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Mid-rise Timber Construction in Finland

A Study on Material, Technology and Market Maturity

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The purpose of this bachelor thesis was to study the technological, economical and political aspects of Finnish timber construction in the mid-rise residential sector. It aimed to paint a broad picture of current material availability and market maturity in order to identify the advantages and disadvantages of the industry.

Significant portion of the thesis was based on literal research from governmental documents, company progress reports as well as journals and articles from websites. Additionally, interviews with leaders in the construction industry were carried out. Targeted interviewees included CEOs of architectural firms, construction companies as well as researchers from governmental agencies.

The findings from the researches and interviews covered a wide range of advantages and hindrances Finland is facing in the timber construction sector. Technological, economical and political issues all provided unique opportunities, as well as information necessary for the progression in the industry.

By conducting the researches, an overall understanding of the Finnish construction market in the timber sector is established. The information can be used for a company to justify venturing into the market, as well as better prepare for possible market turbulences.

Keywords	Timber, wood, construction, building, material, technology

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1 Introduction

1.1 Background

Amidst the ever-changing building construction industry, sustainable solutions often employ specific materials and technologies to support the boundaries of architectural design. These strategies are also influenced significantly by peculiarities within the existing market margin. In order to generate a healthy momentum towards practical and profitable solutions within the industry, every major component in the market value chain should be examined carefully. Although Finland has been progressing as a pioneer in its participation of the world race in environmentally friendly practices, particular circumstances within the Finnish construction industry possess the propensity to hinder progression in an aggressive manner. More specifically, the usage of timber as a primary construction material in the mid to large scale projects has been onerous and unsuccessful [1].

The tradition of wooden construction in Finland was practiced predominantly in 1930s when the international style influenced the thinking of Finnish architects [2]. The increasing labour cost promoted single housing builders to explore options to provide housing solutions at an industrial scale. The American example of urbanisation and industrialisation at that time provided sufficient inclination for architects such as Alvar Aalto to explore possibilities like prefabrication [3]. The focus of construction was derived exclusively from natural resources, such as the abundance of Finnish forests. Single homes were constructed using solid wood logs harvested directly on-site [4].

In the 30s, Finnish forest in its use for the paper and lumber industry contributed to the country's industrialization. During this period, the technological advance in Finland's forest sector positioned the country in close connection with its international partners. Alvar Aalto was responsible for the design of several multi-residential housing units, as well as the residences for the owners of prominent forestry-based companies [5]. These large industry entities employed large workforces in order to meet the demands of commercial scale production and export. The often volatile pricing of forestry products during that period promoted a search for a safe channel to steadily consume the local production. Housing demands from within the labour communities themselves provided a most suitable answer. [6.]

The second World War resulted in a shortage of construction materials and a demand in community and settlement constructions in a timely and cost-efficient manner. Alvar Aalto's AA system was designed specifically to utilize the prefabricated elements to maximize the potential for the exploitation of Finland's forest resources. [2;57.] The AA system was a continuation of Finland's prior experimentation of the framing system emulated from its American predecessor [7]. However, circumstances such as unfavourable weather conditions and high cost of labour resulted a low engagement to this practice, despite the heavy investment and an overall positive influence of practices on Finland's architectural development [2;51].

The end of the war brought wooden facades to Finland's new and peaceful settlements and communities [8]. The characteristics of prefabrication during the war time ensured the position of this specific housing solution in the Finnish construction history. This construction method effectively provided a solution to the population boom and rapid urbanization and migration from the more rural areas to the city centres in the developing country [2;59]. Often prefabricated, the quickened construction speed was welcomed by local builders and contractors. The following decades saw a dramatic increase in Finland's economic growth which required even more stable solutions, more suitable for rapid expansion. In conjunction with the booming modernistic movement internationally, concrete flourished in the construction scene in the late 1960s and became the overall prevalent material for medium to large scale construction projects. [9.]

The national interest in modernistic concrete construction was primarily influenced by the international influence of minimalistic post-war approach as a suitable response to the booming population. Several architectural styles such as brutalism and the Japanese metabolism employed simplistic approaches in construction which utilized concrete as a primary choice of material [10]. The dominance of concrete continued as its infrastructure and production chain became increasingly efficient and cost-effective.

In the early 1990s, Finland initiated a piloting effort in exploring the potential for the return of timber construction [11]. This was in the backdrop of Finnish buildings association with the traditional Finnish cultural values and a return to de-industrialisation in a tendency to move factories away from the expanding shorelines [12]. Alvar Aalto in the late 1950s expressed an argument in the choice of returning to timber construction not as an agreement to traditions but an agreement to the characteristics of wood as a suitable material [13].

However, the resulting effort in the 90s proved successful in a few pioneering projects which propelled the validity of wood as the next primary construction material. In the latter portion of the decade the momentum generated by this push lost its strength due to a number of factors. The primary reason could be designated to the overall economic fluctuation at a national level, yet, numerous disciplinary-associated factors played a much more significant role in the momentary halt of the timber apartment progression. [11.]

The economical boom in the late 90s generated a large amount of interest in the advancement of the construction industry. In essence, the new building systems within the timber sector were generated almost entirely out of industry leaders' courage in advancing into unknown business territories. However, the forestry industry, primarily responsible for the supply of construction materials, did not have enough vision to collaborate with the engineers and designers to construct a suitable building system which would be able to compete with the concrete practice. Consequently, the industry advocated the timber faction adopted North America's platform framing technique as an attempt to venture into the market margin. [11.]

Although the resulting pilot projects proved successful, the disassociation between the engineers and the product manufacturers severed the new-born tie between disciplines to a certain degree. The forestry industry did not have the foresight to venture into further providing technical assistance for the establishment of timber construction standards, thus resulting deficiency in standardization and collaboration which further reduced timber's chance to compete with the matured concrete industry. At that time there were no prominent industry leaders willing to invest large amount of funding into the research and development efforts. [14.]

Additionally, the economical boom also brought upon a temporary shortage of labour on site. Workers often sought after higher paying jobs other than construction work due to its low pay and high intensity. With platform framing being largely dependent on on-site assembly, the shortage also contributed to the discontinuation of the practice in the construction method's infant stage. In the meantime, design firms and engineers were still struggling to adopt a practical solution to the platform framing method in the Finnish context. The fire safety regulations, acoustic requirements and other logistical challenges were slowly starting to manifest themselves in a counter-productive manner. The added labour cost in conjunction with the often confusing on-site instructions resulted a cool down in the mid-rise timber residential construction sector. [11.]

The second wave of timber boom started in April 2011 when the change in Finnish building code allowed timber frames and facades to be included in the projects. In addition, the maximum allowed building height for a timber building was increased to eight storeys. At this juncture in time, large timber product manufacturers such as Stora Enso and MetsäWood decided to venture into the mid-rise timber residential sector one more time. The difference was these entities were willing to venture further down the production pipeline and provide technical assistance to prospective clients, in addition to providing their products at the same time.[11.]

The direct result of this level of collaboration was an added level of trust between the constructors and product manufacturers. Collaboration became easier. Communication between disciplines became much more efficient. On top of this, the clients of these industry entities began to work and collaborate with the manufacturers not only because of the additional soft value of their product distribution, but also because within a prefabrication mind-set, easier control over labour related logistics was present. [11.]

To further expand on this, there was a concern over the work done on-site in that the workforce itself often comprised personnel limited in experience which reduced the contractor's labour cost. This shortcut in saving construction cost was often associated with unregulated tax reports and, consequently, tax evasions. Furthermore, the lack of properly trained workers on-site together with a shortage of supervising capabilities often deployed significant expenditure associated with a reduction in productivity. This further drove the cost of the production upwards, making it difficult for the buyers to absorb the impacts. To counter balance this phenomenon, Stora Enso initiated a closed-factory engineered timber manufacturing procedure which takes away the sporadic labour deficiencies from the open job sites. The closed-factory setting ensured worker safety and production irrelevant of external weather conditions. Additionally, employers could execute better regulating efforts for worker competency and monitor and report worker income levels, which greatly improved the honesty in labours' income tax submissions. This was the starting point of the second wave in Finland's prefabrication approach to the mid-rise timber construction industry. [11.]

Within the timber context, Finland is currently facing a unique challenge in its tendency to leave behind established practices and move on to adopt the new. The manufacturing capability of Finnish timber related products reflects a stark contrast in its consumption of timber in the multi-storey residential sector. This contrast in the backdrop of heavy urbanization imposed a disconnection in the continuity of Finland's value production engine. In other words, the under-utilization of timber in the mid-rise sector imposed significant complications both economically and politically. While the current concrete industry enjoys safety in its usage on both the economic and regulatory level, stagnant practices within concrete as a material in its technological headroom could only elevate the attractiveness of this material to a certain extent. The emerging global push for environmental considerations sets the fundamental mentalities of concrete towards the opposite direction. [14.]

Furthermore, the global economy engine significantly diverted the focus of Finnish construction technology towards natively suitable solutions. This means that the thin value return of concrete has hindered the utilization of one of the defining characteristics of Finland's global image – its vast forest resources were not fully utilized internally as they should have been. [14.]

1.2 Intent, structure and scope

This thesis examines the materialistic, technological and political aspects of wood as a suitable, primary construction material for Finland's mid-rise residential sector. It explores the potential opportunities for builders and contractors to study the fundamental principles behind product types and their suitability in resolving Finland's expanding urbanization effort. The aspects studied in this thesis paint a broad stroke in understanding the essential ingredients necessary for a building construction to be carried out sustainably from a number of aspects as previously mentioned.

With this intention in mind, the structuring of this thesis is built upon three parallel notions of construction and architecture. A broad overview of timber as a primary construction material is first discussed in order to set the foundation for the technological differences between construction methods utilizing the materials. A thorough market study on timber construction's maturity within the Finnish context is then carried out in order to gain an understanding of the position with respect to the industry. The connections between the elements in the thesis paint a picture of the opportunities, advantages and hindrances

Finland is facing. The topics discussed within this thesis are based on literal research and interactions with industry officials. In other words, documentation of timber construction with respect to the global market is not part of this research. The premise of evaluation of Finland's potentials in utilizing timber is studied exclusively within the national scope as governmental policies strongly influence the outcome of this approach.

1.3 Methods and limitations

The methods employed by the purposes of this thesis involve researching the broad topics of product data, brochures, annual reports and all available documents both online and offline. Additionally, for the purpose of understanding the market situation, a collection of market information was derived from various databases, journals, articles and reports. Official governmental guidelines played a significant role in explaining target actions in national programmes. For the purpose of clearance in delivery, information relating to official documents was paraphrased as an attempt to transcribe the most accurate intents. Furthermore, documents in Finnish were translated both via interpretation by Finnish speaking individuals as well as Google Translator when external help was not available.

Interviews with leading industry professionals were conducted for the purpose of this study. In order to maintain a certain level of objectivity regarding the timber market, personnel from the concrete faction were also interviewed to provide a counter argument to the movement towards timber solutions. This was to ensure that the opinions, intuitions and observations made within this thesis were not based on a biased mentality.

Additionally, in order to cover a more dynamic scope of the intended market, individuals from various professions including design, construction, manufacturing and research were all part of the information assembly. This was an attempt to cover the groundwork of significant disciplines to understand the hidden dynamics between them. These traces of connection were highlighted to provide a more visual display of the market pulse. As such, a greater overall quality of the research could be achieved.

The primary market research process involved interviews conducted with 19 individuals with extensive experience in their respective fields. There was a wide range of professions among the interviewees as well as their professional stances and opinions. This disparity served in supporting the objectivity principle of this thesis, that is to say, information coverage from conversations varied by a large range of degrees. This broad coverage was necessary to draw detailed connections between different instances, such as objectified rationale behind a certain market trend and concluding effects based on certain industry practices.

Conversations were mostly carried out in person. When circumstances did not allow, conference calls were also included as preparation for this thesis. Recordings of all conversations were carried out with the permission of the interviewees. In general, viewpoints of different individuals coincide with each other on a regular basis. Where rare conflicting opinions were present, a fair interpretation on said issue was appropriated to make a judgement on the different opinions and presented within the topic.

As a general guideline, each individual was asked similarly structured questions as a means for systematic information extraction. The questions covered a range of topics from general market description to specific profession of opinions on a standalone construction practice. This was to ensure that a broader understanding of the topic would be focused and relevant to the scope of this thesis. By structuring similar questions, slight differences in professional opinions would resonate throughout the overall database of information. This was the primary method in obtaining deeper insights into certain interview topics. The detailed list of interview participants can be found at the appendix 1 of this thesis.

Initial scheduling of the conductance of this thesis was carried out in the summer break of 2015. However, this period coincides with the traditional Finnish working holidays when most professional workforce was not available. This imposed significant difficulties in carrying out the necessary interviews. Alternative scheduling had to be arranged based on the availability of the targets which potentially disrupted the workflow and progression. The continuation of topic exploration is often shifted based on information revealed by later individuals, in that sense, covering the understanding of topic could not be verified.

Although all interviewees spoke English, the level of their communications differs. This lead to scenarios where certain terminology and understanding were not clearly delivered. Although confirmation on specific details of the dialogue was enforced to ensure the clarity, it was impossible to guarantee a perfect recollection of every exchange.

Measures have been taken to ensure the validity of the conversations, however, where discrepancies occur, secondary research was in place for confirmation purposes.

