Industrialized timber housing in Sweden

Industrieller Holzbau in Schweden

La construction bois industrielle en Suède

Costruzione in legno industriale in Svezia
Industrialized timber housing in Sweden | L. Stehn
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In total, less than 20,000 flats are built annually in Sweden, with a 60/40 division between multiple-unit dwellings/small houses. Since the mid-1980s, the timber housing manufacturing industry has dominated the Swedish building of small houses, with ca. 90% of single-family housing built in wood. But a change in the Swedish building regulations in 1995, where wood is even permitted now in higher buildings, shows experiences in which one also receives cost-effectiveness for multi-unit dwellings as a result of using timber as the structure material.

But how is the actual architectural layout – the design – of the modern multi-unit dwelling in timber? Many in Sweden turn to Central Europe and among others, Austria, for inspiration, partly architectural, partly design-wise. During the discourse conducted in this article, the fact that different driving forces in Austria than those currently in Sweden has emerged; hence, products and timber construction in Austria have had differing paths than in Sweden (see the fact diagram regarding the development in Austria). There are good examples of how the usage of timber in structures can contribute to a simultaneous development of modern design and cost-effectiveness that can be used in Sweden. Of course, what is well known is that the various materials (steel, concrete and wood) offer different technical possibilities and performances that in many instances differ substantially. However, the focus on process concerns themselves is important in streamlining the Swedish housing construction. The article comprehensively describes, therefore, the developmental trends seen in both timber construction countries Austria and Sweden and how the most efficient companies in the Swedish timber construction industry have formulated their business models.

1. The building industry in Austria, with a focus on housing construction

Ever since Austria was formed in 1955, the state has had great influence on housing construction, partly through building regulations and partly through the object managed subsidy. Austria does not have common building regulations, but rather respective Bundesland (states) – a total of nine, as well as certain larger cities that issue regulations. The usage of wood as structure material is permitted today, but with varying limitations, e.g. maximum height, only together with the ground floor in concrete or brick, etc. As one of the few remaining European countries to still have a housing subsidy system that is mainly directed towards the object – the building, and only to a minor extent towards the subject – the person. The fundamental idea is that by having the state subsidize housing, rental levels can be maintained down and steer development towards aims other than only economical. According to information for the period up to 2005, approximately 80% of all projects contain some form of subsidy, either directly for some type of installation or indirectly via advantageous loan conditions. In recent years, an increased interest for environmentally related building has emerged and thus, in particular, the construction of buildings fulfilling “Niedrigenergie” (low-energy) or “Passivhaus” (passive house) requirements.

In total, almost 40,000 flats are built annually in Austria, with a 60/40 split between multiple-unit dwelling/small houses. For small houses, the share of timber structure is barely 40%.
However, the share of timber within multiple-unit building is low, under 5%. Several interacting reasons for this are:

- Tradition and structure: A building industry that is designed around the usage of brick and concrete as structure material, and where timber is only used in roof construction and interior solutions with the use of special craftsmen for the tasks.

- Regulations and competencies: Without common building regulations for the country, which protects the development of the building process as well as the development of the building system and products, e.g. a timber building system with a level of prefabrication. After a long-term ban, changed building regulations that permit timber as structure material in higher buildings imply a gap of knowledge among both planners and implementers within the civil engineering sector.

1.1. Example Mühlweg – Multiple-unit dwelling in passive house design

The project consists of four freestanding units on four floors and a roof flat (figure 1). The sizes of the flats are comprised of 2, 3 and 4-room flats, each an average of 88 m$^2$ plus a glassed in balcony with a clear focus on the energy and heat function and with a high level of prefabrication. To achieve a Passive House standard and other requirements regarding sustainability, stability, acoustics and fire protection, a concrete/solid timber construction was chosen, see Figure 2.

![Figure 1: Mounting of outer walls](image1)

![Figure 2: Lower floor and stairwell in concrete to satisfy the requirements from Vienna’s building regulations and where the latter functioned as a load transfer from the respective floors](image2)

To attain the best possible efficiency regarding economy, precision and production time, the solid timber component is prefabricated as much as possible, which, for example, means the sawing out of the windows and doorways and installation of the windows and joints to achieve the best impermeability, see Figure 3. In total, approximately 10 weeks of work went into completing the timber structures and work pertaining to the four buildings in the project.
1.2. Lessons

Prefabrication provided an increased functional quality through the work being conducted in an indoor climate and with good and orderly working procedures. The shorter time during erection of the structure, which was made possible through the prefabrication and a developed logistic, could unfortunately not be used to shorten the total building time. Unfamiliarity with timber and prefabrication in general among the craftsmen was given as a reason for this. Transport restrictions in Austria can render a development towards module building more difficult.

