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# Timber Multi-Storey Apartment Buildings in the Basque Country

**Asier Aurrekoetxea Etxebarria**
MSc Sustainable Architectural Studies, University of Sheffield

## Abstract
Timber, as a renewable material, has great potential to reduce the environmental damage caused by construction industry, responsible for the world's 40% of energy use, 30% of GHG emissions and 30% of raw material use, by replacing energy intensive materials. When timber is used for permanent structures such as building components or furniture, the carbon that was sequestered from the atmosphere during its growth is not released back to the atmosphere while its waste by-products can be used as biomass to produce energy.

The analysis of recent case studies such as Waugh Thistleton Architect's 'Stadthaus', Kaden & Klingbeil's 'E3' and Brendeland & Kristoffersen's 'Svartlamoen housing' reveal that timber is an economically viable alternative to concrete and steel, especially applicable in the Basque Country, where forests occupy the 68.5% of the surface and medium-rise multi-storey apartment buildings are the main dwelling typology in both cities and villages.

Keywords: Sustainable Building Materials/ Timber/ Biomass/ Resilience/ Bioregionalism

## 1 Introduction
The built environment is a major contributor to the global warming. Its overall environmental footprint includes world's 40% of energy consumption and about 30% of GHG emissions (SBCI, 2010). But not only energy and emissions are to be considered when analysing the sustainability of the built environment. World's 30% of raw material use, 25% of solid waste, 25% of water use and 12% of land use can also be attributed to construction (SBCI, 2010), resources that in its majority are non-renewable, making the damage to the environment permanent. Therefore more sustainable construction practises are necessary to mitigate the damage that the sector causes to the planet.

The Basque Autonomous Community (BAC), a south-western European nation located at the western Pyrenees that is the target area of the research, is a densely populated European region (300.5 inhabitants per km2) that puts considerable pressure on the environment (Eustat, 2012, Eurostat, 2012). Its abrupt mountainous geography results in population concentrated not just in cities but also in small villages, the total urban area occupying just the 5.8% of the total surface of the territory (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2005). In terms of construction materials, concrete has an absolute monopoly in the Basque Country. as reveals the fact that the 74% of the construction materials consumed in the Basque Autonomous Community are aggregates (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2004), the main raw material of concrete.

In a situation like the present, where the vast majority of the construction relies on a single material, the resilience of the area, its capacity to absorb disturbances or to adapt to changes (Walker et al., 2004), is very limited in terms of building materials. By contrast, introducing a renewable material that is capable of replacing concrete without

significantly altering the current construction trends of the BC, it would dramatically increase the resilience of the Basque Country while reducing the contribution of the construction industry to global warming.

## 2 Sustainable building materials

Concrete is the most widely used building material on earth (Ashley and Lemay, 2008), due to its low cost, versatility, ease of use, acoustic dampening, and durability. (Mackechnie and Alexander, 2009). Despite having a relatively low energy cost, concrete is very CO2 intensive material due to emissions from chemical processes involved in cement production (GRID-Arendal, 2008). Moreover, cement industry is the third biggest greenhouse gas pollutant worldwide, after transport and energy (Hall, 2006), with 5-10% of global CO2 emissions (Schoof, 2011). It also causes important resource consumption of different raw materials that are needed for its fabrication.

On the other hand, concrete structures are assumed to be largely maintenance-free and to provide long service lives (Ashley and Lemay, 2008, Mackechnie and Alexander, 2009). Its high thermal mass and low air infiltration helps make buildings more energy efficient, and usually can be sourced locally, thus reducing transportation needs (Ashley and Lemay, 2008). Moreover, recycling and reusing steel and aggregates can diminish the raw material consumption and the embodied energy of the building. In addition, and by using energy efficient technologies and renewable energies the energy intake and emissions can be also reduced by up to 25% (Greenspec, 2012b).

Timber, one of the oldest building materials used for shelter (McLeod, 2010), is from the construction point of view, a very versatile material, as it can be used to produce almost any type of building component. Moreover, it is recognised that timber outperforms other building materials in terms of malleability, adaptability and structural performance (Schittich, 2012). Additionally, new applications that were beyond reach, like urban large-scale multi-storey buildings are being added to timber solution's catalogue (Schittich, 2012), continuously overcoming the limitation for timber structural buildings.

If managed responsibly, timber is a renewable material that does carbon sequestration during its growth, (Yeang and Woo, 2010), therefore reducing the concentration of greenhouse gases responsible for global warming. Using harvested wood products (HWP) such as furniture or as a building material, the carbon that was previously absorbed is stored (Grêt-Regamey et al., 2008), while the trees that were cut can be replaced by new trees that will continue to absorb CO2. An additional advantage of wood is that is completely recyclable (McLeod, 2010), and when it becomes useful no more, it can be burned as biomass to generate electricity or to heat buildings, reducing the demand for fossil fuels (Zeumer et al., 2009).

