and private sectors.

<http://www.iso.org>

LEED® 2009

The US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) is a third-party certification program and the nationally accepted benchmark for the design, construction and operation of high performance green buildings in the United States. <http://tiny.cc/pHgT7>

LEED® Canada Green Building Rating System

LEED® Canada for New Construction and Major Renovations version 1.0 is an adaptation of the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design Green Building Rating System (LEED®), tailored specifically for Canadian climates, construction practices and regulations.

<http://www.cagbc.org/leed/systems/index.htm>

R-2000 Standard

Developed in partnership with Canada's residential construction industry, R-2000 is an initiative of Natural Resources Canada's Office of Energy Efficiency. Its aim: to promote the use of cost-effective energy-efficient building practices and technologies

<http://tiny.cc/0wAHA>

Super E® Program

Super E® is a Government of Canada initiative to adapt and promote high-quality, high-performance Canadian housing to the world's growing community of environmentally and quality-conscious builders. <http://tiny.cc/i10nP>

UK Building Regulations: Approved Documents

This Planning Portal is the UK Government's online planning and building regulations' resource for England and Wales. The site offers information about planning and building regulations and related technical documents. <http://tiny.cc/kCYkL>

6.2 Associations

CaGBC (The Canada Green Building Council)

The CaGBC leads the transformation of the built environment to create buildings and communities that are environmentally responsible, profitable and healthy places to live, work and play, through the engagement and enablement of industry and government and the support of related organizations to accelerate sustainable building and development in Canada. <http://www.cagbc.org/>

CHBABC (The Canadian Home Builders' Association of British Columbia)

The CHBABC is the voice of the residential construction industry in British Columbia, dedicated to fostering a housing environment in which the industry operates effectively and professionally while maintaining affordability and profitability. <http://www.chbabc.org/>

CMHI (The Canadian Manufactured Housing Institute)

The CMHI is the voice of the factory-built housing industry in Canada. The site offers industry—news and events, reports and education programs—as well as consumer information about modular, manufactured, panelized and pre-engineered homes. <http://www.cmhi.ca>

MHABC (The Manufactured Housing Association of British Columbia)

MHABC is the industry group for those who build and sell Mobile and Modular Homes in British Columbia. <http://www.mhabc.com>

MHI (The Manufactured Housing Institute)

MHI is the national trade organization representing all segments of the factory-built housing industry. MHI serves its membership by providing industry research, promotion, education and government relations programs, and by building and facilitating consensus within the industry. <http://www.manufacturedhousing.org/>

MHI Canada

Trade Association to the Manufactured Home Industry. <http://www.mhicanada.ca>

NACB (National Home Builders Association)

US trade association that helps promote the policies that make housing a national priority. <http://www.nahb.org/>

NZEH (The Net-Zero Energy Home Coalition)

The NZEH Coalition is a multi-stakeholder organization comprised of companies in the forefront of advanced energy efficient residential construction and building products, the utility sector, research and development and, manufacturing and deployment of onsite renewable energy technologies. <http://www.netzeroenergyhome.ca/>

6.3 International Organizations

BDF (The Association of German Prefabricated Building Manufacturers)

The Bundesverband Deutscher Fertigbau e.V. (BDF) is an association of manufacturers of prefabricated timber buildings. <http://www.bdf-ev.de/english/association.html>

CIB (The International Council for Research and Innovation in Building and Construction)

CIB is a worldwide network of 500 member organizations active in the research community, in industry or in education, which cooperate and exchange information covering all fields in building and construction related research and innovation. <http://www.cibworld.nl>

DFV (Deutscher Fertigbauverband e.V.)

The DFV is an association of manufacturers dedicated to factory-built housing. The site is in German. <http://www.dfv.com/>

EGBF (The European Green Building Forum)

EGBF provides information on European buildings and neighbourhoods, focusing on energy-related issues. Their "Green File" looks at how sustainability relates to the construction industry. <http://www.egbf.org/>

EOTA (The European Organisation for Technical Approvals)

EOTA consist of the 'Approval Bodies' nominated to issue European Technical Approvals (ETAs) by 27 EU Member States and European Free Trade Association (EFTA) States (Iceland, Liechtenstein, Norway and Switzerland) who have contracted to the European Economic Area Agreement. <http://www.eota.be/>

