Meeting nature halfway: A sustainable future built with timber

By Werner Slabbert

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Buildings, be they domestic, commercial or industrial, are major consumers of energy the world over and this applies to much more than just their day-to-day running. From basic components, transport, construction, operation and final decomposition after its useful life, a building has significant potential for a gentler environmental footprint.

In defining energy efficiency, the term is often confused with ‘energy conservation’ and ‘sustainability’. While these terms are most certainly related, they are not the same thing. Energy conservation means to save or use less energy by minimising or cutting back on the energy we use; switching off unnecessary lights and washing fewer loads of laundry, for example. But energy efficiency implies fulfilling the same tasks or functions as before, but with less energy. These both contribute to the sustainability of a structure or operation, which is popularly defined in the 1987 *Brundtland Report* as “[meeting] the needs of the present without compromising the ability of future generations to meet their own needs.”[1]

From seed to site

When applied to construction, there are a number of materials and technologies available to us today to render a project more energy efficient and sustainable. While there is a place for all types of construction materials, timber boasts many properties that make it particularly well suited to the homeowner, builder or property developer looking for a building option that is kinder to the environment, not just during its useful life, but across its entire lifecycle. This means that we need to pay attention to where the timber comes from, how it was grown, processed, treated, stored and transported before it reaches the construction site; all the energy that goes into that piece of timber from seed to site is known as embodied energy, which is a significant determinant in how sustainable a structure is. We also need to think about what happens to timber after its useful life.

All construction materials, whether they are grown or mined, will have to undergo processing, storage and transport, which means that once they arrive on site, they will all carry a measure of embodied energy. Timber, however, is unique in that during its ‘manufacturing’ process, it takes up carbon dioxide from the atmosphere, stores the carbon molecule (which it uses for energy) and releases oxygen in a process commonly known as photosynthesis. Furthermore, since wood is grown and is not a finite resource, like oil, for example, timber remains the only truly renewable building material available to us.

Interesting fact: The amount of the carbon taken up by a tree is dependent on a number of variables, "including tree species, growth conditions in the environment, age of tree and density of surrounding trees."[2]

SA pine, predominantly used in timber frame construction in South Africa, has the propensity to take up and store between 600kg to one tonne of carbon from the atmosphere per cubic metre of wood. Timber is arguably the only building material that starts out having removed carbon from the atmosphere before its working life, which means it has a head start on mitigating the activities that will later make up its embodied energy by the time it gets to site, and the potential to contribute to a structure with an effective zero net carbon footprint.

Timber, as a construction material, also adds value from the very start of its journey. Not only does it fix carbon from the atmosphere as it grows, it supports employment in the forestry sector, it is lighter than other 'traditional' building materials and therefore more energy efficient and less costly to transport.

Plantations, not natural forests

In South Africa, most timber frame companies use timber grown in responsibly managed pine plantations and not natural forests. These plantations are like working factories with the sole purpose of growing timber in a controlled environment for the market. Managed and/or overseen by reputable bodies like the Forest Stewardship Council, for example, these plantations are run in line with the highest standards for ensuring sustainability.

Construction and energy efficiency

Laws in South Africa regarding both energy usage and energy efficiency in buildings were promulgated in 2011. These apply not to the embodied energy of a given structure, but rather to the performance of the structure in how it consumes energy during its working life. Both SANS 204: Energy Efficiency in Buildings and SANS 10400 section XA: Energy Usage in Buildings set clear guidelines in place for the architect and builder on how to provide for an allowable level of energy usage of a structure through design and compliance with deemed-to-satisfy requirements outlined by the National Building Regulations.

According to Jacques Cronje of Jacques Cronje Timber Design, the more typical issues that impact on a construction's energy efficiency include the structure's orientation, window size and positioning, shading, material choices with consideration for thermal and insulating properties, solar heating, natural cooling and considerations for natural light. The regulations take the performance of all aspects of a build into account, including walls, roofs, water heating and lighting, in line with requirements per climatic zones in South Africa.[3]

Cronje notes, "Non-masonry walls shall achieve a minimum total R-value of R2.2 in climatic zones one and six and an R-value of 1.9 in climatic zones two, three, four and five. Insulation of roofs has been determined as the single biggest factor impacting on energy efficiency [… and] the minimum R-value of roof assembly (i.e. all components of the roof and ceiling) required in zones one and four is R3.7 with the other zones only marginally less."[3]

"Timber frame homes are included in the South African National Building Regulations standards in SANS 10082: Timber Buildings. When built to these standards, they also automatically achieve the standard required for registration with the National Home Builders Registration Council (NHBRC) and are easily designed to meet the requirements of the recent energy efficiency regulations."[4]

Calculating R-values and heat loss

R-value refers to the thermal resistance of a material. The higher the R-value, the more effective its insulating properties. R-values are usually represented in physical units of m2K/W or square metre Kelvin per Watt.

Heat loss per square metre is calculated by dividing the temperature difference by the R-value of a given material. So if a home's internal temperature measures 20°C and the temperature in the roof cavity is at 10°C, the temperature difference is 10°C (or a 10K difference). Holding the assumption that a ceiling is insulated to an R-value of two, for example, energy will be lost at a rate of 10K ÷ (2m2K/W) = 5W per hour for every square metre of ceiling.