Within the literal research section, portions of the documents written in Finnish were translated via automatic translation machines such as Google Translate. Therefore, the accuracy in interpretation is based on Google Translate's ability to deliver meaningful results. Certain technical terms, phrases and abbreviation had to be assumed and hypothesized on the basis of other research.

2 Materials

The forest sector is a pillar in the Finnish economy: it currently accounts for roughly one fifth of Finland's entire GDP [15]. The industry employs about 42,000 people in Finland where more than half work in the wood products industry [16]. Within the nation, forests cover more than 70% of the entire landmass [17]. In 2014, the statistical volume of forestry resources in Finland reached 2,360 million cubic meters [16]. Although there are only 80 days of growing season, the annual growth exceeds 100 million cubic meters which equals more than one million cubic meter per day [18].

The combined production value of Finnish timber for construction reached 2.1 billion € in 2014 [19]. However more than 1.5 billion € worth of products were for export purposes [20]. This is an indication that the local consumption channel possesses same potential in growth which would widen the profit margin of Finland's abundant natural resources. Within the mid-rise sector, 90% of Finland's entire building stock is constructed with concrete as a primary material choice [21]. Although almost all of the single residential units are constructed with wood, as is the tradition of Finnish housing, only towards the end of 2015 the target 10% share of timber construction was reached [22]. This was under the push for a target criteria based on the national wood program specified in 2011 [23].

2.1 Engineered Wood

Predominantly, there are two major construction methods involving wood. Firstly, engineered wood is a product which special qualities are achieved by the application of mechanical or chemical reinforcements [24]. Through these applications, certain disadvantages such as moisture absorption are eliminated while certain qualities such as compression and bending strength are improved [25]. It serves as an alternative building material to be used together with concrete and sawn timber to provide a most feasible and practical design solution.

The incentives for using engineered wood are plenty and varied. Apart from its obvious, wide ranging architectural design opportunities, engineered wood typically weighs less than equivalent volumes in concrete while exhibiting higher level of moisture prevention potentials with proper treatment [26]. As a 100% renewable material, using wood in general provides a significant reduction in the environmental impact of a building project [27].

A common method in manufacturing high-strength engineered wood products is to produce the desired properties. The properties can be achieved by the specific applications through binding, fixing of the wood strands, gluing of particles veneers pieces with chemically design adhesives under extremely high pressure as well as any other methods which yield properties researched and tested for international standards[28]. The overall process is dependent on the application requirements. However, in some cases, the production of engineered wood does not necessarily mean a less than normal encompassing energy consumption than alternative materials such as concrete [29].

Generally speaking, the orientation of the strands decides the mechanical property and consequently the purpose of engineered wood. Parallel orientated strands overcome weight enacted perpendicularly onto the timber itself in its bending strength, while compressive load is carried by strands parallel to the force. The lignin that binds the fibres together can be easily separated by force splitting the cellulose. A properly manufactured engineered timber product can provide equal if not more strength than concrete in similar dimensions. [30]

There is currently a large variety of engineered wood products in the market.

Structural wood panels, as illustrated in picture 1 manufactured using cross-laminated veneer by adding alternating lumber’s grain direction with moisture resistance adhesives to achieve high structural strength [31]. Variations include Oriented Strand Board or Structural Composite Panels.

Figure 1. OSB Panel [32]

Glued Laminated Timber or Glulam, as illustrated in picture 2, is a composite product consisting of layers of glued dimensional lumber which yields certain desired structural properties by application. Equivalent volume of Glulam weights 30% less than steel and 83% less than concrete [32]. Yielding similar strength, the energy consumption of the production of glulam is less than 10% of the energy consumption for its steel counterparts [33].

Figure 2. Glulam,[35]

Parallel Strand Lumber as illustrated in picture 3, is produced by gluing veneer strands in parallel positions to provide a higher load bearing capacity. It is normally used as beams and columns in common post and beam constructions. The higher yield in its structural capacity comes from the randomly dispersed knots and deficiencies. This method reduces the strength differences between the sections of the product thus making it more robust in carrying loads [34].

Figure 3. PSL as a beam, [37]

Laminated Veneer Lumber as illustrated in picture 4, is typically available in North America. It is produced by gluing together long grains of veneer sheets resulting in stronger lumber similar to traditional dimensional lumber. It is typically used as rim joists for its dimensional stability and various mechanical properties. The composite nature of Laminated Veneer Lumber makes it much less prone to warping, shrinking or bending than conventional dimensional lumber [35].

Figure 4. Laminated Veneer Lumber as dimensional lumber, [39]

Cross Laminated Timber, as shown in picture 5, is a structural panel made of laminated lumber cross-jointed adjacently to produce higher rigidity and strength. Cross Laminated Timber products allow for larger spans in all suitable assemblies including walls, floors as well as roofs. One of the advantages of Cross Laminated Timber is that a modularized building component could be prefabricated in a factory and brought to the site for a quick and easy assembly. [36]

Figure 5. Cross-joined lumbers provide two-way structural support. [41]

Laminated Stranded Lumber or Orientated Stranded Lumber, as shown in picture 6, is produced using flakes of wood strands glued and formed into a sheet, then pressed together to form the desired dimensions. Laminated Stranded Lumber or Orientated Stranded Lumber produces the highest length-to-thickness ratio, when combined with properly designed adhesives. It has excellent fastener-holding strength and mechanical connector performances. It is commonly used as rim boards and studs. [37.]

Figure 6. Laminated Stranded Lumber, [43]

With pieces of dimensional lumber jointed together with chipped and glued joints to form longer lengths, it is possible to provide shapes and dimensions without any form of deficiencies with Finger-jointed lumber, as shown in picture 7. This high quality lumber is usually used in furniture and appearance-dependent products. [38]

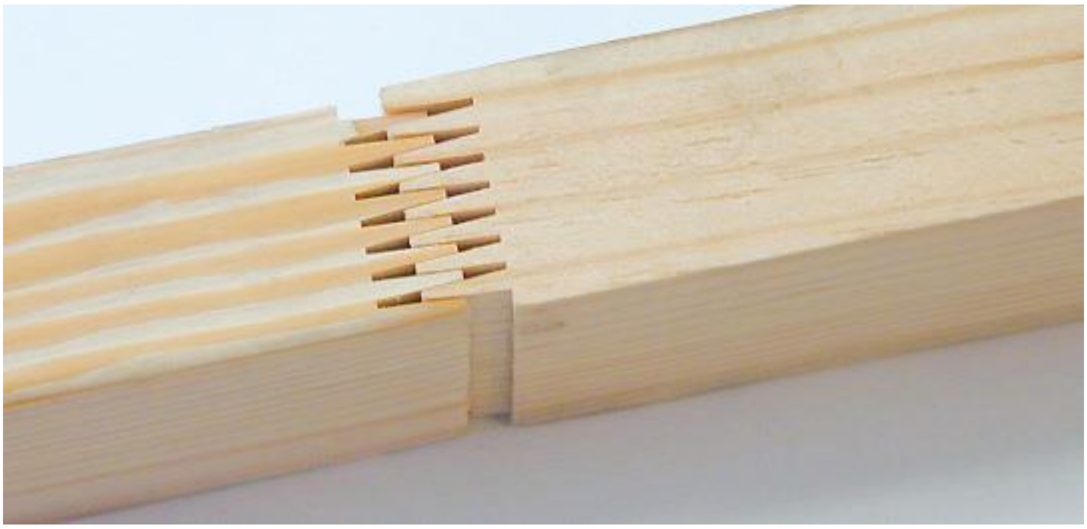


Figure 7. Finger-jointed connection between lumber pieces, [45]

Similar to I-shaped beams, I-joists as shown in picture 8, consists of top and bottom flanges with various widths connected together with webs of various depths. I-joists or beams allow for large spans of uniformly distributed load with minimal amount of wood material, which in return allows for better accommodation of mechanical ducting or fire safety equipment to pass through. [39.]

Figure 8. Various dimensions of I-joists, [47]

2.1.1 Structural Properties

A great quality of engineered wood products is their relatively high level of structural strength. The general rule of thumb is that the denser the wood is, the stronger it becomes.[40] The slow growth rate in the Finnish forests allows for an ideal environment for high quality, high density wood [41]. The technology used in the production of engineered wood involves high-pressure compression while inducing chemically enhanced adhesives [42]. This way, the loose strands of the empty air pockets within the structure itself get compressed to a much lower degree, further increasing the compression strength of the product. Engineered wood products manufactured with this process exhibit higher strengths than steel or even concrete with similar dimensions [43]. For example, glulam is widely accepted as an alternative for concrete with similar dimensions. Also according to the Engineered Wood Association, comparing similar masses, the compressive strength of Glulam is stronger than that of steel [25].

Additionally, wood structures exhibit a high amount of bending flexibility [44]. This characteristic is important in absorbing any lateral movements during an earthquake or in windy conditions. The flexible nature of wood allows deflection to occur slowly during structural failure instances prior to total collapse. This deflection period serves as a warning for occupants to exit to safe areas.

Although engineered wood stands out for its excellent structural capacity, the question regarding the choice of material by its strength is difficult to answer. In reality, applications utilizing a mixture of these two materials are common and often. A successful project should utilize the advantages of all kinds of materials to suit the individual desire from various aspects. Often, a project that chose to use wood had a rationale beyond reasoning limited to structural aspects. Elements such as cost, aesthetics, environmental responsibilities as well as project complexity are at play.

The definitive understanding of the structural properties of engineered wood is dependent on the project designer's motivation and vision. From an environmental impact point of view, the choice of using wood as a construction material has much less to do with its structural properties and a lot more with the potential of Green House Gas emission reduction [33]. In that sense, the structural properties of engineered wood play a secondary role in the decision making process.

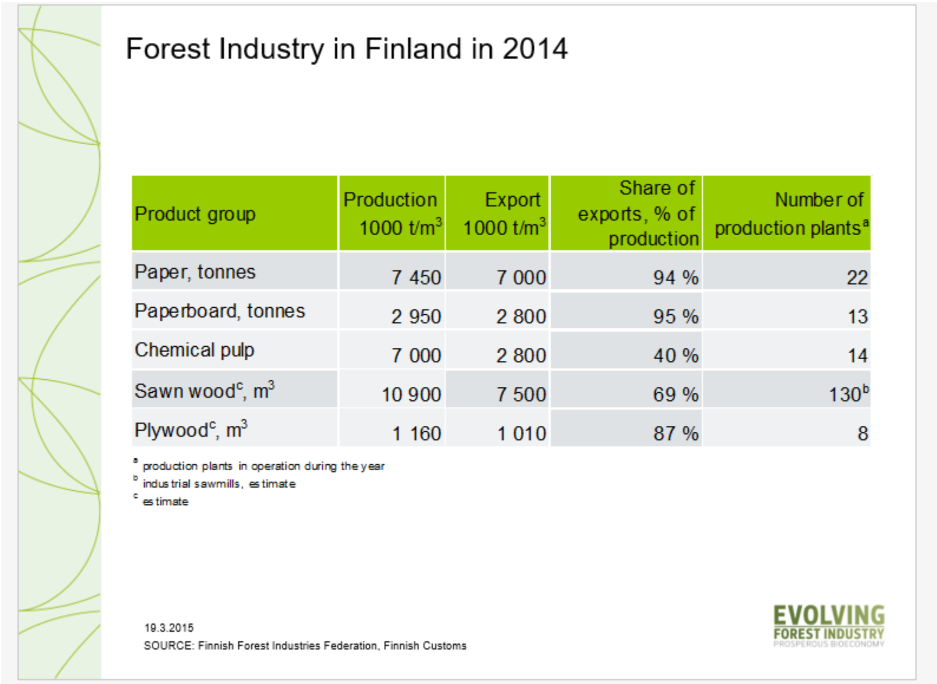
2.1.2 Design Choices

It is commonly accepted that architecturally, one primary incentive for a good design comes from the comfort of its occupants. Wood being a natural material, it encompasses the notion of being with and becoming part of nature. Throughout history, wood buildings have consistently shown to increase the psychological comfort of their occupants by clever design incorporated with both the aesthetic effectiveness and structural capacities. Exposed wood surfaces create an innate sense of warmth welcomed by occupants[45]. This natural elegance and visual satisfaction could have a positive influence on the occupant's state of mind. There have been many studies on the health effects of using wood in a hospital environment [46]. A Finnish study recently showed that wood promoted convalescence, reduces stress and encourage a love of life [47].

Wood exhibits benefits in indoor environmental qualities by passively regulating indoor temperature. Certain species produce a natural scent which improves the experience of a natural environment [48]. Studies have shown that wood also has the ability to absorb and release indoor moisture content which helps to regulate relative humidity and reduce the building's dependency on active mechanical equipment [49].

2.2 Sawn Timber

As mentioned in the previous chapter, more than half of Finland's export of wood products is sawn timber [shown in Picture 9]. The industry is extremely well prepared for local demand when given the proper economic opportunities. The Finnish market of sawn timber within its single residential housing market sees 95% of its buildings constructed in timber [50]. However, only 10% of apartment housing units higher than two storeys were built in wood. Comparing to Finland, the majority of North American mid-rises were built in wood because of the saving potentials provided by mature local regulations, infrastructure and local labour market [51].



