Innovations for sustainable building

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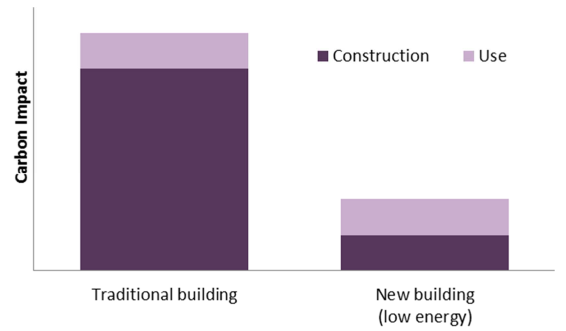
With an increasing focus on carbon emissions and a progressive strengthening of regulatory constraints in the building sector, the environmental impact of construction materials is becoming a major concern. In the medium term, these factors could lead to the emergence of 'low carbon' varieties of concrete or steel, or indeed to a better structuring of the wood sector, which currently remains underdeveloped despite offering certain advantages from the point of view of climate. What, then, are the investment opportunities that these trends present today?

In 2010, the building industry accounted for more than 20% of global greenhouse gas (GHG) emissions,[1] which have almost doubled since 1970 (IPCC, 2014).

The origin of this climatic impact varies according to the type of building. For 'traditional' buildings, the production of construction materials represents on average only 15% of their carbon footprint. For this type of structure, therefore, the issue is essentially to reduce operational energy consumption. Action on this front consists principally in better insulation and more efficient heating systems.[2] Indeed, despite the advantages in terms of thermal inertia and the reduction of thermal bridges put forth by the concrete industry, the choice of construction materials (concrete, steel, wood, brick, etc.) has in fact only a marginal influence on the energy consumption of buildings.[3]

The impact of construction materials should nevertheless not be neglected, primarily for two reasons. On the one hand, with the progressive reinforcement of regulations aiming to improve the energy efficiency of new buildings, the impact of materials is gaining in importance relative to use, reaching up to 50% of the energy total.

Figure 1: Carbon emissions profile of buildings by life-cycle phase



Source: Mirova 2015.

On the other hand, in the context of a growing global population and increasing urbanisation, in particular in developing countries, the production of construction materials will continue to have a significant impact. China, for instance, consumed more cement in the past three years than did the United States in the whole of the 20th century,[4] and emissions tied to the production of concrete and steel currently represent 5% and 8% of global CO_2 emissions, respectively.[5]

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[1] According to the IPCC, 18.4% of GHG emissions result from the energy consumption of buildings, to which must be added emissions tied to the production of construction materials.

[2] This point is already amply treated through our investment themes. See notably: http://www.mirova.com/Content/Documents/Mirova/publications/va/8themes/MIROVA_8%20sustainable%20themes.pdf

[3] On this question, see notably (CIM Béton, 2011)

[4] According to the Mineral Commodity Summaries of the USGS, China produced 6,191 million tonnes of cement from 2010 to 2012, whereas the USA produced 4,283 million tonnes between 1900 and 2000. See: http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-2012-ch.pdf

[5] It should be noted that, while concrete and steel are used for the most part in the building industry, this use is not exclusive: concrete is also employed in the construction of roads and other infrastructures, and steel has many other applications (manufacture of machines, automobiles, etc.). These figures may not therefore be attributed solely to the building industry.

Concrete, steel, wood: differences in environmental impact

Numerous materials come into play in the construction of a building. However, concrete, steel, and wood, being among the most used, require particular attention.

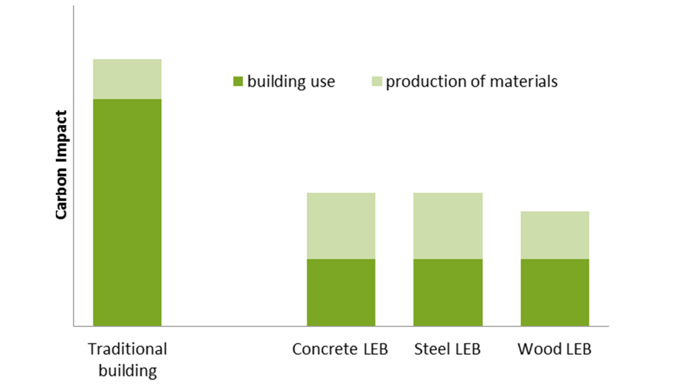
From a climate perspective and adopting a life-cycle approach, the choice of the construction frame – wood, concrete, or steel – has little or no impact on emissions tied to use. The difference in CO_2 emissions among different buildings is thus determined in terms of the emissions associated with the production of the materials.