For the same temperature difference, but with insulation bearing an R-value of onw, the heat loss calculation will resolve as follows: 10K ÷ (1m2K/W) = 10W per hour for every square metre of ceiling.[5]

How does timber add value to the sustainability equation?

Aside from its potential for relatively low embodied energy, other significant contributors to a timber construction's potential for high thermal resistance and energy efficiency performance are its inherent thermal properties as well as its propensity to take on bulk insulation and limit thermal bridges.

According to Wood Solutions, the Australian initiative created to offer timber industry professionals "independent, non-proprietary information about timber and wood products", when considering the physical properties of wood, "timber, a naturally insulating material, makes for an excellent choice. Air pockets within timber's cellular structure create a natural barrier to heat and cold".[6]

Furthermore, "Of all the timber options in construction, lightweight timber is the best insulator overall as thermal conductivity increases with density. In addition, thermal conductivity will vary slightly with moisture content, residual deposits in the timber such as extractives, and natural characteristics such as checks, knots and grain direction."[6]

"Construction design with a focus on energy efficiency through lightweight timber can greatly contribute to maximising comfort and minimising non-renewable energy use. […] The natural thermal properties of timber also maximise the energy efficiency of insulation material as wood will not become cold or dissipate heat, therefore requiring less energy to maintain warmth throughout a building."[6]

While the higher the thermal resistance of a material in construction, the better; the lower its thermal conductivity, the better it will insulate. According to the Peter Müller website, "Thermal bridges are areas where, for example, heat is lost through a switch in materials than in neighbouring structural elements. Thanks to the low thermal conductivity of wood, the thermal bridge effect of wooden structural elements is very slight."[7]

The walls, floors and roof of a timber home have the capacity to take on almost any type of bulk insulation, which means that the structure's ambient temperature will behave more moderately regardless of seasonal changes and require less energy for heating and cooling, provided it is designed in line with energy efficiency regulations.

Building envelope sealing is also a significant potential contributor to a structure's thermal performance with the addition of plywood or oriented strand board (OSB) and sheathing overlaid with the cladding of choice, all adding thermal value to the wall structure and limiting thermal transmittance. One can implement all kinds of energy efficiency measures, but if the building envelope is not properly sealed, the thermal performance of the structure will drop significantly, negating all the energy efficiency measures implemented in the first place.

Making comparisons

In a recent South African study conducted for a local association, research concluded that clay brick walling (both thermally insulated cavity walling and solid clay brick) outperformed timber frame, among others, in terms of energy usage across varied contexts. While it is important to keep an open mind, especially when presented with new information that could well be at odds with one's own understanding, I find it somewhat troublesome that this study's outcomes are overwhelmingly in favour of the industry on behalf of which it was conducted and far less so towards its counterparts. The study also suggests that a building material's embodied energy is a far less important consideration than the operational energy usage of the structure it makes up, which contradicts today's commonly held understanding among industry professionals that a structure's entire lifecycle – from cradle to grave – is important when we think about a structure's sustainability. This is especially disconcerting in the light of overwhelming evidence from studies done across the world that timber frame, built to standard, has excellent potential to lead in terms of energy efficiency.

Australia, New Zealand, America and Europe have long embraced the benefits of timber frame construction, where this construction type is the norm, as opposed to the exception, as has a small but burgeoning and well-informed market in South Africa keen on a lighter construction footprint. The majority of new houses in these developed markets are built using timber frame, which begs the question why.

Being one of, if not the biggest contributor to greenhouse gas emissions, "buildings represent [at least] a third of global emissions, and a third of energy and materials worldwide".[8] Concrete and steel account for 8% of all greenhouse gas emissions and "clay for bricks is extracted from the earth, i.e., it is of a finite quantity, and then fired in an energy intensive process".[9] Interestingly, a 2009 study found that "emerging economies cause nearly 60% of the global construction sector total CO2 emission".[10] So I ask, what are we missing in the local context? Are we the only ones who believe that brick and mortar outperform timber frame by default, despite global evidence to the contrary?

The words of Rear Admiral Grace Hopper come to mind: "The most dangerous phrase in the language is 'we've always done it this way'." What better time than the present to really consider what big industry is trying to sell us and why, who is set to profit from the heedless buy-in and why we are so afraid of change. If we all knew just how well timber frame performed globally across a number of variables, how would our construction and housing markets begin to change over time?

Working towards a more sustainable future

The construction sector globally has a duty to make more responsible, better informed decisions about how it plans and executes its work for a more sustainable future; there is no more room, excuse, or time for ignorance and self-indulgence. While timber alone may not be a silver bullet for our carbon footprint woes, it does represent nature's commitment to the solution. With well-considered planning, sourcing of responsibly grown timber, adherence to legislation governing energy efficiency and usage, timber as a construction material is poised to be at the forefront of energy efficient and sustainable design and construction in South Africa.

There is no denying that all building materials have something to offer the construction sector and its end users, but there is no more urgent time for timber to fully occupy – and be appreciated for – its role as a viable construction material with high potential for legitimately sustainable construction. Nature has come to the table; it is time we begin to arrive there as well.

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