Euroconstruct

Euroconstruct is the main network for construction, finance and business forecasting in Europe. <http://www.euroconstruct.org/>

FSC (The Forest Stewardship Council)

The FSC is an international, membership-based, non-profit organization that supports environmentally appropriate, socially beneficial, and economically viable management of the world's forests. <http://www.fsccanada.org/>

LABC (The Local Authority Building Control)

LABC is a publicly accountable, independent building control provider in the United Kingdom. <http://www.labc.co.uk/>

LCI (The Lean Construction Institute)

LCI is dedicated to global good practice in lean thinking applied to construction and construction-related activities. <http://www.leanconstruction.org/>

ÖFV (der Österreichische Fertighausverband)

The Austrian Prefabricated Housing Association <http://www.fertighaus.org>

PHI (Passive House Institute)

Passivhaus Institute is an independent research institute under the direction of Dr. Wolfgang Feist with an interdisciplinary team of 23 employees, conducting research and development in the area of the highly efficient energy use with buildings. <http://www.passiv.de/>

SBCA (The Structural Building Components Association); formerly WTCA

SBCA is an international trade association representing manufacturers of structural building components; offering a wide range of programs, services and events aimed at furthering the success of the structural building components industry. <http://www.sbcindustry.com/>

SBIC (The Sustainable Buildings Industry Council)

SBIC is a Washington, DC-based independent, non-profit association of architects, engineers, product manufacturers, professional building associations; promoting sustainable design. <http://www.sbicouncil.org/>

SHE (Sustainable Housing in Europe)

Demonstration Projects; 714 dwellings in four countries. <http://tiny.cc/8YeUW>

6.4 Canadian Initiatives

EnviroHome

Check out some of Canada's most energy-efficient and environmentally responsible homes

<http://www.envirohome.chba.ca>

Equilibrium™ Initiative

Equilibrium™ is a national sustainable housing demonstration initiative, led by Canada Mortgage and Housing Corporation (CMHC), that brings the private and public sectors together to develop homes, and eventually communities that are a model for sustainable living. <http://tiny.cc/baEyp>

SBRN (Solar Buildings Research Network)

SBRN is a unique, joined effort by 24 top Canadian researchers in solar energy and buildings from 11 Canadian universities to develop the solar-optimized homes and commercial buildings of the future.

<http://www.solarbuildings.ca/>

Solutions for Wood

A program for manufacturers of wood products such as doors and windows, kitchen cabinets and furniture and building components, delivered in the western regions by Forintek, Canada's wood product research institute. <http://www.solutionsforwood.ca/>

6.5 Crown Corporations & Governments Canada

CCHT (The Canadian Centre for Housing Technology)

Canada's research, testing and demonstration resource for innovative technology in housing.

http://www.ccht-cctr.gc.ca/main_e.html

CMHC (The Canadian Mortgage & Housing Corporation)

CMHC works to enhance Canada's housing finance options, assist Canadians who cannot afford housing in the private market, improve building standards and housing construction, and provide policymakers with the information and analysis they need to sustain a vibrant housing market in Canada.

<http://www.cmhc.ca/en/inpr/>

Forintek (Forestry, Industry, Technology)

Canada's national wood products research institute supports the forest products industry in optimizing manufacturing processes, extracting higher value products from the available resource and meeting customer's expectations of performance, durability and affordability.

<http://www.forintek.ca/>

6.6 Media

Automated Builder Magazine

Provides management, production and marketing information on all segments of home, apartment and commercial construction. <http://www.automatedbuilder.com/>

Building Excellence® Magazine

CMHI's Building Excellence® magazine offers information on a range of topics, such as design and development; codes and standards, exports, education and training and builder profiles.

<http://tiny.cc/le47p>

Building Systems Magazine

United States-based trade magazine read by builders, developers and general contractors using or considering using innovative construction technologies. <http://www.buildingsystems.com/>

Constructech Magazine

Constructech Magazine provides professionals in the construction industry with expert perspective on the technology, building automation and automated home technology decisions that will ultimately improve bottom line results. <http://tiny.cc/Cr8eg>

Engineered Wood Journal

The Journal covers a wide range of subjects of interest to the engineered wood products industry, including processing trends and innovations, research and development issues, marketing challenges and opportunities, technical developments, quality assurance trends, certification and regulatory developments, industry safety programs, etc.