The production processes of the three materials entail significant CO_2 emissions: ~100-150kg CO_2/t of concrete, 1.8t CO_2/t of steel, ~50kg CO_2/t of wood. However, these figures cannot be compared as such since, for the same structural element, the weight of the material used will differ significantly. For example, given equivalent technical requirements, a wooden and a steel beam will have a relatively similar weight, while a concrete beam will weigh at least three times as much. It is thus necessary to reason in terms of the building as a whole in order to compare different systems of construction.

> “ Wood’s natural capacity to stock carbon entails more limited CO_2 emissions than other building materials

The various analyses published on this subject by industry researchers or academics (Woodeum CLT, March 2014) (CORRIM, 2009), (CIM Béton, 2011), (Citherlet & Defaux, 2007) yield rather different results depending on the methodologies adopted, but the principal point to be retained is that steel and concrete buildings have a roughly equivalent carbon footprint, while wood presents a certain advantage, notably due to its natural capacity for storing CO_2. Indeed, in the course of their growth, trees absorb a part of the CO_2 present in the atmosphere. When used as a construction material, wood can thus maintain a stock of carbon that will not be released until the end of the building’s life cycle, several decades after its construction. In the end-of-life phase, the wood can potentially be used to produce energy as a substitute for fossil resources.

Figure 2: CO_2 emissions profile of buildings by construction material



Source: Mirova 2015

LEB: Low-Energy Building

Given the importance of the stakes for the climate, these emissions profiles constitute the heart of the environmental assessment of construction materials. The production of concrete, steel, and wood nevertheless entails other environmental impacts:

- for steel and concrete: the emission of other pollutants (NOx, SOx) during production, environmental impacts linked to mining, etc.

- for wood: deforestation concerns requiring certification to guarantee the sustainability of the resource (e.g. FSC or PEFC), sanitary concerns tied the use of glues and biocides necessitating the development of ‘green’ substitutes.

In search of green innovations for concrete and steel

For many years, in order to reduce production costs while limiting their impact on climate change, concrete and steel manufacturers invested in efforts to improve the energy efficiency of their production processes. Today, however, these optimisation strategies have reached their limit, leading companies to innovate in order to cut their emissions more substantially.

In 2010, steel manufacturers from the ULCOS (Ultra Low CO_2 Steelmaking) consortium developed the HIsarna technology, a bath-smelting process that uses smaller quantities of coal in place of coke, thereby reducing CO_2 emissions by 20%. This process may also facilitate the partial substitution of other types of energy (biomass, natural gas, or hydrogen) for coal and thus reduce emissions and energy consumption across the industry even further. The process is currently being tested by Tata Steel (until 2015), while the LIS[6] (Low Impact Steelmaking) consortium, a French public-private research programme, has taken over the ULCOS project, focusing its research on the development of blast furnace injection and calibration technologies (TGRBF, for 'Top Gas Recycling Blast Furnace'), as well as new CO_2 valorisation technology (VALORCO). Steelmakers are also seeking to increase recycling levels, currently representing ~1/3 of global production, as the production of recycled steel reduces energy consumption by more than 50%, thereby limiting the associated CO_2 emissions.

As for concrete, the major manufacturers have principally focused on two types of solution. The first consists in the creation of low-carbon concretes on the basis of 'reduced CO_2 cements' containing up to 50% recycled material (blast furnace slag from steel production or fly ash from coal combustion) and allowing for a carbon footprint reduction of up to 40%.[7] The second solution, under study for the past 15 years, is based on a completely different formation of the cement that composes concrete. The production process is altered through the creation of new binders: by lowering the minimum required temperature from 1,450°C to 1,300°C, they reduce emissions by 20 to 30%.