To understand the implications of the timber-structure multi-storey apartment buildings, Waugh Thistleton Architect's Stadthaus, Kladen und Klingbeil's E3 and Brendeland Kristoffersen's Svartlamoen housing case studies have been analysed to understand the various factors and complex real-life situations that influence the whole process. Although in all cases timber was selected by the architects for sustainability reasons, what ultimately made possible to build them was the economic viability that timber prefabricated systems demonstrated, thanks to their short construction times. Even though the buildings had an environmentally positive effect, in some cases the timber had to be transported from other countries (Lowenstein, 2008, Anon, 2005), uncovering the lack of specialised industries in the sector.

Figure 1. Stadthaus, E3, Svartlamoen (author's own, 2012, based upon (Waugh Thistleton Architects, 2012), (E3 Berlin, 2012), (Brendeland & Kristoffersen, 2012))

## 3 Timber applicability and appropriateness in the Basque Country

The Basque Country is a territory of remarkable biodiversity, whose 68.5% of the surface is covered by forests (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2005). To understand the potential of timber as main construction material in the Basque Country, it is necessary to evaluate not just its natural resources, but also technical and economical viability, current regulations, resource management and possible interferences with other activities such as biomass fuel and paper and furniture industries.

### 3.1 Wood resources

The annual growth of the Basque forests is 3,831,250m3, just between 1,500,000 and 2,000,000m3/year of which have been used annually on average over the last decade, which leaves approximately the half of the wood unused (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2007). Additionally, the radiate pine, a very appropriate tree species for construction, is the main tree species of the BAC as it represents the 90% of the Basque forestry activity, the 48% of the total number of trees, the 35% of tree surface of the BAC and the 60% of the total annual growth of the Basque forests (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2005, Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2007).

Table 1. Main Tree Species in the BAC (author's own, 2012, based upon (Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2007))

| Tree Species (English) | Tree Species (Latin) | Stock (m3) | Annual Growth (m3) |
|---|---|---|---|
| Total | | 54,816,506 | 3,831,250 |
| Radiata Pine | *Pinus radiata* | 26,328,724 (48%) | 2,297,780 (60%) |
| Eucalyptus | *Eucaliptos* | 1,445,607 (2.6%) | 253,223 (6.6%) |
| European Beech | *Fagus sylvatica* | 8,278,223 (15.1%) | 217,991 (5.7%) |

Since the amount of timber required to build a fully timbered apartment building depends on the number of storeys, the structural timber typology, the layout, the regulations, the architect's and engineers' decisions etcetera, existing timber multi-storey buildings -Stadthaus, Wälluden and Viiki housing buildings- have been taken as benchmarks to calculate the proportion between the floor area and the consumed amount of timber.

Taking into account that for every m3 of processed timber between 1,75m3 and 2m3 of roundwood are required (Egoin Technical Service (egoin@egoin.es), 2012, Zeumer

et al., 2009), between 250,000m3 and 475,000m3 of processed radiata pine timber can be produced annually by using currently spare pine wood. Depending on the amount of available timber between 18,500 and 9,750 fully timbered buildings could be made every year using radiata pine. Being built 16,322 the maximum amount of annual dwellings over the last decade, the average of the same period 11,500, and in the context of the global economic recession around 7,000 dwellings in the last 3 years, the BAC shows the potential to build a significant proportion of them just using timber as structural material. Furthermore, considering that producers such as Binderholz produce CLT panels using breech tree which is not currently exploited in the BAC, the amount of prospective timber dwellings would also increase (Binderholz, 2010, Department for the Environment Spatial Planning Agriculture and Fisheries Basque Government, 2007).

### 3.2 Ability to meet requirements

Timber's ability to replace other materials such as concrete depends on its technical capacity to fulfil the demand of the specific target building typology of the area. In that aspect, the Basque built environment is very particular. In one hand, there is no difference between the density of the most populated cities and the municipalities with more than 25,000 inhabitants (around 4,500 inhabitants per m2) (Eustat (Basque Institute of Statistics), 2012). On the other hand, even though big cities, usually don't exceed 8 storeys height in their city centres (Bilbao City Council, 1994), The result is a homogeneous built environment where medium rise multi-storey apartment buildings are the dominant urban typology in both cities and small towns.