<http://www.apawood.org/>

Fine Homebuilding Magazine

Fine Homebuilding is the largest and most trusted residential construction magazine in the United States. The majority of readers are professionals.

<http://www.taunton.com/finehomebuilding/pages/>

Free Construction Magazines

This is a resource for free magazines for the construction industry that provide the latest news, tips, trends and information for the professional builder.

<http://www.freeconstructionmagazines.com/9/categories.aspx>

Green Building Magazine (UK)

This magazine provides in-depth coverage of building project designers, builders, product reviews, forecasts, building exhibitions and more. <http://www.greenbuildingmagazine.co.uk/>

Lean Construction Journal

An international refereed journal devoted to Lean Construction practices and research.

<http://www.leanconstruction.org/lcj/lcj.html>

SBC (Structural Building Components Magazine)

SBC aims to increase the knowledge of and to promote the common interests of those engaged in manufacturing and distributing structural building components.

<http://www.sbcmag.info/index.php>

ToolBase E-News

This is a bi-weekly electronic news service that focuses on residential construction industry news, particularly news dealing with information technology and home building.

<http://www.toolbase.org/Newsletters/EnewsHome.aspx>

6.7 Automation Technology in Europe

Hundegger Maschinenbau GmbH

<http://www.hundegger.de/>

Randek BauTech House Production Technologies

<http://tiny.cc/0akua>

Weinmann Holzbausystemtechnik GmbH

<http://tiny.cc/PuZFY>

6.8 Education & Training

MHI Educational Institute

The institute supports the educational purpose of the Manufactured Housing Institute by creating and delivering professional programs and resources for the manufactured housing industry.

http://www.manufacturedhousing.org/educational_institute/

The Manufactured Housing Consultant (MHC)[®] Course

The course is designed for front-line people in the industry to help them increase their knowledge, professionalism and ability to provide a superior home buying experience to their customers.

<http://tiny.cc/miOhi>

6.9 Videos

Build TV - Modular Housing Home Design & Related Videos

View a variety of videos about modular homes-related topics. <http://tiny.cc/pqK2z>

Modular Home Construction Videos

Watch the construction of a 6,800 square foot model home using the modular home building process. Look for related videos elsewhere on that page. <http://tiny.cc/ky8hV>

6.10 Manufacturers

Tour some of the world's factory-built houses and manufacturers:

Toyota Housing Corporation

http://www.toyota.co.jp/en/more_than_cars/housing/

BC-based Britco's Glidehouses

<http://www.glidehouse.com/>

Weehouse

<http://www.alchemyarchitects.com/projects/weehouse.htm>

Dwell Home monster prefabs

<http://www.re4a.com/modern-modular/dwell-home.html>

LoftCube, a German portable penthouse

<http://www.loftcube.net/>

FabPrefab, assorted models on the market

<http://www.fabprefab.com/fabfiles/fablisthome.htm>

6.11 Construction Parts

Dataholz.com

Catalogue of reviewed timber building components for thermal, acoustic, fire performance requirements and ecological drivers <http://www.dataholz.com/>

Walco Connectors (Knapp GmbH)

The Walco wall connection system is designed for connecting entire sections of house walls in accordance with DIN 1052 statistical calculations. The connections are pre-fabricated and can be slid into place easily and simply on site.

http://www.knapp-verbinder.com/index_en.html

Sherpa Connector Link

The Austrian firm, Vinzenz Harrer GmbH the "leading specialist for solutions in the timber-frame construction" develops. The construction with wood encloses many areas and, hence, requires an extensive knowledge.

<http://www.sherpa-connector.com/desktopdefault.aspx>

Herrmann's Timber-Frame Homes

This Ontario-based timber frame company is building also distributes products (e.g., Sherpa Links), with the support of suppliers from across Canada and Europe.

<http://www.herrmannframes.com/>

6.12 Miscellaneous Resources

Builder Online

The Information source for the homebuilding industry.

<http://www.builderonline.com/default.aspx>

BC Building Info

The sole purpose of BC Building Info is to provide members of British Columbia's home building industry with credible building information. It is designed as an "online community" to serve builders, renovators, sub-trades, product suppliers, professional service providers, trade associations, government agencies, and industry organizations.