Solid layers of timber are experienced as an integrated design and building element with good potential in multiple-unit building thanks to their good strength and resistance qualities, heat insulating capability (in relation to the main material – brick) and that is essentially an ecologically sustainable material.

By using the qualities of various materials in the best way possible, good potential has been experienced in design-wise and cost efficient manners to achieve the formal requirements of authorities and specific demands placed by building contractors.

2. Swedish timber construction with a focus on cost efficiency

The major driving force in Sweden for increased timber house building during the mid-1990s was the building industry’s search for new, cost-effective building techniques that could compensate for rapidly reducing housing subsidies. It was the North American low cost of house building that inspired the testing of timber construction techniques for multiple-unit dwellings even in Sweden. The early experiences from the building of multiple-unit dwellings showed that the cost reduction was not large enough to break the practice of building with concrete.

If examining today’s situation, one notices that approximately 12% of frame construction for multiple-unit dwellings occurs through the usage of various prefabricated module systems. The timber-based system dominates this industrialised house-building niche. Of 12 module/structural system manufacturers today, 6 use timber as system bearing material. The production is comprised of a light stud system, solid timber system, or both. The volume building technique has dominated. The timber volumes are completely prefabricated in the factory with everything from installations to complete fixtures. When the volumes are ready, they are transported to the building site and attached together by the firm’s own employees into turnkey houses, see Figure 4.
2.1. The industrialisation of building

The paths chosen by Swedish firms within the building industry can be characterised in two ways

- **Industrialised building**: The current building and planning process is being finely tuned and managed according to industrial principles (among others pre-manufactured components), a considerable part of the production occurring at the building site.

- **Industrial building**: Manufacturing processes occur in a closed industrial environment, only assembly work at the building site, a clear process owner with a clear focus on product.

A slightly rough wording fits industrial building best for the building of housing. Industrial building does not imply the developing of standardised housing. It is important that that house fits its surrounding and suits the urban environment, and in particular what residents are asking for in the way of function, economy and security. Therefore, the interface between market, efficiency (technology) and flexibility (architecture) is critical in an industrial building and is typically:

- A limited number of components that, like Lego, can join together into house variants (products) with large variations from both interior and exterior design.

- An earlier held projecting with fewer actors collaborating in a team is also typical. The process to outline, build and design is decided and all actors are in agreement. Late changes to the design are not permitted – a standardised process with loyalty versus the previous choices.

- That the architecture must adapt itself to industrial manufacturing. In the industrial process, the vision, design and architecture (in a broad sense) occur within the framework for a system choice, where the same work within traditional building implies that the architecture comes from a vision and a choice of structure. This is a new way of thinking and way of working from the architect's standpoint; hence, the system (the products) must be transparent and not too complicated in their construction – the suppliers of these industrial systems must make it easy for the architects to develop the system.

It is only within house building in timber, with the development of small house building within prefab technology behind it, where one sees the most obvious development trends versus simply developing industrial building.
2.2. What does a successful business model mean?

Research within business strategy has increasingly concluded that successful companies satisfy three highly placed criteria regarding:

- Proximity to markets and customers
- Innovation in products/systems and processes
- Operative (production) excellence in the activities
- The firm must support these requirements in its business models when developing:
  - Its market positions
  - Its offerings to the market
  - Its resources, which we choose to call operational platforms

From these general business model descriptions, which can be said to apply to most producing firms, we investigate in our joint research questions that affect everything from projecting to industrial manufacturing and coordination at the building site, see figure 5.

![Diagram](image)

Figure 5: Ingredients in a successful business model.

2.3. Industrial building in Sweden as conducted by a timber-building firm

With the starting point for how industrial housing building of multiple-unit dwellings in timber develops and the described business model definitions above, I can clearly see that:

- **Timber construction firms are driving the development of industrial building in Sweden.** Since the investment by the Swedish international entrepreneur company NCC, when industrially produced buildings with concrete – prefab technique were shut down in the autumn 2007, timber construction firms are driving the development of industrial building in Sweden.