Forest Industry in Finland in 2014

Product group	Production 1000 t/m^3	Export 1000 t/m^3	Share of exports, % of production	Number of production plants[a]
Paper, tonnes	7 450	7 000	94 %	22
Paperboard, tonnes	2 950	2 800	95 %	13
Chemical pulp	7 000	2 800	40 %	14
Sawn wood[c], m^3	10 900	7 500	69 %	130[b]
Plywood[c], m^3	1 160	1 010	87 %	8

[a] production plants in operation during the year
[b] industrial sawmills, estimate
[c] estimate

19.3.2015
SOURCE: Finnish Forest Industries Federation, Finnish Customs

Figure 9. Finnish forestry export figures, [60]

Sawn timber itself in comparison to engineered wood is a much cheaper and quick alternative. It is basically a piece of a tree trunk cut at standardized dimensions without any post-harvest treatment. Each piece of lumber carries a standard compression strength which with many in connection, serves the load bearing purpose similar to a uniformly loaded Cross Laminated Timber pane.[52]

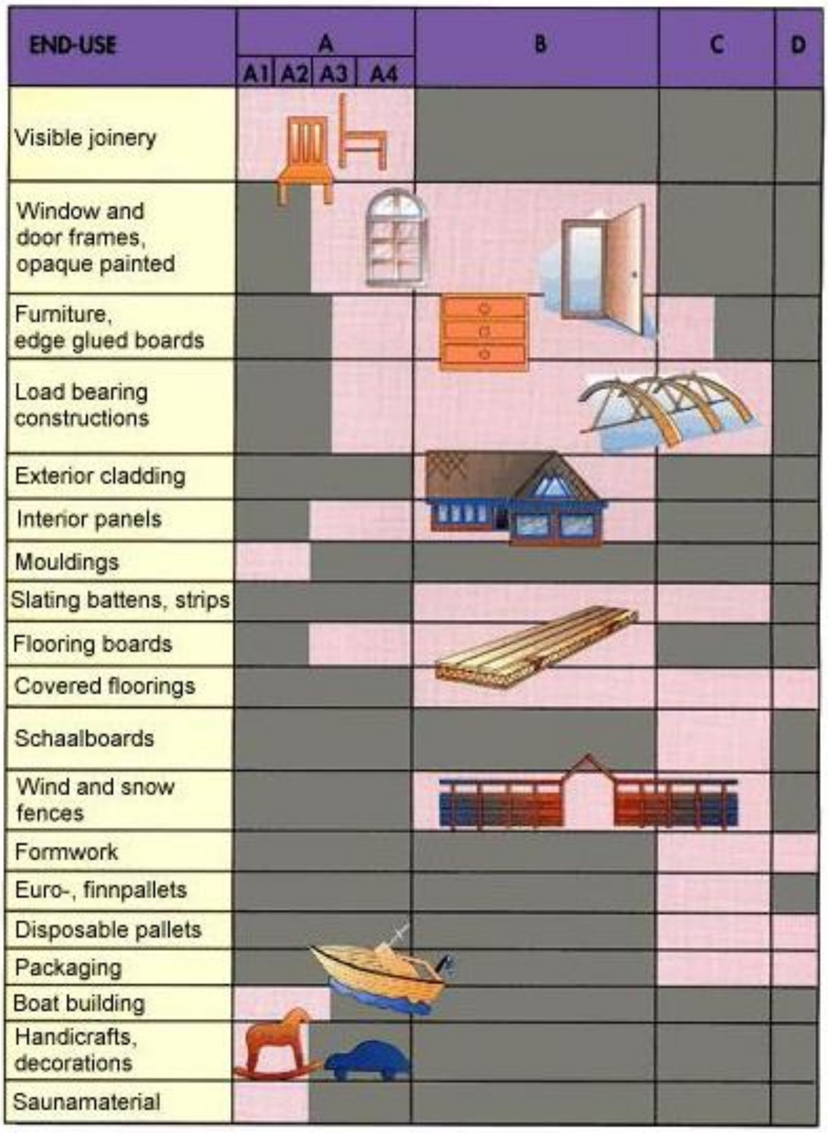


Figure 10. The four different grades of sawn timber products and their uses in Finland, [62]

In Finland, there are typically four kinds of dimensional lumber as shown in picture 10 [53]. The highest quality is class A, which is then organized to sub-categories of A1-A4. Depending on the design, different grades of the timber are used for different purposes. The appearance is often the deciding factor on the use of these products as even with visible defects and impurities, the structural strength of these elements is often similar. [54.]

Usually before the finished products are delivered to end users, fresh cut sawn timber has to go through a drying process which reduces the moisture content to below 24%.

This is negotiated between the contractor and the provider since the drying process requires a good amount of time and energy. For framing purposes, moisture content below 14% is recommended. For interior finishing purposes, less than 10% is recommended. [55]

Most sawn timber products vary in length between 2.7m and 5.4m in steps of 300 mm [56]. Custom length sawn timber is rare and requires extra effort to produce [56]. Due to the required efficiency of timber production, a deviation is allowed for the dimensions for the different kinds of sawn timber as shown in figure 11.

Maximum permitted dimensional deviation for sawn-surface sawn timber	
Dimension	**Dimensional deviation**
Thickness and width ≤ 100 mm	- 1.0 ... + 3.0 mm
Thickness and width ≥ 100 mm	- 2.0 ... + 4.0 mm
Length when sorted according to length	- 25 ... + 50 mm
Length when cut to the specified size	±2.0 mm

Maximum permitted dimensional deviation for dimensioned sawn timber	
Dimension	**Dimensional deviation**
Thickness and width ≤ 100 mm	±1.0 mm
Thickness and width ≥ 100 mm	±1.5 mm
Length when sorted according to length	- 25 ... + 50 mm
Length when cut to the specified size	±2.0 mm

Maximum permitted dimensional deviation for all-round planed sawn timber	
Dimension	**Dimensional deviation**
Thickness ≤ 20 mm	±0.5 mm
Thickness ≥ 20 mm1	±1.0 mm
Width ≤ 100 mm	±1.0 mm
Width ≥ 100 mm	±1.5 mm
Length when sorted according to length	- 25 ... + 50 mm
Length when cut to the specified size	±2.0 mm
1) The maximum permitted dimensional deviation for thickness in floorboards is always ± 0,5 mm	

Figure 11. Permitted dimensional deviations, [67]

3 Technologies

On the foundation of examining the two major types of timber as a suitable construction material, this chapter of the thesis attempts to explore the most commonly used construction methods involved in utilizing wood. The historical background explained in the first chapter of the thesis dealt partially with the originality of timber framing in various parts of the world. Essentially, following the advancement of technology in the modern ages, factory produced timber products became readily available and abundant. The post-war scenario greatly influenced the pace in which timber construction was realized throughout the world, in the meantime, so was the advancement of steel and concrete technologies.

In hindsight, technologies push forward the boundaries of possibilities in construction regardless of the material choice. It is often the political and economic engine behind the wheels of economic progression that often shaped the general direction of which the development of materials is carried out. In the context of this introductory thesis, two primary schools of construction methods are studied in order to understand the current situation in timber construction.

3.1 Heavy Timber Construction

A most common construction method with engineered wood is heavy timber or post and beam construction. This traditional construction method brings both benefits and challenges to the consideration of an architectural design. Heavy timber construction uses engineered timber as a structural support to form a “skeleton” of a building without panels or insulations. Consequently, this lack of continuous, uniform structural support opened up opportunities for large openings that resulted in high quality sunlight, visual and special comfort. With proper structural design, engineered wood columns can carry floors without intermediate supports. As a result, interior spaces with high ceilings and large spans are common among heavy timber buildings. [57]

Heavy timber framing was common until the early 19th century when building technologies improved to allow more precise, lighter timber to be produced in bulk. Traditionally, tree trunks were sawn and prepared directly without external treatment and used on-site for construction purposes. In modern days, however, the invention of engineered wood completely negates the risks associated with issues such as fire safety, moisture and rotting damage with the addition of increased structural capacities. Modern timber frame buildings exhibit elegance, design flexibility and often provide an economic advantage over similar concrete structures.

On the other hand, while detailing the construction of heavy timber frames, because there is a lack of continuous support between columns, a miscalculated positioning of insulation often causes condensation during cold seasons. The structure itself forms a thermal bridge between the indoor and outdoor spaces. The connecting joint between the insulating portion experiences pressure differences due to temperature fluctuations. This pressure difference can cause building envelope related issues which are common in modern buildings. [58.]

3.1.1 The RunkoPES System

In 2006, Finnish structural engineer Tero Lahtela, in collaboration with Finnish Wood Research Oy, invented a standardized structural system for the construction of wood projects. The drive behind this development was to standardize industry practices on wood constructions with simplified dimensioning systems combined with various structural assembly categories. The RunkoPES system utilizes a standardized connection detail system to solve all problems associated with structural properties. In addition, the interlocking connection detail also addresses issues related to moisture prevention, fire spread and thermal conductivity.[59]

Within the connection detail, a two-tier grid system was used to facilitate the collaboration between the designers and the structural engineers. The “Modular” grid was used to align the inside face of structures, allowing architects to efficiently design internal spaces to accommodate challenge such as clearances and turning radii. The “Assembly” grid, on the other hand, allowed structural engineers to align load bearing elements to better understand the potential troubles which were usually difficult to spot as illustrated in picture 12. This two-tier system effectively eliminated the chance for errors in the communication between the architects and the structural engineers. [59]

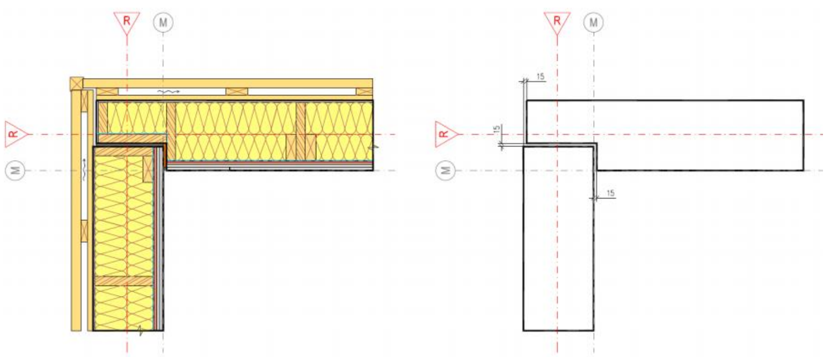


Figure 12. The two grid system employed by RunkoPES [59].

Finnish Wood Research Oy has currently improved the RunkoPES system to its second iteration with improvements in all aspects. Standard details for every connection and situation are available publicly on their website. In the interest in pursuing advanced building information technology, RunkoPES system comes with a standard set of BIM objects to implement the required internal design infrastructure. The BIM objects use the same grid principle with generic building elements for designing purposes, and upon design completion, detailed elements can be quickly added within the predesignated design solutions. This is the reason behind a quicker and more efficient work flow.[59]

3.1.2 Stora Enso's Prefabricated Modules

One of the most promising heavy-time construction methods developed in Finland is StoraEnso's prefabricated modules. More specifically, Stora Enso from Finland is one of the world's leading manufacturers of Cross Laminated Timber panels [60]. Factory fabricated home modules are produced according to a certain design specification and can be assembled quickly without delay. Matti Iiramo, the architect responsible for the Eskolantie Wood Quarters project, as show in figure 13 [61], expressed a high level of appreciation in working with prefabricated Cross Laminated Timber modules. The expanded manoeuvrability in designing the facade was considered by him the most rewarding experience in working with engineered wood products [61].

Because the modules were produced in a closed environment, outdoor temperature does not have any influence on the productivity of the system. Unfavorable weather conditions which usually delay the construction progress were rendered irrelevant in this regard. The Eskolantie project assembly took place in the winter season between August, 2014 and February 2015. Thanks to the prefabricated the productivity has increased and savings were created.[61]

Within the prefabricated module itself, the uniformly distributed load onto the panels allowed the architect to freely design the exterior facade without worrying about cladding support. The result is an expressive cladding composition which the architect considers would otherwise be difficult to achieve with conventional methods.[61.]

Figure 13. The Eskolantie project in Helsinki by StoraEnso utilized its modular construction with CLT technology, [63]

3.1.3 Traditional Heavy Timber Framing

The so-called "heavy timber" construction typically refers to the timber elements being used as blocky wood products unlike the more lightweight dimensional lumber. Also referred as "post-and-beam" construction, this method is perhaps the oldest framing construction in the history of timber houses. The principle of this method traces back hundreds of years when lumber was still being hand sawn into usable pieces [64]. Technologies in the past did not offer readily available lumber in suitable dimensions at large quantities. In order to build houses with larger volumes, heavy, solid piece of wood would be used for structural purposes only, thus the name post and beam [65].

However, with the advancement of material producing technology, engineered wood slowly replaced traditional posts and beams as a more aesthetically pleasing and suitable material. The benefits of sawn timber as a cheaper alternative for the construction of mid-rise buildings became less attractive. Post and beam construction in modern ages allow larger panels and infills to be utilized for architectural purposes. The advancement of technologies for glazing allowed openings to be placed between the posts without too much of concern over the structure’s loss of energy efficiency, as shown in figure 14. Insulation infills have already achieved qualities beyond the capability for light frame construction due to the elimination of thermal bridging effect, as shown in figure 15.