<http://www.bcbuildinginfo.com/>

BDB (Austrian Construction Databank)

Database of the Austrian construction industry; search for information on builders, manufacturers and products. <http://www.bau-online.at>

BSC (The Building Systems Councils)

America's resource for the concrete, log, modular and panelized home building industries. Its primary focus is to promote benefits of systems-built housing within the industry and to consumers, and identify and work towards resolution of regulatory and legislative issues particular to systems-built housing.

<http://www.nahb.org/>

CEPHEUS (Cost Efficient Passive Houses as European Standards)

Construction of ca. 250 housing units to Passive House standards in five European countries, with in-process scientific back-up and with evaluation of building operation through systematic measurement programs.

<http://www.cepheus.de/eng/index.html>

CMHC Housing Market Information

Canadian Mortgage and Housing Corporation's Market Analysis Centre tracks information and provides analysis of local, provincial, regional and national housing markets and trends.

<http://www.cmhc.ca/housingmarketinformation/>

CMHC Housing Market Outlook — Canada

National, provincial and local forecasts of housing starts, resales, house prices, and outlook for key economic indicators <http://www.cmhc.ca/en/inpr/homain/foan/index.cfm>

Construction Carbon Calculator (North America)

This tool estimates the embodied energy and subsequent carbon amounts released during construction. The measurements account for building materials, processes and carbon released due to ecosystem degradation or sequestered through landscape installation or restoration. <http://buildcarbonneutral.org/>

CSA Class 8131 Factory-Built Building Manufacturers in British Columbia

- **Britco Structures Ltd.**
<http://www.britco.com/>
- **Chaparral Industries (86) Inc.**
<http://www.chaparralhomes.com/>
- **Homedelivery™**
<http://tiny.cc/BEGQh>
- **Freeport Homes Ltd.**
<http://www.freeportindustries.ca/>
- **Moduline Industries**
<http://moduline.ca/>
- **Shelter Industries Inc.**
<http://www.shelterindustries.com/>
- **SRI Homes ULC**
<http://www.srihomes.com/>
- **Willow Ridge Homes Ltd.**
<http://www.willowridgehomes.ca/>

EN-TECH (Ireland)

En-Tech is comprised of a number of companies who are all specialists in their respective fields of renewable energy solutions, offering services, including supply, installation, resources and support.

<http://tiny.cc/8PFXQ>

E-Star™ - House as a System

E-Star™ is a division of the Smart Energy Living Alliance™, a Colorado-based nonprofit that is committed to advancing energy efficiency in housing. <http://tiny.cc/YhTPp>

Framing the American Dream

Information about "**Framing the American Dream®**," a project sponsored by SBCA (formerly WTCA), individual component manufacturers, supplier companies, and the Building Systems Council of NAHB, featured two 2,600 square-foot homes built simultaneously. <http://www.sbcindustry.com/fad.php>

FSC & LEED: Gaining Multiple Credits with FSC Wood Products

PowerPoint presentation <http://www.fsccanada.org/resourcecentre.htm>

Green Building Bible, The

This site gives a comprehensive, practical introduction to green building.

<http://www.greenbuildingbible.co.uk/>

Green Building Home Guidelines

Published by the National Association of Home Builders (NAHB) Research Center, written by a group of builders, researchers, environmental experts, and designers to provide guidance for builders engaged in or interested in green building products and practices for residential design, development, and construction.

<http://www.nahbgreen.org/Guidelines/nahbguidelines.aspx>

Green or Zero-Energy Building

A definition of "green building" with many links to related resources.

http://en.wikipedia.org/wiki/Green_building

Greener Homes for the Future

This leaflet highlights what the British Code for Sustainable Houses is about; how it works and what it means to have a mandatory rating for new homes. <http://tiny.cc/VXmGZ>

Homes across America

This site provides a medium to share information between homebuyers, builders, designers, and technical assistance providers. <http://tiny.cc/xmg9O>

IG Passivhaus Österreich

Acting as a central organization, IG Passivhaus is an information network on passive houses in Austria by regions. It's objectives are information dissemination, know-how exchange, networking, quality management and continuing education. <http://www.igpassivhaus.at>

iiSBE (International Initiative for Sustainable Built Environment)

The iiSBE is a Canadian initiative to advance the energy and environmental performance of buildings; many resources. <http://www.greenbuilding.ca/>