It should be noted that certain technologies allow for even greater reductions, with a carbon footprint up to 70% lower than that of conventional concrete. Solidia Technologies is notably developing technology based on research conducted at Rutgers University (New Jersey). Total Energy Venture has recently acquired an interest in this company, alongside Lafarge, Bill Joy, KPCB, Bright Capital, BASF and BP. One must nonetheless remain cautious with respect to this type of project in its research stages. In the past, similar initiatives such as Novacem in England or Celitement in Germany[8] were undertaken that have yet to demonstrate the economic viability of their technology.

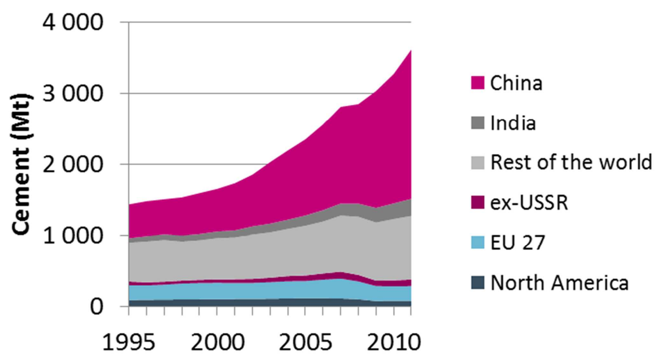
Minimal consideration of climate issues

At present, the question of environmental impact has only a limited effect on the choice of construction materials. Indeed, concrete, employed in 2/3 of constructions across the world, is the most widely used construction material, with steel a distant second. Low-carbon concrete and steel make up a very small minority, while wood, despite its carbon advantage, is still struggling to gain a significant share of the market.

On a global scale, this predominance of concrete can be explained by the perceived low cost of materials, its ease of use, and the abundance of available resources necessary for its manufacture.

More particularly, concrete and steel have seen strong growth in the past 15 years, principally fuelled by China.

Figure 3: Global evolution of cement production



Source: (USGS, 2013)

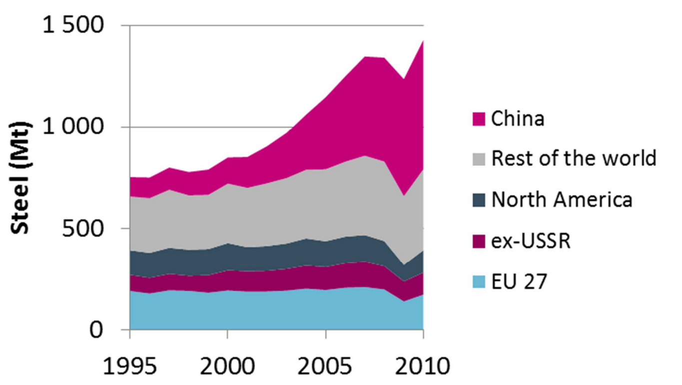
[6] *This research programme is founded on the results of the ULCOS consortium (2004-2012) and is being lead, for the period 2013-2019, by a consortium composed of the University of Lorraine, the Institute of Chemistry of Clermont-Ferrand (CNRS, or National Centre for Scientific Research), financed by the ADEME (Agence de l'environnement et de la maîtrise de l'énergie), ArcelorMittal (the research centre of which will coordinate research as of 2015 in Maizière-les-Metz), Air Liquide and ICAR.*

[7] *It should be noted that the carbon benefit associated with the use of slag and fly ash is subject to debate: should these substances be considered as recycled waste having no carbon impact, or rather as co-products accountable for part of the emissions linked to the production of steel or electricity? The first hypothesis is very favourable to the cement industry, the second much less so.*

[8] *Novacem: a start-up developed through research by Imperial College London in partnership with Rio Tinto, Laing O'Rourke, WSP, and in which Lafarge has recently invested, which proposes a firing temperature of clinker of 700°C.*

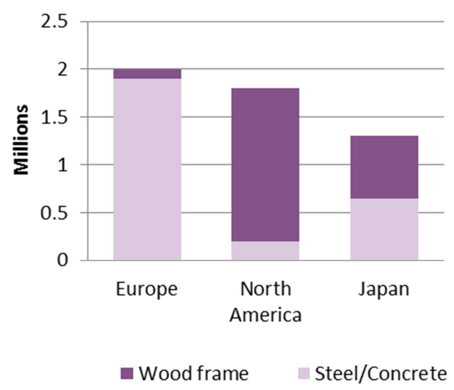
Celitement : a partnership between the University of Karlsruhe and Schwenk Zement KG which, thanks to the modification of the composition of clinker, lowers firing temperatures to 200-300°C.