Figure 14. Typical post and beam construction with large window openings, [66]

Figure 15. The thermal bridging effect of a typical stud wall with dimensional lumber, [68]

The most recent case of traditional heavy timber frame in Finland is the PuuMERA project located in Kivistö, by Reponen RKL as shown in figure 16. This project is currently the largest residential project in Europe built with wood as a primary construction material. It hosts more than 180 units in its seven storey structure with concrete as the first floor and six heavy timber framing units above.[69] PuuMERA utilizes glulam beams as the structural support with infill walls clad with compsite panels for its basic wall assembly [69]. In an interview with Reponen's CEO Mika Aiksela, it was disclosed that the construction process of PuuMERA was shortened by roughly 50% due to the fact that it was built in wood.[69]

Figure 16. PuuMERA project under construction, [70]

3.1.4 Metsäwood's Multi-storey System

In addition to the previously mentioned construction systems, MetsäWood in Finland established its own construction system as a channel to utilize its Kerto line of heavy timber products. Similar to a traditional post and beam system, instead of publicly available engineered wood products, MetsäWood's own Laminated Veneer Lumber line works in conjunction with its prefabricated panels with openings as part of its own wall system. The advantages of this system include easy installation, adaptability, excellent quality control. [71]

MetsäWood's multi-storey system is not fundamentally different from the traditional post and beam construction as shown in figure 17. However, the company has packaged the service with its own support such as construction instructions, customized suitability for cladding choices etc. This freed the construction companies from being specialized in timber construction in general, thus reducing risks associated with construction quality.

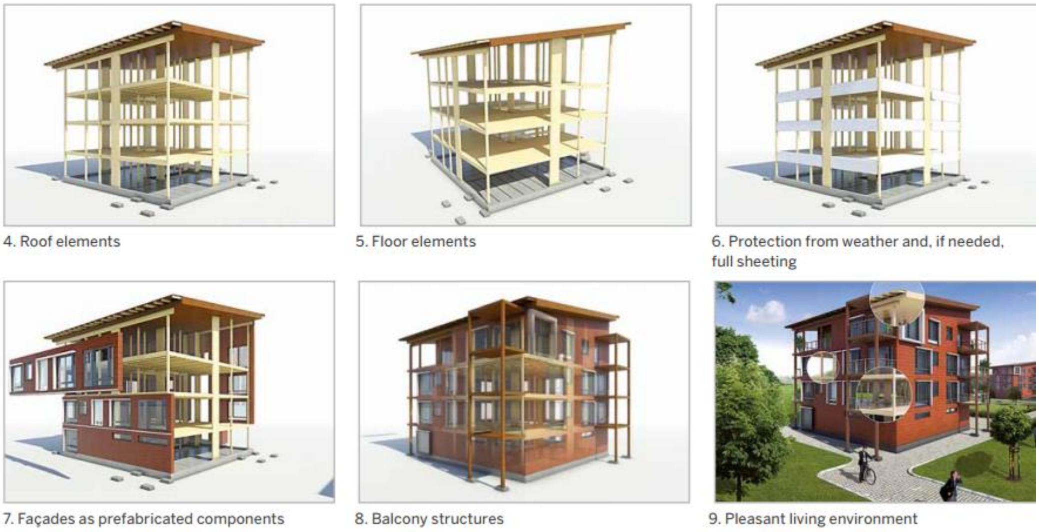


Figure 17. The barebone approach by MetsäWood for its in-house construction method. [71]

The MetsäWood's multi-storey approach is a direct competition to the RunkoPES system within the market margin. It's one of the several timber construction systems available on the market which resulted in realized projects [72]. Current products of MetsäWood include a series of two to four-storey residential constructions in Helsinki near Latokartano. The finished buildings house 104 dwelling units with more than 6 000 square meters of sellable space. Further down the production line, MetsäWood is involved in the execution of the Espoon Tuuliniityn Puukerrostaloalue project which will house more than 500 dwelling units and occupy more than 38 000 square meters of gross floor area as shown in picture 18 [72].

Figure 18. MetsäWood's Viikki campus, [72]

3.2 Light Frame Construction

The post and beam construction was the dominant form of wooden construction since early history. It used heavy timber to form columns and beams which allowed for open, large spans of interior spaces. By the 1800s, the economical progression in North America had laid the foundation for timber harvesting and production of sawn lumber. Predominant lumber yards were established to produce standardized timber studs which gave birth to light-frame construction [73].

3.2.1 Balloon Framing

There are two dominant forms in light-frame construction: Balloon Framing and Platform Framing. In the 1830s, balloon framing was introduced primarily in North America for its cost-saving properties [74]. The basic concept behind this method was to use smaller pieces of lumber for more uniformly distributed load bearing purposes. Continuous timber studs were run from the bottom sill of the first floor to the top plates of the top floor. Intermediate floor joists were then nailed or etched onto the vertical pieces as shown in figure 19. The wide availability of factory made nails and a relatively easy learning curve made balloon framing an attractive alternative for its simplicity in lower density wooden buildings.[75]

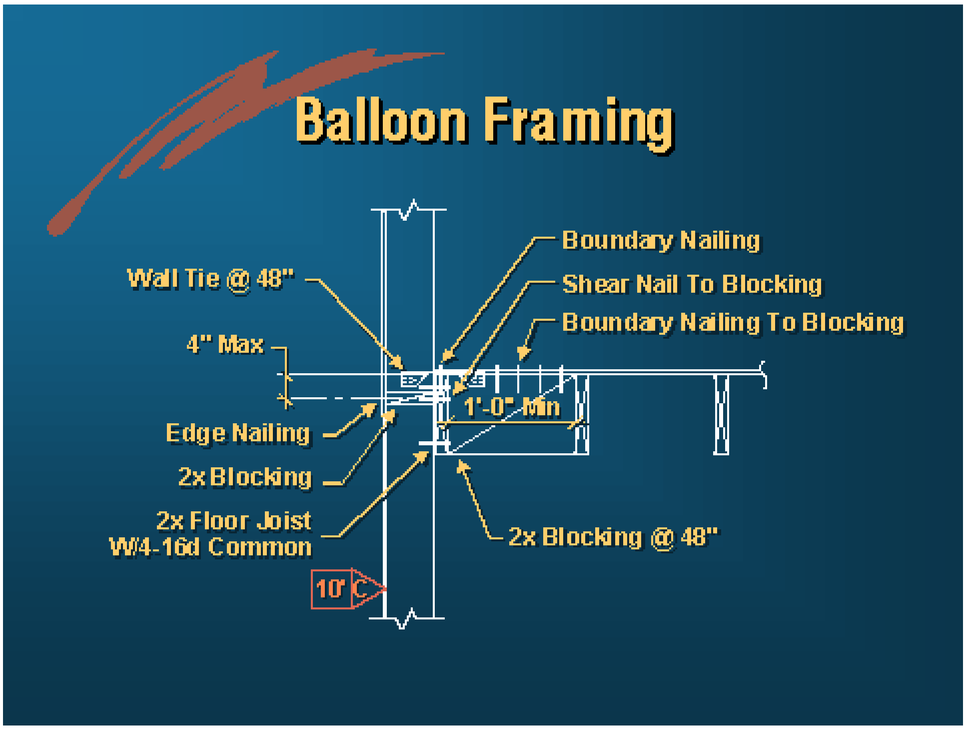


Figure 19. Typical balloon framing section detail. Notice the continuity of vertical elements. [76]

In the 1940s, the fire safety concerns of balloon framing were becoming evident in timber constructions. Because of the continuity of the vertical elements, a fire that starts in the lower floors can easily migrate to upper floors without effective fires topping methods in place. In addition, the requirement for longer, continuous pieces of timber made it difficult for workers to carry the studs and work with them. There was a lack of platform for workers to support themselves when they were building higher floors.[77.]

3.2.2 Platform Framing

The concerns over fire safety with balloon framing resulted in a wider usage of the platform framing method. Platform framing utilizes the availability of shorter studs to create a “platform” of wood floor before locating the support for the upper floors. Once the walls are framed, floor joists are added on top of the plates. In sequence, the framing of the next level then began. One of the major benefits of the platform framing is the ease of application during the framing stages when workers could simply stand on the top of the first framed box and continue building the second box.[78.]

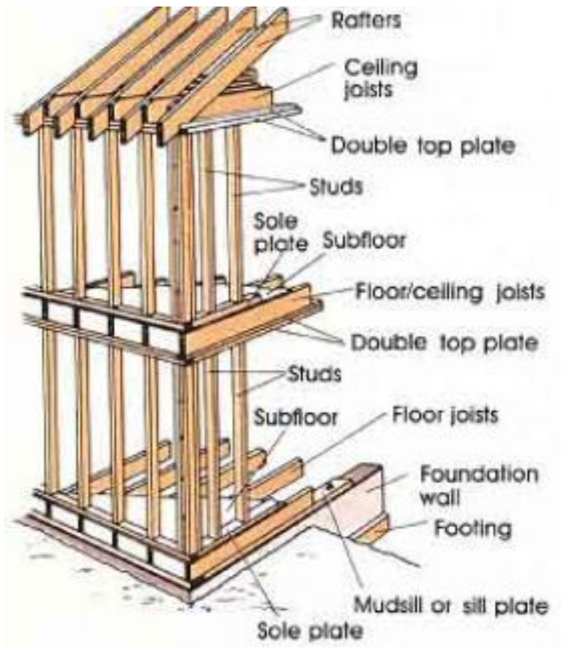


Figure 20. Typical platform framing diagram, the walls are broken into sections as a load bearing element carries the “platform” above. [78]

The material choice for the first floor is usually slab-on-grade or suspended slab with cast-in-place concrete, depending on the foundation type. After the curing of the concrete components, two bottom sill plates, typically regular sized dimensional lumber, were nailed flat down on top of the foundation walls. Vertical timber studs were then placed over the plates at typically 450mm spacing. The “walls” of the first floor were then completed. Next, horizontal pieces of dimensional lumber were laid over the plates on top of the walls which formed the floor for the second level. [78]

Usually a Laminated Veneer Lumber with dimensions similar to the floor joist studs was placed at the perimeter edge of the plates to help prevent the horizontal movement of the floor joists. Larger pieces of sawn timber are then used for floor support purposes. In some cases, engineered I joists are used instead of dimensional lumbers due to lower dead load and larger clearances for mechanical equipment. The expanded spacing between floor joists allow servicing items to be placed adequately, removing the needs for dropped ceilings with additional farming. [78.]

Platform framing became the norm also because it eliminated the fire transfer potential of balloon framing constructions. Embedded between the vertical studs, fire stopping mechanism including sprinklers, gypsum wall boards and fire sprays efficiently stopped the flame spread and gave occupants on upper floors ample time for escape during a fire.[78.]

The vast forestry resources in the USA and Canada provided a fertile ground for the lumber industry to accommodate the market demand for dimensional lumbers. Standardized Precision End Trimmed studs of high quality with lengths precise to one eighth of an inch were widely available and drastically reduced the construction cost of platform framing projects. The majority of the lower to medium density residential housing in US and Canada were buildings under six storeys.[79.]

In Finland, the potential for platform framing of mid-rise buildings calls for a market with sufficient softwood lumber supply. In other words, the supply situation in Finland is extremely well prepared for such a shift in construction method. As the figure below shows, a total of 35 sawmills are evenly distributed all over Finland. The transportation cost itself is a huge saving factor for locally produced sawn timber, as shown in figure 21.[80]

Additionally, light-framing construction replaced traditional heavy post and beam construction due to its affordability. The construction period for a light-frame is similar to that of well-prepared prefabrication construction, but the potential for savings when using ready-made lumber is very attractive to construction companies. Shorter transportation costs, boosts to local economy, short learning curve and inexpensive materials all call for the examination of the feasibility of light-frame constructions.