- **Business models comprise a clear process ownership.** By taking a process ownership, building technology (operational platforms) is placed in a context where the building firms devote more and more to customer inquiries and market offerings. In a greater context, this is also a trend (so-called developing), which the large contract firms have specialised in.

- **Joint industry R&D:** During the second half of the 1990s, the technical attributes for timber structures underwent verification, where the timber material proved to fulfil the functional requirements. During the beginning of the 2000s, process and building technologies developed, utilising the timber’s attributes – the combination of strength and low weight. This means the development of prefabricated units that resist long transport distances. Timber volume construction moves most of the building
site work to the factory and solid timber provides increased possibilities to long spans. What research and firms are now devoted to is system integration, where the building’s maintenance systems (installations) join together in the industrial structure concept.

2.4. **What is a system integrator?**

A system integrator owns the entire building process, deals directly with the client of a housing project, and is responsible for delivery to the manager/owner, see Figure 6. The system integrator shorts the traditional building process and assumes the commitment of the general entrepreneur. A system integrator has defined a determined product. The offer to the client is, therefore, ‘narrower’ and less ‘flexible’ than what a general building entrepreneur and consultants traditionally offer. Thus, it is determining for the system integrator to enter the decision process early on. A business critical competence is simply the action in earlier phases with the client and architect.

![Figure 6](image)

**What is typical for the timber-building firm?**

- **Market customer need and sell**: Most usual is direct purchasing in cooperation with the supplier and a package deal in combination with the implementing entrepreneur (foundation).

- **Design**: Architecture and Construction design from the firm’s own (or purchased) competence. Installation projecting more traditional to purchase. A volume can be designed as a part of a room, see Figure 7, and this leads to open and flexible floor plans. But the ‘total measurement flexibility’ is limited depending on the production- and transport restrictions (lorries, train tunnels, etc.).

- **Production**: Manufacturing and prefabrication with a repetitive production process in a controlled factory environment. Approximately 95% of the manufacturing and installation occurs in the factory or weather protected at the building site. This protection implies a very short build time. It requires almost 5 weeks to manufacture, transport, install and complete a house consisting of 20 flats.
- **Installation and logistic**: The firm has worked along its own and very rigorous quality assurance program and routines to ensure a dry building. All stages in the process have elaborate checkpoints from goods reception of components to factory, manufacturing, module transport, module installation and building work on site.

![Diagram](image1.png)

Figure 7: Several potential layouts are possible with timber volume building technique (see also www.travolymbyggnad.se).

### 2.5. Process and product questions important

Timber has many goods qualities. It is light and strong in relation to its weight, and has the least effect of all building materials on the greenhouse effect as measure in carbon dioxide and energy consumption. The positive qualities combined with how the firm faces building process costs and process ownership are keys.

By joining together the costs that arise in a house-building project in timber, we know that in Sweden approximately 55% of the total cost comprises the direct production cost. The cost to produce the building can then be roughly divided into ¼ building site costs, ¼ costs for the sub-contractor, ¼ cost for one's own work and ¼ material costs. We know that approximately 12% of the material costs originate from the timber itself, which from a total perspective then means that the cost for timber is less than 2% calculated on the total cost (and 3% of the production cost). At the same time, system related costs are much larger – more than 25% of the production cost. Therefore, it is by reducing these process costs that we can reduce the price level.

### 3. Concluding remarks

Timber building in Austria has been developed with other driving forces, for example material development – new products, more pronounced usage of natural materials, and environmental consciousness. The illustrated building example from Vienna is a good example of just the developmental trend in Austria where:

- Product- and material usage has driven development towards large-scale timber components, making exciting architecture and flexible solutions possible, while utilising the largest possible prefabrication.

- The driving forces for these building components in timber were, among others, to create a building that involved minor stress on the environment and simultaneously facilitated low energy consumption and high cost efficiency.
However, it must be noted that the system with state subsidies has no doubt worked as a particularly supportive driving force.

In Sweden, a somewhat different picture is forming:

Building system integration with a strong focus on cost, process management, collaboration between actors and an increased level of standardisation are factors when production- and construction platform timber building systems are being developed.

Simply standardised construction platforms to render Swedish timber building more efficient through increased modularisation and prefabrication have been pointed out as the most obvious way to reduce production costs and provide the actors (possibly foremost the contractors and entrepreneurs) increased profits. Swedish timber volume building is a good example of this trend. In Sweden, no state subsidies similar to those in Austria exist.