Figure 4: Global evolution of steel production



Source: (World Steel Association, 2013)

Figure 5: Number of new houses built (1999)



Source: (United Nations, 2001)

However, this predominance of concrete does not always appear justified. The risks involved in the implementation of new construction solutions tend to push principal contractors to favour materials the technical mastery of which they have already acquired, which leads to significant inertia in the industry.

Indeed today, from a technical point of view, the performance of the three materials is comparable in numerous cases. Concrete, steel, and wood display different natural resistances to compression, tensile strengths, and thermal conductivity, but their natural deficiencies can be reduced in order to extend their use to all types of structure. Concrete is reinforced to increase its tensile strength, steel is pre-treated to counter the normal effects of compression, and the development of processed wood products has pushed back the dimensional limits of natural solid wood. In the world today, there are wood-structure buildings reaching 10 stories, such as the Forte Living residence in Melbourne, Australia, and certain projects are currently under study that would go beyond this limit to reach up to 30 stories.

As for operational ease, it is strongly linked to the history of construction in each region. Indeed, there are different construction trends according to region and country. For example, in the United States, Canada, northern countries, as well as Scotland, the construction market for individual houses is largely dominated by wood. In Japan, wood is rivalled by concrete/steel, notably due to seismic constraints, while in the United Kingdom, the Netherlands, and France, concrete is clearly dominant.

One of the reasons for the weak presence of wood in the building industry is clearly the lack of sector structuring. Indeed, while many highly-structured multinational corporations are present on the cement and steel markets (Cemex, Lafarge, Arcelor Mittal, etc.), no company in the wood industry today has reached the critical mass necessary to better develop the sector.

Toward reinforced regulatory constraints

Given this inertia in the building industry, it would appear that only a regulatory framework integrating a global vision of the environmental impact of construction materials could truly be in a position to favour the emergence of more sustainable materials.

At present, only environmental certifications (e.g. BREEAM, HQE, and LEED) provide an incentive for deploying more sustainable construction materials via environmental product declarations (FDES in France, EPD at the European level). Based on ISO 14025, they are multi-criteria and multi-stage, drawing on qualitative and quantitative data, thereby allowing for comparisons among different products and the results of environmental efforts and actions.

While such procedures remain voluntary, interest is growing for this type of approach, with each label having seen a substantial increase in the number of certifications over the past 10 years. Higher expectations with respect to climate change should lead to higher expectations for low-carbon innovations: low-carbon concrete and steel, the development of wood, notably via the emergence of wood/steel or wood/concrete mixed structures.

Note that in France, a 2010 decree had attempted to impose a minimum quantity of wood in certain new constructions. It was struck down, however, on appeal to the Constitutional Council by cement and concrete manufacturers.[9]

What are the consequences for investors?

Innovations in low-carbon concrete and steel thus remain relatively marginal today. One should remain cautious with respect to declarations made by established manufacturers in the industry, who have very largely relied on standard production processes for the past several decades. Moreover, even though wood presents environmental advantages, the development of the sector will require more time before substantial actors emerge.

As a result, investment opportunities tied to environmental innovation are for the most part confined to non-listed companies. Nevertheless, efforts in research and development as well as potential targeted acquisitions by major groups are factors that may be taken into consideration today: since the environmental stakes of the industry are significant and growing, getting a head start could have a structuring effect over time.

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[9] See: http://www.conseil-constitutionnel.fr/conseil-constitutionnel/francais/les-decisions/acces-par-date/decisions-depuis-1959/2013/2013-317-qpc/decision-n-2013-317-qpc-du-24-mai-2013.137109.html

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