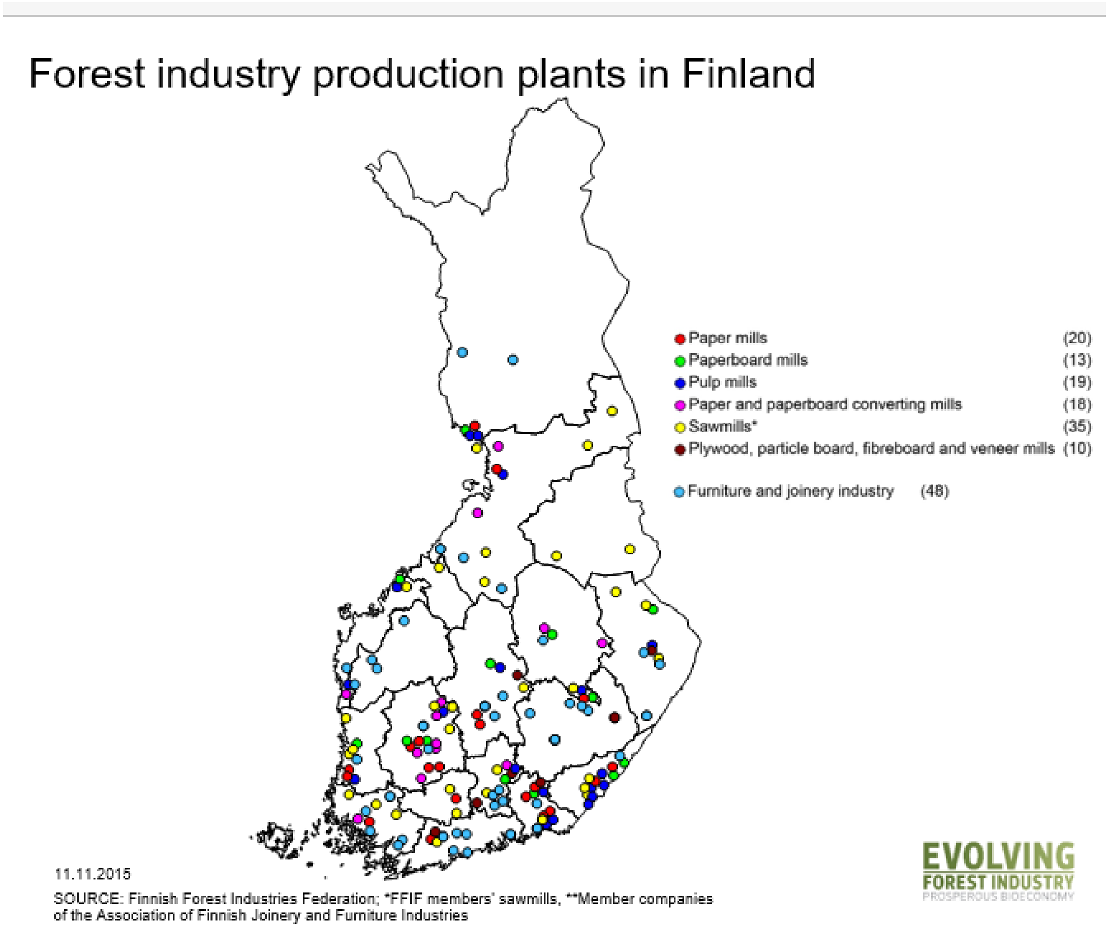


Figure 21. Forest industry production plants in Finland [80]

The Finnish housing market has matured progressively maturing in the medium density prospect. Majority of the housing construction material choice is concrete and steel for mid-rise residential and commercial units. This maturity of the market demands a maneuvering space for the adoption of new materials. In the context of environmentally responsible practices, the economic incentives do not yet justify the risks associated with investments for researches and negotiations.

In the National Building Code of Finland, section A2 – Building Designers and Plans, one of the objectives of the building guidance is to promote buildings based on solutions which have sustainable and economical life-cycle properties. The design should be socially and economically viable and should create and maintain cultural values. In this regard, the challenges facing light-frame construction manifest themselves in multiple facades including

- Envelope performance research,
- Structural examination,
- Economic feasibility study,
- Code and bylaw implementation
- Framing related education,
- Marketing strategies and
- Adaptation to the Finnish environment.

Many of these difficulties lie within the adoption of a new system, regardless of material choices. In the meantime, many challenges can be easily resolved by the absorption of international experiences related to light-frame construction. The international community, especially in North America, has become very mature in utilizing light-frame construction methods for the majority of their housing needs. The precedents of sustainable, economically viable solutions are evident and available. Information is readily available both in the perspectives of education possibilities and practical experiences. The roadblock ahead is the willingness at Finland's determinations to participate in this new race.

4 Market Maturity

4.1 Market Data

In this section of the thesis, the premise of the research defines the scope of market study in an aspect that visualizes the investment potential. In essence, an overview of the market situation serves as a practical starting point to determine the penetration point to order to help better strategize an initial involvement. Granted, without proper experience, a certain level of disadvantage is expected, which often involves expenditure on a pragmatic level. Among which, additional research and development, marketing, education and overall preparation of the subject would be a necessary first step. However, similarly to any initial stage of progression, one must look beyond the immediate return and exhibit a higher level of vision in understanding the potential of long-term development. In the context of this study, it is imperative to draft a broad-stroked background information as a fundamental entry point into understanding the current market situation. In return, an in-depth analysis of the market can then be conducted to position the approach at the most appropriate level.

For the purpose of the data collection, four categories were organized in order to draw a clear picture of the current market situation. An overall review of economic data related to the construction industry sets the backdrop of the current market margin. The overview involves statistical information from the forestry industry which was a primary boost in the Finnish economy. Next, an overview of the current construction market trends, data and valuation were highlighted in order to provide a blanket coverage of the situation. Further, a collection of existing, current and planned mid-rise timber apartment buildings was documented as supplementary information to further visualize the market composition. Additionally, the projects served as a function to highlight significant entities leading the market in certain directions. Due to the unique historical progression in Finland's construction industry, pioneers shaping the market may not congregate on single disciplines. That is to say, a large variety of professions and trades form the overall movement of the mid-rise timber-residential market. Denoted by this factor, a standalone section of leaders of market entries were included in this chapter to highlight their functions and contributions to the market shift.

4.1.1 Finnish Forestry Industry

As a pretense of timber construction data collection, the backdrop of Finnish forestry's significance should be highlighted in order to properly understand the potential for growth in the construction sector from a material supplying point of view. Specifically, the manufacturing of wood products supported by the forestry industry serves as an important factor in Finland's ability to further advance into the wooden construction market.

The Statistical Yearbook of Forestry in 2014 indicated that 75% of total land mass in Finland is covered by forests. The current total volume of Finland's forest reserve is over 2,3 billion cubic meters. Within less than three months of growing seasons, more than

100 million cubic meters of timber are added to the reserve per year. The annual lumber harvesting of forestry resources continuously stays below the annual growth. For example, between 2009 and 2013, around 72 million cubic meters of lumber were harvested for commercial use [16]. This means that Finland has been consistently increasing its stock of lumber reserves on a yearly basis. In 2015, a study by Yale University indicated that Finnish forest was the densest among the world at more than 4 500 trees per Finn[80].The economical return of Finland's forestry industry accounted for close to 20% of its entire export income. The forestry industry currently employs around 200 000 Finns which comprised about 8% of workforce [81]

Timber construction is a member of national mechanical forestry industry which generated approximately 11,5 million cubic meters of production per year. Of the sawmill industry production, 69% is exported while the export rate of plywood was at 84 % [15]. The strategic position of timber construction in relation to the forestry industry was emphasized by the industry's large share of consumption of sawn timber production. In essence, around 80% of the forestry industry's entire softwood timber products were used for construction purposes [20]. The level of consumption dictated the important position of timber buildings with respect to Finland's national economy, whereas currently more than half of Finnish sawn timber products were exported and not utilized locally [82]. The argument brought forth during the interviews was that local consumption of the production could increase the unit-value of Finnish sawn timber.

Although timber made up to roughly 40% of Finnish construction material consumption, the majority of its usage occurred in single residential projects and mostly in Finnish summer cottage homes as shown in figure 22 [83]. The greatest potential in the economical headroom lies within multi-storey residential buildings. Statistics have shown that in the mid-rise, multi-residential sector, less than 8% of the entire market share was constructed with timber as the primary material [1]. The concrete industry has monopolized this sector since its maturation in the early 60s. The prolonged development period and consequently mature technologies for concrete helped secure its position in material choices among Finnish projects. This was the fundamental circumstance in the hardship in timber's progression in the residential sector.

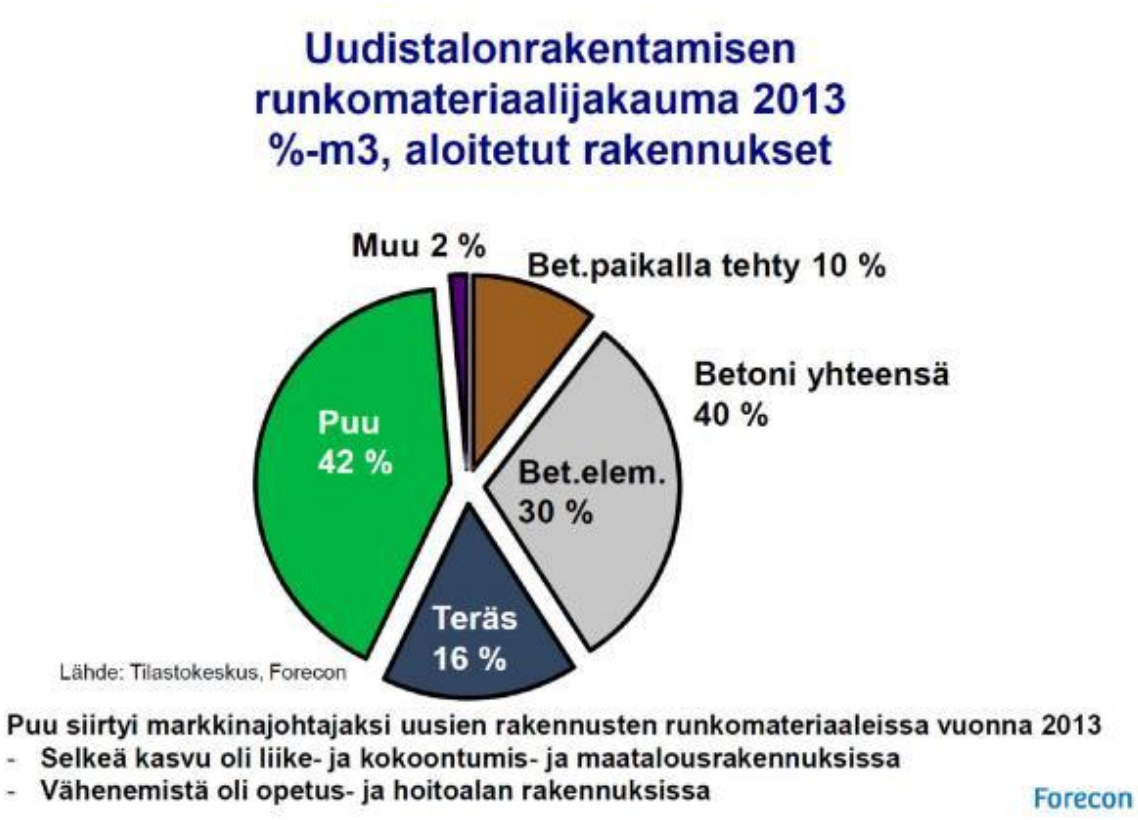


Figure 22. Share of construction materials in Finland [83]

4.1.2 Housing Margin, Trends, Valuation

In Finland, more than 70% of building projects were for residential uses. Among all of the member states in the European Union, Finland came in second with 43% of its population living in apartment buildings higher than two storeys [1]. This translated to around 1.4 million families living in mid-rise multi-residential buildings. This data defined the fundamental margin where the market for timber buildings could potentially advance into. The National Wood Programme initiated by the Ministry of Employment and Economy specified a target of a 10% market share for mid-rise multi-residential apartments built in timber by 2015 [23]. The market data above could be roughly translated to around 28 000 potential households being in the timber mid-rise sector.

According to the statistics in the early 2015, housing price in the multi-storey residential sector increased by 1.1% [84]. Average housing price in this area per cubic meter was €•2,393 throughout Finland. In more urbanized areas such as Helsinki, price went up to €3,682 [85]. On the other hand, construction costs stayed relatively the same this year with a marginal increase of 1% in labour costs and 1% decrease in material costs. However, the number of building permits granted in cubic-meter volumes in 2014 saw a dramatic decrease of 17% compared to the numbers in 2013 as shown in figure 23 [84]. Within the granted volume, the number of dwelling units increased by 7% while the buildings areas decreased by 3.3 %. This data indicates that denser and smaller units were more common in 2014 than in the previous year. Specific reasons for this fact are given at later chapters of this thesis. Between Helsinki and the rest of the country, pricing for dwelling units showed an upward trend with Helsinki leading the figure with a 1.8% increase in the month of September 2015 [84].

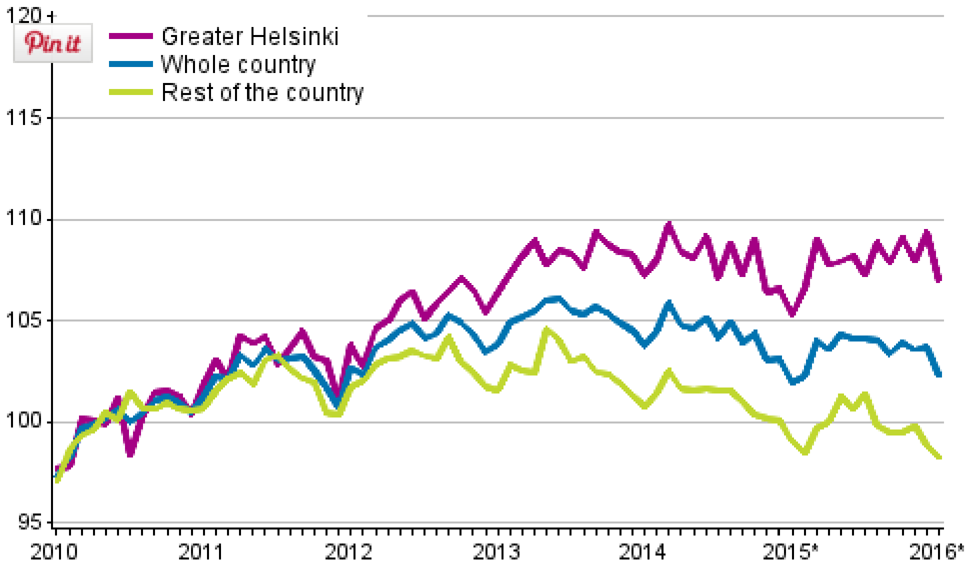


Figure 23. Housing price throughout the region, [84].