Innsbruck University Holzbaulehrstuhl

Institute for Timber Construction (in German) <http://www.uibk.ac.at/holzbau/#>

International Literature

In this section, you'll find publications featuring the international usage of engineered wood products. If you want to refine your search (i.e., to a specific language), use the keyword search function below; most are free. http://www.apawood.org/level_c.cfm?content=pub_int_libmain

ToolBase Services

A US housing industry's resource for technical information on building products, materials, new technologies, business management, and housing systems. <http://tiny.cc/WQK6E>

Whole Building Design Guide

This web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-related guidance, criteria and technology from a 'whole buildings' perspective. <http://www.wbdg.org/>

Wood & Green Building Resources

The Forest Stewardship Council of Canada's resources on FSC-certified wood and green building.

<http://www.fscanada.org/woodresources.htm>

6.13 Model Home Shows

The following tables provide a more detailed overview of model home shows and villages currently open to the public in Germany, Austria and Switzerland; including a link to a list of manufacturers*.

6.13.1 Model Home Villages in Germany

Location	Contact Information or Website	Homes
Haus im Grünen (Hamburg) 21435 Stelle	http://www.hausausstellung-hamburg.de	16
Haus im Grünen 15711 Königs Wusterhausen	http://www.dfv.com/musterhaus/index.html#4	34
Unger Park Dresden 01458 Ottendorf-Okrilla	http://www.unger-park.de/dresden.htm	26
Unger Park Chemnitz 09114 Chemnitz	http://www.unger-park.de/chemnitz.htm	24
Unger Park Leipzig-West 04430 Dölzig	http://www.unger-park.de/leipzig.htm	15
Unger Park Erfurt 99198 Erfurt	http://www.unger-park.de/erfurt.htm	15
FertighausWelt Nürnberg 91093 Heßdorf	http://www.fertighauswelt.de/german/zentren/Nuernberg/index.html	17
Eigenheim & Garten, Bauzentrum Poing 85586 Poing/Grub	http://www.musterhaus-online.de/43.php	57
Hausbau-Center Ulm 89073 Ulm/Donau	http://www.uag.de	19
Eigenheim & Garten 70736 Fellbach	http://www.musterhaus-online.de/42.php	62
Ausstellung Villingen-Schwenningen 78056 Villingen-Schwenningen	Not provided	10
Oberrheinische Fertighaus-Ausstellung 77652 Offenburg	http://www.messe-offenburg.de/	11
Deutsches Fertighaus-Center Mannheim 68163 Mannheim	http://www.deutsches-fertighaus-center.de/	42
Fertighausausstellung Estenfeld 97320 Estenfeld	http://www.dfv.com/musterhaus/index.html#3	10
Eigenheim & Garten 61118 Bad Vilbel	http://www.musterhaus-online.de/41.php	64
Hausausstellung Mittelrhein 56218 Mülheim-Kärlich	http://www.musterhauszentrum-mk.de/	51
Eigenheim & Garten 42279 Wuppertal-Oberbarmen	http://www.musterhaus-online.de/40.php	47
Musterhauszentrum Oberessendorf 88436 Oberessendorf	http://www.schoeneswohnen.de/	5
FertighausWelt Berlin 15711 Königs Wusterhausen	http://www.fertighauswelt.de	25
FertighausWelt am Flughafen Hannover 30855 Langenhagen	http://www.fertighauswelt.de/german/zentren/Hannover/index.html	15
*For a list of manufacturers go to: http://www.musterhaus-online.de/44.php		

6.13.2 Model Home Villages in Austria

Location	Contact Information or Website	Homes
Fertighauszentrum "Blaue Lagune" A-1070 Wien	http://www.blauelagune.at/musterhaeuser/stadtplan	85
*For a list of manufacturers go to: http://www.blauelagune.at/musterhaeuser/aussteller		

6.13.3 Model Home Villages in Switzerland

Location	Contact Information or Website	Homes
Home Expo Suhr CH-5034 Suhr	http://www.homeexpo.ch/53.php	16
*For a list of manufacturers go to: http://www.homeexpo.ch/52.php		

6.13.4 Low Energy Houses in Canada

Low Energy Houses In Canada: National Initiatives And Achievements (6.2 Mb pdf)

http://www.annex32.net/pdf/presentations/Annex32_workshop_HPC2008_Candanedo.pdf