As proved by Waugh Thistleton Architects' 'Stadthaus', the world's tallest timber residential building, it is technically possible to build 9 storeys high using timber as structural material without compromising architectural quality (Waugh Thistleton Architects, 2012), what means potentially almost every dwelling in the Basque Country could be built using timber. Moreover, 'Stadthaus' complies with the current Spanish building codes (CTE) that would apply to this building if it was located in the BAC. In that hypothetical case, it would require a fire resistance of 90 minutes for evacuation routes and a sound insulation of 50dB (Spanish Government Department for Promotion, 2010) (Spanish Government Department for Promotion, 2009), both achieved in the finished original building, 90 minutes of RF where necessary and 55dB between flats and 53dB between floors (Waugh et al., 2009). Achieving high levels of thermal insulation is also compatible with modern timber structural solutions, as seen in Helen & Hard's 'Skadbergbakken housings' where Passivhaus requirements (Helen & Hard, 2012). Finally, Timber multi-storey buildings have proved economically viable in other countries, which is a key factor for the viability of any constructive solution.

### 3.3 Wood-consuming activities

Currently, timber is far from being a widely used structural material in the Basque Country. Concrete is used for almost every building in the BAC. Nevertheless, some remarkable efforts to boost timber are taking place boosted by official bodies together with some companies that commercialise timber products and the forestry sector. Apart from construction, paper and furniture industries are the most relevant activities that use wood.

The paper industry is an important traditionally rooted economical activity in the BAC that is responsible for the 1.2% of its total GDP (SPRI, 2006). As paper industry uses mostly eucalyptus and pine wood as raw material (The Cluster of Paper, 2008), if construction industry required more timber, the exploitation of eucalyptus, –which is

as it is not appropriate for construction and is currently far from the maximum– could increase leaving more pine for construction, the other tree species used for paper (Egoin Technical Service (egoin@egoin.es), 2012). The furniture industry, by contrast, has a reduced influence on the Basque economy, distinguishing itself as an award-winning quality sector committed towards sustainability rather than for producing large amounts of manufacture products (Arratibel, 2012).

In terms of energy, the Basque Country is extremely exterior dependant, with just the 5.8% of the energy being locally produced (EVE (Basque Energy Body), 2011), almost all of which is renewable, being biomass the most important type with the 64.2% of the production (EVE (Basque Energy Body), 2011)what makes biomass a very important energy source for the BAC. Timber, like other organic materials, has the ability to be burned as biomass to generate electricity, and can be obtained in two formats, grown directly as 'energy crop', or as a waste by-product (Greenspec, 2012a), in which case part of the carbon absorbed by the trees remains sequestrated. What is more, the United Nations consider that from GHG emissions point of view, it is preferable a cascade use of HWP, firstly using wood products, then reusing or recycling them and lastly obtaining energy from them, rather than their direct use as fuel (Hetsch, 2008), what makes compatible and also recommendable the combination of timber as construction material and the increase on biomass production. Therefore, increasing the demand of harvested wood products such as timber structures would automatically mean a rise in the amount of waste and consequently the available biomass fuel.

### 3.4 Bioregionalism

Finally, as the issue of using timber as construction material is to some extent relative to the management of natural resources, following bioregionalism, a body of thought that connects the socially-just human activities with region-scale ecosystems in a sustainable manner (Aberley, 1999), is more logical rather than considering the limited resources of a specific political body as isolated elements. The Spanish National Geographical Institute (IGN) recognises different bioregions, one of which is the 'Cantabrian-Atlantic Bioregion', comprising all of the autonomous communities that face the Bay of Biscay, including the BAC (IGN (Spanish National Geography Institute), 2011). As all these areas are less densely populated than the BAC (Eurostat, 2012), resulting in a favourable framework of presumably less dwellings demand in comparison to their natural forestry resources. Additionally, the south-western part of the French state, could probably be included in the same bioregion as it has similar climatic and geographical conditions, forming the bioregion of the south of the Bay of Biscay or the 'Biscay bioregion'.

## 4 Conclusions

Figure 2. Bioregion of Biscay (author's own, 2012, based upon (IGN, 2011b))

Recent building projects demonstrate that multi-storey timber buildings are not only economically competitive, high constructional and design quality but they also can be a step forward to achieve CO2 neutral cities (Kaltenbach, 2010, Gustavson et al., 2006). Timber made from sustainably managed forests can reduce the CO2 emissions thanks to the carbon stored within, it has a lower energy demand to be manufactured than energy intensive materials, CO2 emissions resulted in cement fabrication are avoided and increases the availability of biomass fuel as timber waste by-product, which is more effective in reducing GHG emissions than energy crops (Hetsch, 2008), which can be specially positive in highly energy dependant area such as the Basque Country.

Timber multi storey buildings proved to be highly applicable in the Basque Country, capable of perfectly fitting within the current built environment. What is more, the territory shows the capacity of producing a considerable amount of its annual dwelling demand by using timber, what proves the timber's great potential to increase the resilience of the Basque Country in terms of construction materials.

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