In general, housing prices, costs in Finland stayed relatively the same as last year, while the production volume saw a significant decline. This could be contributed to the effects of the current global downturn with other factors such as national strategies coming in play as well.

4.1.3 Existing, Current and Planned Mid-rise Timber Projects in Finland

An effort of building a detailed database of every existing, current and planned timber construction in the multi-residential sector was carried out for the purpose of this report. Since the implementation of a new building code regulation in 1997 which allowed timber facades to be installed without significant permit application procedures, Finland has seen a few spurs of growth in this sector. The overall positive growth rate in the past few decades only improved Finland's overall knowledge in building timber buildings for multi-residential uses.

Between 1995 and 2015, a total of 1 129 apartment buildings were issued occupancy permits which allowed them to take in households. These apartments were constructed among 47 buildings in 20 projects. Locations of these projects covered mainly larger Finnish cities such as Helsinki and Oulu. The average area of the buildings located further away from urbanized areas was roughly 80 square meters while apartments located closer to central locations had an average area of 57 square meters.[85]

Under the push of the National Wood Programme, between 2015 and 2016, it was estimated that more than 2,500 new apartments would commence construction throughout the country. This number equals roughly 8-10% of the total planned construction in the multi-residential sector in the same period. Among the new constructions, Turku and Tampere took the top spots in location with 450 and 458 units respectively; while Oulu came in with 240 and Rauma with 160 [72]. This was a significant increase in unit volume as the total commencements within one year overtook the total volume constructed in Finland since 1995. This was an exponential growth in itself. Further from 2015, roughly 7 000 units have been planned at various stages of their parent projects, as shown in picture 24. It is necessary to point out, however, that not all of these projects would come to fruition as factors such as national economic strength, opportunities and politics could hinder them.[72.]

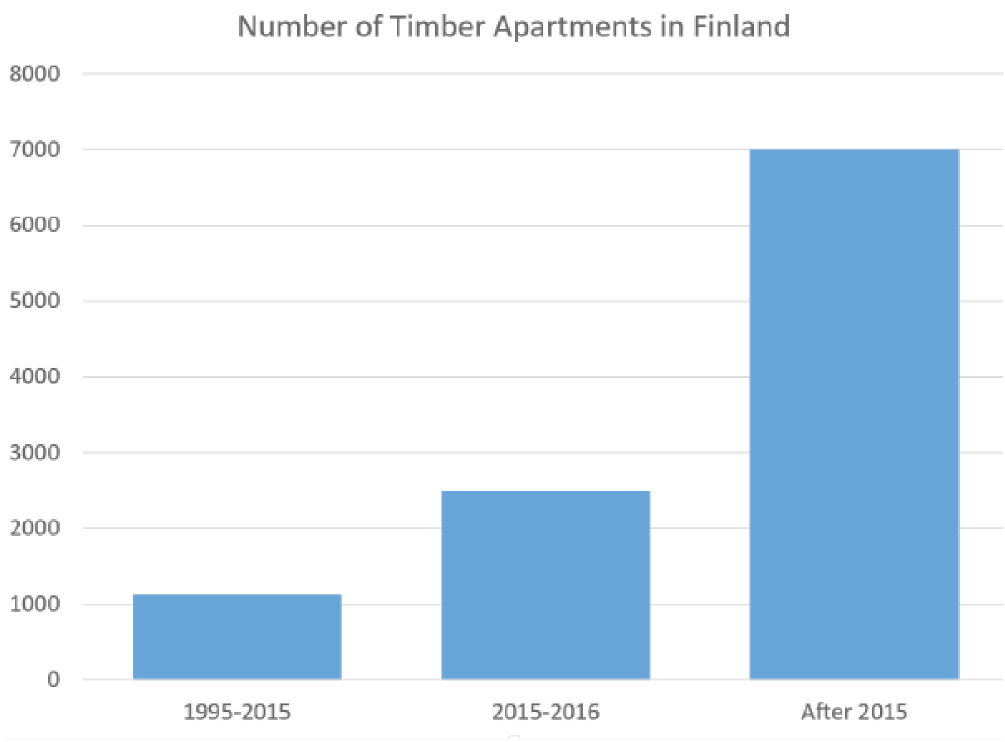


Figure 24. Growth of timber apartments in Finland, [72]

By calculating the potential for growth with respect to its percentage on the national number of households, it was estimated that 28,000 more households would be located within mid-rise multi-residential timber apartments. Although this is only a national guideline, this number further confirms the huge market potential in which timber solutions could march into.

The collected data of existing, current and planned mid-rise multi-residential buildings is found in the appendix 2 of this report.

4.1.4 Significant Industry Entities

One of the aims in the previous chapter was to highlight significant members of the industry with contributions and functions influential enough to shape the market trend and composition. On the other hand, this collection of significant members of the industry also serves as a secondary support for structuring the overall design of this report. This accumulation of company information was devised to analyze the market under the preposition of certain events or historical factors, which contributed to the shaping of the sector itself.

Among the chosen entities, certain aspects of its operations, philosophies or behaviors all invoked certain consequences on the market sector. In essence, these entities were factors comprising the entirety of the market margin. It was necessary to note that the relationships between the companies often dictated their operational models, business scales as well as client choices. This was also the reasoning behind the choice of order in the listing of these entities, as the overall connections among the members dictated their position.

Lakea Oy, Developer

Prefacing the introduction of relevant entities, it was necessary to follow the origins of the investment flow, which in the case of the construction industry often came from the developers. Lakea Oy in this respect, stood out as one of the most prominent and significant member in the real estate management and development sector. Lakea Oy is a Finnish nationwide real estate developer with close to 40 years of investment experience in both residential and commercial sector. Since its founding, it has completed over 11,000 dwelling units throughout the country. Although Lakea Oy is not the largest developer in the construction industry, it is, however, the most significant in its activities in the multi-residential timber apartment sector. [86.]

Currently, Lakea Oy is owned by 15 municipalities with the intention to invest into all areas of projects. Its focus on sustainable development is, however, the highlight of its operational philosophies. The owners of the firm firmly believe in the potential of timber and its environmental benefits in project design and construction. The long term returns on investment via sustainable development and managment projects formed its unique perspective in business management and operations. This is demonstrated further by its portfolio of investment efforts in Finnish residential projects.[86.]

To minimize the inevitable risks associated with Finnish timber construction, Lakea Oy currently invested 20% of its business into residential timber apartments while 80% was placed on concrete projects. Nevertheless, among all developers audacious enough to venture into the unfamiliar territory of timber apartments, Lakea Oy currently stands atop as the pioneer developer in this sector with the most extensive experience. With projects such as Jyväskylän Puukuokka in Jyväskylä, the first 8-storey timber apartment building in Finland, and Vanhasatamalahden Puukerrostalokortteli in Kokkola, a 190 unit, 4 – 8 storeys high apartment project planned for construction commencement in 2015, LAKEA is progressing rapidly in becoming a major driving force in this sector of the market.[86.]

In 2015, Lakea Oy aims to tackle the issue of the higher densified urbanization trend by providing adequate rental opportunities for the migrating population. The upcoming new technologies and knowledge were embraced by Lakea Oy’s vision of sustainable development and long-term benefits not only to the company itself but to the industry as a whole.[86.]

<u>Stora Enso Oyj, Product Manufacturer</u>

Stora Enso Oyj stands behind the operations and the financial backbones of Lakea Oy. As the leading product manufacturer it is in the position to influence and drive the market in certain directions. Lakea Oy works with Stora Enso Oyj exclusively for its capability to deliver desired products at qualities and quantities suitable for the vision incepted by its developer.[87]

Stora Enso Oyj in itself, however, is one of the world’s leading paper, packaging, wood products and bio-materials manufacturer. Its revenue in 2014 reached €10.4 billion with wood products accounting for 11% of its operational activities. Among the wood products, Cross-Laminated Timber accounts for the majority of its activities in different variations both in standalone elements and pre-fabricated modules. [87]

One of their primary benefits of Stora Enso Oyj’s prefabrication modules using CLT elements is their possibility to be manufactured in a closed-factory setting. This methodology removes the concerns regarding external conditions such as unfavorable weather as well as logistical difficulties involved in labor-related aspects. To expand further, traditional labor consumption on-site typically involves unregulated safety measurements, pay guarantees and benefits. The employment of international migrants often results in lower wages which undermines the various aspects of production quality. Having the workforce situated in a closed factory setting, more thorough inspections and quality assurance applications could be instigated without additional expenditure. [87.]

Additionally, pre-fabricated elements allowed quick and easy on-site assembly, where unfavorable conditions are more prominent. This fact has been significantly advertised by the manufacturer as a primary concept in reducing construction time and, consequently, costs. This characteristic trait, in combination with Stora Enso Oyj’s value in advancing timber-related sustainable design, put the company in the center of Finland's mid-rise timber residential sector. [87.]

To further expand in this respect, Stora Enso originally devised two preliminary construction systems in an attempt to improve the efficiency in its production line. With the introduction of Finnish Wood Research Oy's RunkoPES construction system, Stora Enso strove consistently in adapting to the new methodologies and technical concerns. The attractiveness of the flexibility in RunkoPES system in design prompted a curiosity about its potential to improve Stora Enso's marketability in its standalone CLT line. In conjunction, an interest in pre-fabrication was introduced and subsequently the CLT module technology was developed and put in production. Over time, the benefits and consumer interest in the module system grew which diverted Stora Enso's production strategy into more modularized assemblies with interior finish up to furniture and dry walls. This ensured Stora Enso's leading position in CLT prefabrication among Finnish manufacturers. The module technology developed over time to compensate for a wide range of obstacles in terms of technical difficulties and challenges. At present, Stora Enso's pre-fabricated modules are planned to be utilized in one of the largest timber projects in Finland.[87.]

Reinforcing the success of its prefabricated modules, Stora Enso Oyj has expressed an interest in pushing for more standalone CLT elements within the Finnish market as well. This is seen as an expansion to its global market - as previously only CLT modules were available to the local industry sector.[87.]

Based on its methods of operation, Stora Enso maintains currently an exclusive list of clients to sustain a high standard of quality production. Two major market regions contributed to its revenue base for its CLT and pre-fabrication function. Internationally, its factories in Ybbs and Bad St. Leonhard, Austria, provide standalone elements globally while its numerous operational locations in Finland provide elements and modules locally. Based on the information gathered from the interviews, companies who exercised joint ventures with Stora Enso all expressed positive evaluations about their experiences working with the firm. Highlights were placed on Stora Enso's customer services, technical support, as well as its professional attitude. Partially because of this excellent working dynamics, Stora Enso has only employed external designers for its significant projects such as the collaborative efforts exercised on the first 8-storey timber residential building in Finland - Jyväskylän Puukkoko. Additional significant projects include the Jätkäsaaren Wood City in collaboration with SRV as well as the Eskolantien Energiatehokkaat Puukerrostalot located in Vantaa as shown in figure 25. [87.]

Figure 25. The WOODCITY project with SRV [87]

<u>MetsäWood, Product Manufacturer</u>

Similar in function and market contribution as Stora Enso, MetsäWood, part of Finnish MetsäGroup operating exclusively in the forestry sector, is responsible for a wide range of activities including paper, packaging and forestry-related products and services. The revenue of MetsäWood was €0,9 billion in 2014 with around 20% of its market share located in Finland. The most significant line of products is its sawn timber capabilities with varying grades and qualities. In this regard, it is important to acknowledge that all of MetsäWood's sawn timber products are originated from top quality and traceable Finnish north forest harvests. The short growing season in Finland results in a dense structure in Finnish lumber which significantly improve its qualities such as structural strength.[90]

A second product line by MetsäWood is the Kerto® brand of Laminated Veneer Lumber [LVL]. LVL is a branch of engineered wood products which employs a technique of chemically binding several layers of thin lumber to yield a much stronger load bearing softwood veneer. Branches of the Kerto® line include products with cross and parallel binding veneers. The Kerto® products are typically used as load bearing beams due to their excellent dimensional stability. As an attempt to promote the Kerto® line products, MetsäWood devised the "Plan B" concept in 2014 which encompassed a notion of redesigning and constructing historical landmarks with the Kerto® line engineered products. The purpose of this exercise was to demonstrate the structural stabilities of the products and promote collaboration among different disciplines associated with the realizing such an effort.[88.]

Current market contributions of MetsäWood include a series of two to four-storey residential constructions in Helsinki near Viikkin Latokartano. The finished buildings house 104 dwelling units with more than 6 000 square meters of sellable space. Further down the production line, MetsäWood is involved in the execution of the Tuuliniitty Puukerrostaloalue project in Espoo which will house more than 500 dwelling units and occupy more than 38 000 square meters of gross floor area.[88.]

SRV Rakennus Oy, Construction, Project Management

One of the exclusive clients of Stora Enso Oy which it shares a long and stable relationship with is SRV Rakennus Oy, a leading construction and project management company. SRV's primary functions are housing, infrastructure and logistics with 8% of its revenue generated in Russia and the rest in Finland. In 2014, despite the national and international economic downturn, SRV was able to generate more than € 600 million in profit. This was largely due to SRV's unique operational method in project management which distanced itself from obligations related to insurance costs, staffing overheads and localized labor cost inflations, explained in the following paragraph. [89.]

SRV's project management module allows it to be free from external economical turbulence during the contractual period. The company takes on responsibilities on the higher tiers of the production chain and employs sub-contractors to tackle specific tasks such as technical solutions and problem solving both on and off construction sites. This operational model allowed SRV to employ lesser but more capable professionals with the intention to manage and oversee. Consequently, internal overhead was reduced efficiently while the overseeing position allowed SRV to take on projects often on a short notice. The success of this business model prompted other similar construction companies to operate under similar principles.[89.]

Working exclusively with Stora Enso, SRV leads the timber multi-residential market with a multitude of significant projects. The Penttilänrantan Puukerrostalokorttelit in Joensuu is a long-term development envisioning 350 timber apartments occupying more than 26

000 square meters of gross floor area. The estimated development period extends till 2030 and the majority of construction in Joensuu will be associated with this project. The Jätkäsaari Wood City project just broke ground in its parking structures in August 2015 while the rest of the production will carry the project further till 2030. The Wood City project is a pilot community plan showcasing the benefits of engineered wood in its capability to produce 8,000 square meters for residential uses as well as additional area allocations for office, hotel and commercial uses.[89.]

In 2015, SRV Rakkenus Oy prepared to embrace a challenging year as the economic situation in Russia continued to deteriorate. Locally in Finland, the company expressed optimism in its position in the market as it recognized the potential of increased national requirements due to Finland's internal migration. Conversations in the interviews with SRV exhibited a level of confidence in the company's capability to adapt and transform itself to better suit the unique Finnish market demands.[89.]

RKL Reponen Oy, Construction

Similar to SRV as a construction entity, RKL Reponen Oy stands out as a company with a unique position in the mid-rise timber residential market. The opportunities currently utilized are extremely particular in their potential contribution which may propel Reponen into one of the leading construction companies in Finland.

A locally established and traditional construction company, Reponen currently employes 60 people with its operations carried out in Greater Helsinki area only. Previously, Reponen was responsible for a 5-storey, 27-apartment building in Vierumäki, finished in 2011. Despite the project's relatively small production size, Reponen was able to develop a "MERA" concept which encompassed the notion of energy efficiency from a perspective of the entirety of a building's life cycle. [90.].

Following its own energy efficiency model, Reponen has made progress on Europe's largest timber residential building located in Vantaa. The PuuMERA project located in Kivistö includes 186 units occupying 11,800 m^2 of marketable space. The first level of concrete structure was built to support six more levels of timber structures utilizing engineered wood products such as glue-laminated timber. In an interview with Mika Airaksela, CEO of Reponen confirmed that the transition from concrete to wood allowed the construction time to decrease by more than 25%. However, savings gained by this shortened construction period were mitigated heavily by the additional costs of having timber as a primary structural material. The added costs of fire safety, acoustical and structural designs almost completely negated the savings on construction time. [90.]

The upside, however, is that Reponen's internally devised operational construction methodology became significantly matured during the commencement of this project. Gathered from various interviews, it became clear that the secret to Mika Airaksela's confidence lied within his vision in the reduction on the technical, and consequently, cost headroom associated with engineered wood and its construction practices. A confirmation was received from Mr. Airaksela on the project's profitability over similar concrete counterparts. Combined with its physical location within close proximity of the Vantaa Housing Fair 2015, the Kivistön PuuMERA project was the pivotal point from which Reponen could gain global attention.[90.]

Continuing in 2015, Reponen has planned two more similar residential projects totaling 158 dwelling units. Both projects are located in Helsinki and construction is expected to finish late 2017. Mr. Airaksela has expressed an optimism involving their experiences and future expectations. The company has matured its open-construction system and is in the process of realizing the reduction of cost headroom associated with timber practices. To a certain extent, the void of industry standardization served as a benefiting factor for Reponen as the majority of competitors similar in capacity have not devised a noticeable impact on the market yet. [90.]

Finnish Wood Research Oy and Puutuoteteollisuus Ry, Research, Lobbying, Information

At the back end of the production chain, a series of research and development support helped educate, advocate and promote timber mid-rise residential construction in the most essential and progressive manner. The governmental programme support in this aspect proved the national interest in the utilization of Finland's abundance of natural resources. Furthermore, the recent economic downturn put a significant amount of pressure on the industry to seek innovative and effective solutions. Among which, timber construction in its material utilization was considered one of the more prominent ways of resolving the issue. [91.]

Among a number of research organizations in Finland, Finnish Wood Research Oy [FWR] and its unofficial successor Puutuoteteollisuus [Finnish Wood Product Association] stand at the center of the market drivers. Established in 1998 as a non-profit, the Finnish Wood Research Oy held the agenda of organizing and seeking funding for the organization's supported research and development projects in different areas of the timber industry. An interview with one of the senior researchers at FWR revealed the fundamental drive behind its agenda. The global competition from a number of developing countries especially in Asia encouraged Finnish wood product manufacturers to consider the most efficient way to strategize their ability to remain relevant in the global market. As a result, the Finnish Wood Research Oy was constructed as a platform for innovative technologies and solutions to be developed and presented to investors. [91.]

As a main research focus of the Finnish Wood Research Oy, an open and adaptable timber solution suitable for the mid-rise sector was necessary to improve the efficiency of a project process. As a collaborative effort concluded in 2006, the "RunkoPES" construction system was developed together with structural engineer Tero Lahtela for such a purpose. By the unique system which targeted specifically for engineered timber solutions, a number of connection details were conceptualized for standardization purposes. This agrees with Mr. Lahtela's vision of providing a standardized documentation process for the construction phase of a project realization. The current version of the RunkoPES system is 2.0 with improvements on the overall efficiency and quality of the construction system.[91.]

Sources from relevant interviews indicated that in the early 2014, the Finnish Forestry Industry withdrew from lobbying for its wood-base product manufacturers. This vacancy initiated a process to install a concentrated effort and voice for the purpose of industry representation. Furthermore, this representing body would also provide a platform for the construction industry with functions based on collectively identifying efficient ways to promote the industry. As a result, the Puutuoteteollisuus (Wood Product Association) was established as a successor to the Finnish Wood Research Oy after its dissolution in late 2015. The organizing and fundraising functions of the FWR were transferred adequately transferred to Puutuoteteollisuus and embedded as their overall agenda. [92.]

Additionally, Puutuoteteollisuus resumed a number of other objectives in its push for industry imagery and representation. Its primary functions included lobbying for industry regulations as an effort to strengthen the overall facade of timber products as part of

Finland’s bioeconomy strategy. The organization also pushed for more retail opportunities for wood-related product solutions, as well as advocating research based programmes. Its efforts in regulatory standardization was essential in streamlining the overall efficiency in timber applications, specifically during the stage of permit approvals by the official channel. The organization has dedicated a significant amount of its resources in realizing a time frame by which a convergence between European regulations and Finnish regulations was accomplished [92].

4.2 Market Influences

Market trends and manoeuvrability in the context of this thesis serve the purpose of identifying the influential indicators behind the production push. Certain questions of the interviews were targeted at leading professionals for their exclusive experience and insights on market maturity and outlook. Statistics Finland has provided evidence suggesting downward tendencies in housing applications and construction overall. However, testimonies from industry leaders, researchers and architects all point out different theories and predictions. In general, the negative effects of the global downturn altered Finland’s overall imagery of its competitiveness in residential constructions. However, the activities within the timber industry, especially with respect to the multi-residential sector, provided dramatic lifting in its confidence of the market as well as its enthusiasm in adapting to Finland’s national considerations.

To expand further on this front, the National Wood Programme, devised by the Ministry of Employment and Economy, aimed at a 10% hard market share for timber mid-rise residential housings [94]. The exponential growth discussed in previous chapters indicated a confidence in this specific sector despite the overall economic downturn. To better facilitate the recognition of relevant indicators, significant influences were categorized according to their external and internal contributions highlighting their importance in and outside the industry.

4.2.1 External Influences

To visualize a broad coverage of the market situation, drivers behind the extrinsic influences, such as market demand and supply relationships and demographic shifts, were explored for the purpose of this thesis. In general, these drivers often push the market in an involuntary direction without significant leveraging potential from the industry's internal investments and strategies.

Internal Migration

One of the situation drivers identified during the interviews was the nation-wide, localized migrating population phenomenon. The higher level of urbanization in the southern edge of Finland especially within and around the Helsinki region, attracted a significant increase in the aggregation of population during the past few years. Statistics Finland indicated that in 2014, the Uusimaa region alone accounted for 87% of Finland's entire internal migration with close to 18,000 additions to its population. Helsinki accounted for the biggest growth in the year seeing an addition of more than 8,000 people. On the other hand, among municipalities in the rural regions, population continued to decline with only 96 municipalities of the total of 317 municipalities seeing a slight growth. [93.]

Ramifications implied by this level of urban migration could be interpreted at many different levels. On one hand, the increased densities in urban regions have put significant pressure on efficient and affordable medium to high density residential unit production. In other words, the raw market margin for mid to high rise multi-residential building projects should expect a respectable level of growth. This positive demand curve would certainly activate the local construction industry in its efforts to provide suitable housing solutions and result in a shifted mind-set in the residential market composition. [93.]

On the other hand, however, migrants from rural areas of Finland might not be able to absorb the relatively heavy pricing point of urban dwelling units[84]. Their financial capability would not often protect them from the contrasting differences between the remote and the urbanized regions. In 2015, Statistics Finland released data indicating the average housing price for typical dwelling units in blocks of flats to be around €1,700 per square meter. In contrast, typical apartment pricing in the Helsinki region recently reached €4,000 [84]. While this was expected given the supply and demand relationships in real estate pricing policies, to be able to adapt to the local and expensive market, certain strategies would have to be employed to increase the affordability of the dwelling units.

The lowered consumer capacities coming from the increased population, combined with the increased density, promoted smaller unit sizes with more affordable designs as a housing solution. Different rental and purchasing options have been presented to the public in order to meet the more specific demands within the market sector. On a general level, these options will be an acceptable solution on the condition that the economic environment of the country would be relatively stable. However, given the recent turbulences in Finnish economy, construction companies may not have the audacity to venture into the affordable housing market without extensive research on its feasibility in design. Consequently, this lack of feedback in relation to the increased housing demand poses a bottleneck in the overall growth of the Finnish construction market. Some of its direct results would be a lack of consumer confidence and inadequate accommodation of migrants which could potentially alter their decision or experience on becoming part of the productive work force. [92.]

Dwindling and Aging Population

On another front in understanding the shifts in market composition, it became compellingly evident that the aging of the population in Finland would contribute significantly to the change in market composition. The age structure of the Finnish workforce has slowly become unstable in its ability to renew and replace the older generations. Statistics have shown that the number of permanent residents of Finland above the retiring age of 65 has consistently been growing and recently reaching 20% of Finland’s entire population [94]. To put this in perspective, according to a recent study, Finland was considered one of the top five fastest aging countries in the world [95]. Furthermore, the able-bodied workforce in Finland has been steadily dwindling for the last several years. According to statistics, the age group between 20 and 64 has seen a decline for five consecutive years [94]. The combination of these two factors has put tremendous pressure on the industry in adopting strategies and solutions to alleviate the structural concerns. To solve this problem, leaders in the industry provided two possible solutions during the interviews.

The first possible solution is a strategy to allow external labour force to enter Finland and become part of its supporting employment structure in the construction industry [14]. This strategy would promote immigration from other countries to Finland and alleviate some of the more immediate concerns. However, the immigration strategy is a double-edged solution since it will bring about other socio-economic difficulties for both the immigrants and Finland. Cultural and language differences, racial tension, as well as local integration are all part of the difficulties facing multiculturalism and internationalism. The immigration crisis in Europe during the later months of 2015 is a startling reminder of the difficulties Finland would be facing if this strategy was employed.

On the other hand, in order to accommodate the retired group, a certain capacity in senior housing projects will be required in the current market examination of itself. Finnish culture values often promote a self-dependent mentality, especially among the older generations, where living with their children is not a suitable and preferred option. To mitigate this phenomenon, high quality and well-designed senior housing projects could open a market potential on a larger scale. Some current municipality plans have already designated designs and solutions to incorporate projects life this.

4.2.2 Internal Influences

In the industry itself, external factors played a less significant role in pushing the growth into desirable directions. A significant magnitude of influences would often result in a market shift in very specific and unique ways. For the purpose of this thesis, several aspects of influential factors are discussed because of their historical and economical values. This is done for the purpose of contrasting the impacts on various disciplines of the industry.

Standardization of Different Systems

At the core of the issue in market maturation, the Finnish construction industry is facing a crossroad in its regard to available construction systems for mid-rise timber apartment buildings. The short implementation of platform framing was important in its barrier breaking value in introducing a new system into Finnish architectural designs. However, after the initial cool down, Stora Enso's prefabrication system was a step further from this adoption which then resulted in another different construction system to be invented in place of new timber projects. MetsäWood in the meantime slowly derived its Kerto LVL engineered wood system as a variation of North American balloon framing system. Reponen slowly adopted an open framing system in which they utilize individual engineered wood products such as Glulam for columns and beams. Additionally, the Finnish Wood Research Oy introduced a RunkoPES system in direct competition against the BES system, widely utilized through-out the concrete market. [14.]

Although projects done according to these systems have been proven to be structurally sound, the lack of standardization of the technicalities has proven to be a much deeper problem than the construction itself. During the interviews, it became evident that from an outsider's point of view, all four systems would have to be studied prior to design realization in order to facilitate the most optimal option for the project itself. [14.]

The effect of this lack of standardization has posed significant difficulties in many different disciplines among the trades. On a broader scale, timber itself within a Finnish, multi-storey context was a relatively new identity. The associated research and development efforts for any new material were stringent enough to force the performers to be at least conservative. Take the Eskolantie project in Pukinmäki for example, the structural design for the pre-fabricated modules was so new to the structural engineers that during project meetings, a "one hundred times over-design" was proposed in order to make sure that the modules would stay stable. From the developer's point of view, the obvious impact of this conservative point of view was the additional cost. However, the engineers themselves often saw no other solution than to be extremely conservative at a cost of the building design to secure future responsibilities.[96.]

Challenges in adaptation to a newer material were only one side of the overall problem. While the practice of sizing conservatively can somewhat remediate the structural concerns, associated issues such as fire safety, acoustical and vibration accommodations, moisture prevention, as well as energy performance would also require triple, if not quadruple time to analyse. The level of sophistication as the additional, hidden efforts and costs has imposed difficulties on a very singular group of the trades, namely engineers, who were more vulnerable in introducing great chances of error, inefficiencies and additional costs. [14.]

On top of this, in this chaotic environment where there is a lack of regulations, prominent architectural firms excused themselves from attempting to enter the market primarily due to the fear of large scale soft investments. This lack of timber construction knowledge formed a strong insulator for enthusiastic and passionate designers to audaciously venture into the market for its ingenuity and optimism, thus slowing down the progression in possible innovative progression of the overall architectural picture. [14.]

Granted, an architectural proposal as a general solution should always consider external factors such as market demand and innate structure. However, having forced to consider the practice in a much more restrictive and superficial manner such as “how much risk is there” was prohibitive in providing a respectable solution. In that sense, the lack of standardization currently maintains a top reason of the reduction of the overall efficiency in the mid-rise timber construction industry.[14.]

Although it is easy to perceive that standardization should provide unified design solutions to engineers and architects, it is also important to acknowledge that the unification of different systems is a continuous effort and should not be perceived as an end goal. The efficiency of a project design is largely dependent on streamlined knowledge of its execution. In a manner similar to a manufacturer’s profit making procedure, once the more obvious and prominent issues are resolved, hidden and underlying problems will start to occur. This is the process where continued improvements to the systems are identified.[14]

In a way, the sole purpose of the standardization of systems is to prevent unforeseen surprises. It is not the defining factor in shaping the architectural and construction industry, as it is a very gradual and organic process. However, with the implementation of a more streamlined knowledge base, more freedom could be given to designers and engineers on matters such as material choices, thus improving the overall quality of Finnish architecture.[14]

Atop one of the most forefront agendas of Puutuoteteollisuus, the standardization of the systems in combination with their R&D efforts in collaboration with the European codes continues to be the primary cause in the organization’s establishment. The current government has expressed excellent interest in providing timber construction with a fertile ground for its advancement in the market region. Significant programmes at the national level have greatly boosted the confidence of the timber sector. At the core of the governmental support is the reduced taxation of energy intensive industries by an amendment through an energy-tax refund mechanism which could lower the tax obligation by €120 million [99]. Additionally, governmental level efforts have started to streamline the certification efforts by restructuring the building related regulation in an attempt to accommodate timber as a more widely recognized construction material.

<u>Position Shift of Construction Companies</u>

Traditionally, construction companies adopted a simpler role in building assembly and erection. The composition of a construction company was similar to that of the current subcontractors such as dry-wallers, foremen or machine operators. Within the last decade, however, the internal structure of a construction company has changed drastically based on the market shifts. The centralized role of a project manager originally belonged to architect who oversaw the overall progression of a project. The coordination of different trades had to be approved via the designers simply because of the fundamental designer position of an architect given the project context. Change orders, requests for information, as well as project amendments were all part of the progress during the commencement of a project. The original consulting role of an architect was the focal point because every change made to the project could have an implication on its design value. The “job captain” position was almost exclusively assigned to architects.[97]

In the situation of Finland, due to the power balancing between engineers and architects, construction companies assumed the role of project managers in the attempt to concentrate their efforts on managing risks. The internal structure of construction companies slowly adopted to a professional project manager role with a large bank of sub-contractors at their disposal. From a business standpoint, this type of strategy insulated the construction companies from liabilities associated with the workers as most contractors were responsible for the safety requirements themselves. It also promoted fierce competition among the sub-contractors themselves in order to be granted the work.[97][14]

The resulting phenomenon was certainly double-sided. On one hand, capable contractors quickly demonstrated their ability to deliver proficient and high quality products, while the less capable entities had to be competitive to maintain their existing revenue. The competition may result in an improvement in the sub-contractors’ general work quality. On the other hand, in order to meet certain strict deadlines imposed by the construction companies, sub-contractors might choose certain alternatives which could have underlying issues not immediately visible to the construction companies themselves. [98]

Additionally, by assuming the role of the project manager, construction companies started to have the freedom to set the project progression according to their own internal management schedules. Since the relationship between developers and construction companies often became the defining factor for the success of a project, an uneven level of pressure may be pushed onto a sub-contractor for often unrealistic deadlines, which further contributed to the potential decline of construction quality.[98.]

Above all, this entire production chain did not concern itself with the architectural design in any regard. The market itself became a fertile ground for profit seeking between the end contributors of a project process. The role of a designer was insignificant in comparison to the others which promoted a lack of architectural quality in project execution. The emergence of the role of a professional project manager was the direct result of architects distancing themselves from the job sites. At the same time, the communication between the two disciplines became more difficult. Generally speaking, an architect should take on the role at the centre of all disciplines and become the voice of the project itself. In the current Finnish context, this is not the case.[98.][97.]

The combined effects of these external and internal factors placed the Finnish timber construction industry in a very unique and distinctive spotlight. Although these peculiar characteristics were all part of the process for the leaders in the industry, essentially, the momentum of timber construction has been slow to gain market traction. The nationwide efforts to drive the market while maintaining a positive growth has been a rewarding but difficult challenge. However, in the mist of this semi-chaotic situation, orders were established albeit coming from a relatively rudimentary economical drive, but this was the point exactly, as the maturity of the market dependent largely on long-term vision rather than short-term gain. A sustainable and balanced approach should be explored in order to establish a strong foundation.

During the extensive interviews, it was established that in a hypothetical scenario, the collaboration between systems should take precedence in spite of short-term, immediate losses. The collective results should be capable of rewarding pioneers invested in the process. However, in the real world, all sought profits. It was with this sense that the careful manipulation of the influential factors be optimized to achieve a desired outcome.

4.3 Market Strategies

<u>The National Forest Programme 2015</u>

The proposal for Finland's National Forest Programme in 2015 was approved on January 25, 2008 by the Forest Council. The three main visions of the program included strengthening the forest-based business and increasing the value of production and improving the profitability of forestry and strengthening forest biodiversity, environmental benefits and welfare implications. The most significant aspect of the objective was to increase the value of competitive wood products and services and increase domestic usage of its productions. The targeted research and development efforts in this respect had been promoted significantly and given a high priority especially at increasing its internationalization efforts. The domestic production and consumption of wood-based products was essential in revitalizing the industry with added value to its existing products at the lower value-chain.[99]

The anticipated impacts of this objective targets at increasing the general value of the forest industry in both the overall profit level as well as the industry's unit pricing. Additionally, the investment of profits of the wood industry in R&D efforts is expected to increase dramatically. The overall efforts at increasing the domestic value of existing wood products will lead to an increase of exports by relatively similar capacity. In order to achieve these goals, several practical actions were devised in accordance with the vision outlined by the National Forest Programme. Among the actions, the government support for the revision of building regulations played a huge factor in increasing the volume of timber constructions and support the business in that sector. From the interviewees, this affirmative action differentiated itself from the previous government when the research was mostly done on paper.[99.]

<u>The Finnish Bioeconomy Strategy 2015</u>

The bioeconomy perspective for Finland was drafted by the Ministry of Employment and Economy as a strategy to push the Finnish economy into the next stage of transformation. As the traditional fossil fuel based economy started to see a decline, the ministry focused their effort on utilizing Finland's vast natural reserve in many different, sustainable ways in order to boost the Finnish economy. The realistic objective of the bioeconomy strategy is to provide 100,000 jobs and boost the output at €100 billion by 2025. Participants included a wide range of governmental agencies including Prime Minister's Office, Ministry of Agriculture and Forestry, Ministry of Environment, Ministry of Education and Culture, Ministry of Social Affairs and Health, Ministry of Finance as well as research funding agencies such as VTT and Finnish Innovation Fund Sitra.[100]

The strategic goals of the bioeconomy included four primary functions[100]:

- Creation a competitive operating environment for bioeconomy growth
- Generation of new types of business with risk management and mixing industries

- Education of related tasks
- Accessibility and sustainability of natural resources

The primary function of the bioeconomy in the context of timber construction manifested itself within the positive outlook the ministry has provided to the sector. The strategy itself recognized that the largest potential for growth in the timber construction was in the larger scale building sector, such as flats, offices, public buildings as well as various services related to timber construction. There were several channels where the support for wood construction could be utilized to be part of the four strategies mentioned above. Items such as increased educational effort about timber construction and strategic financing of research and development of wood-related products for the benefit of diversifying construction-related services were all areas within the implementation scope of the bioeconomy strategy.[100] The strategy focuses on providing systematic market analysis based on individual research and development projects and allow participants to address significant functioning issues accordingly.

5 Conclusion

The premise of this thesis positioned itself on the foundation of a pragmatic approach in addressing the validity of timber construction in the mid-rise residential sector. The purpose was to unveil an overall picture of the material choice, technologies available and market situation in order to understand the current situation, as well as possible advantages and disadvantages of the industry. In order to obtain sufficient and valuable evidence, a series of literal research together with interviews with prominent industry leaders were carried out. Additional significant projects and entities were highlighted which were then collected and aggregated accordingly to provide a thorough and unbiased market study.

Within the findings from the sources, the study identified major factors which shaped the current situation in the Finnish timber construction industry. An overall visualization of different timber products was followed by traditional and more modern technologies which has increased the profitability and success of timber constructions. The market findings suggested that external influences such as internal migration and aging population had a significant impact on the market composition which defined the appropriate responses from design firms and developers.

Because of market separation by construction systems, challenges arose when prospective industry members attempted to penetrate the market as the solution of each construction system was often different from the others. This difficulty led to the dis-encouragement of potential competitors, thus hindering the advancement of the industry. In connection with the current market situation, several strategies were documented and introduced both from a national programming perspective and as an internal review of possible policies. The Finnish government positioned itself as an advocate and promoter of the timber industry in general, with timber apartments being part of its national programming agenda. Several nation-wide programmes were in place to focus on utilizing natural resources from micro to macro scales. Internally within the industry, efforts on standardizing construction systems were in place, as were lobbying efforts by individual governmental organizations. A shift in the architect’s position was also suggested by interviewees as a partial effort in obtaining more control over design and, consequently material choices.

At the heart of the discussions, the validity of an architectural firm to enter the market could be established by examining the findings in this thesis. Extended on the arguments of market-trend inevitability, it was perceived that the notion to enter the market was no longer a choice, but a necessity. The Finnish market in the timber multi-residential sector is stepping into an era of chain reactions where market shaping events and decisions are being made constantly. In this seemingly chaotic and critical juncture, strategic movements especially by leading industry members could potentially determine the outcome of this market’s survivability. It would be at this point in the Finnish construction history that the defining characteristic of a timber nation is substantiated fittingly.

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Appendices

Appendix 1 – List of Interviewees

Ahto Ollikainen,	architect, Teema Arkkitehdit Oy
Antti Aaltonen,	project manager, SRV Rakkenus Oy
Antti Pirttimäki,	management consultant, Earnest and Young
Anu Pahkala,	architect, L Arkkitehdit Oy
Harri Koskinen,	partner, L Arkkitehdit Oy
Harri Salminen,	partner, L Arkkitehdit Oy
Jaako Lehto,	researcher, Finnish Wood Research Oy
Janne Maninen,	development manager, Stora Enso Oyj
Jari Lonka,	partner, L Arkkitehdit Oy
Jussi Mattila,	CEO, Betoniteollisuus Ry
Mari Ille,	architect, L Arkkitehdit Oy
Marrku Kaijalainen,	development manager, Työ- ja Elinkeinoministeriö
Mika Aiksela,	CEO, RKL Reponen Oy
Mikko Viljakainen,	director, PuuINFO
Niila Aunio,	architect, L Arkkitehdit Oy
Niklas Sucksdorff,	chairman of the board, L Arkkitehdit Oy
Robert Trapp,	CEO, L Arkkitehdit Oy
Sari Samuli,	architect, L Arkkitehdit Oy
Timo Mantilla,	managing director, Lakea Oy

Appendix 2 – Existing, Current and Planned Timber Apartments in Finland