WOOD PRODUCTS IN NSW: ENERGY BUDGET AND DISPOSAL OPTIONS

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ABSTRACT

This project aims to develop an energy budget for wood products used in the building sector in NSW. The proposed research will determine the energy required in the extraction, transport, manufacture and use of wood products, with emphasis on the renewable and non-renewable energy components. This information is critical for use in LCAs for the built environment, and will provide a sound scientific basis for decision-making that will impact on the greenhouse-friendliness of future buildings. Landfill excavations are planned to determine any carbon losses that may have occurred from wood and paper products placed in landfills in NSW. The project will also include the development of a LCA of the main current and potential disposal options for wood products in NSW.

Keywords: energy, wood, paper, greenhouse, waste, landfill

1. INTRODUCTION

Wood products can significantly extend the greenhouse gas benefits provided by forests. In addition to the physical storage of carbon in wood products (both in service and in landfills), further greenhouse benefits can be obtained through the use of processing residues to generate energy in lieu of fossil fuels, and through the use of wood products instead of more energy-intensive materials [1]. Although those benefits are being quantified in the US [2] and in Europe, research in Australia has been largely limited to a few localised studies on the embodied energy of wood products [3-7]. In order to determine the true greenhouse benefits associated with the use of wood products in buildings in NSW, field-based current data is required on the energy required in their extraction, transport, and use, including renewable and non-renewable energy components. This information will provide a sound scientific basis for comparisons between building materials in the context of building energy rating schemes and for use in life cycle assessments (LCAs) of buildings.

New South Wales is the main producer of both sawn softwood (790,000 m^3) and sawn hardwood (316,000 m^3) in Australia [8]. Approximately 75% of the sawn timber is used for residential purposes [9], with about 80% of the sawn pine used for framing applications in houses and approximately 50% of the sawn hardwood used as sub-flooring and fencing [10].

The impact of the disposal of wood products has been largely neglected to date in most life cycle assessments [11]. Doka and Hischier [11] argued that the disposal phase should be included in LCA studies by default. Life cycle assessment is the ideal tool to comprehensively assess the relative environmental impact of the various disposal options. Depending on the disposal path chosen, the greenhouse outcomes vary considerably. Since landfill has been the main disposal option for wood and paper products in NSW for decades, special consideration should be given to its impacts. Wood and paper products account for approximately 50% of the volume of organic materials placed in landfills in Australia [12]. In NSW, it is estimated that approximately 500,000 tonnes of wood products and 750,000 tonnes of paper products were disposed of in landfills in 2002/2003, representing 54% of the total organic waste generated that year [13]. It is estimated that 70% of the wood waste produced in NSW is disposed of in landfills [13].

The anaerobic decomposition of organic components in landfills by bacteria results in the generation of methane and carbon dioxide, in approximately equal proportions [14]. Methane is one of the major greenhouse gases, with a global warming potential 21 times higher than carbon dioxide. In order to determine the greenhouse impact of wood and paper products in landfills, it is essential to determine the rate and extent of their decay. Recent research [15] suggests that decomposition of wood products in landfills in Australia is minimal, but further testing is required to confirm those findings and also to determine the decomposition of paper products.

In addition to determining the environmental impacts of the different disposal options for wood and paper products, it is important to conduct an economic analysis of the cost-effectiveness of each of the options. A number of factors need to be addressed, including the impact of emerging technologies.

This paper reports on the planned activities of a new project aimed at determining the greenhouse footprint of the use of wood products in NSW.

2. GREENHOUSE FOOTPRINT OF WOOD PRODUCTS IN NSW

The NSW Department of Environment, through its Climate Action Program, is funding a project to determine the greenhouse footprint of wood products in NSW. The research is needed to guide policy and management decisions that will optimise the use of building materials and management of end-of-life options, particularly in light of the threat posed by climate change. The objectives of the project are:

- Development of an energy budget for the main types of wood products used in the NSW building sector
- Quantification of the greenhouse gas impacts of the various waste disposal options for wood and paper products in NSW
- Development of an economic analysis of alternative disposal options of wood and paper (landfill, recycling, bioenergy)
- Quantification of the rate and extent of decay of wood and paper products in landfills in NSW and their associated greenhouse gas emissions
- Development of data that will inform further development of carbon trading rules in NSW

2.1 Energy budget

The work in this project will be developed in close collaboration with the industry, both at primary (sawmill) and secondary (factory) processing levels. The studies will include a representative selection of the existing plants in NSW. Where appropriate, energy measuring devices will be used to assist in the accurate determination of the energy usage. The aim is to minimise reliance on estimates or electronic surveys, for which control over the data obtained is minimal. It is envisaged that the results of this research will be useful for inclusion in energy rating schemes and LCAs. The energy usage results will be expressed both in renewable and non-renewable components, to reflect current practice in the industry.

Embodied energy has often been used as an indicator of overall environmental impact, including greenhouse gas emissions and hence contribution to global warming [6]. However, the nature of the energy used, and not its quantum, is more important when quantifying the greenhouse impact of the energy used. If it is assumed that the biomass energy is 90% as effective as the equivalent fossil fuel technology, and the fossil fuel technology emits 10% less greenhouse gases than the biomass technology for the same delivered energy, then the use of one tonne of wood will result in a "saving" of about 0.8 tonnes of fossil fuel carbon (natural gas or oil). The use of one tonne of firewood (from sustainable forests) to generate energy results in the displacement of at least 3.7 tonnes of carbon when electricity generated from brown coal is used instead [16]. Very few studies express embodied energy in terms of renewable and non-renewable components. This is essential information, as in the case of wood products, the use of processing residues to generate energy represents a much better outcome than using fossil fuels, as wood is a renewable resource. It is also important to quantify the greenhouse costs if the renewable energy component was replaced by a non-renewable energy component. There is wide variability in published figures for wood products (Table 1), which reflect differences in practice over time, particularly in relation to wood waste usage for energy and efficiencies of conversion. Use of old data will most likely underestimate the use of wood residues to generate renewable energy or in the manufacture of composite materials and paper in Australia.

The focus of mandatory building rating schemes in Australia has been primarily on operational energy savings and thermal mass modelling. Although it is widely accepted that the operational energy is a major component in the total energy budget of a house, it is likely that a more holistic approach will be adopted in the future to more closely reflect the relative environmental performance of different building materials. Treloar and Fay [17] found that the energy embodied in house construction was equal to 15 to 20 years of operational energy, potentially representing 50% of the total when periodic maintenance and refurbishment are included. Wood products are currently competitively disadvantaged, as their whole-of-life greenhouse impacts are generally not taken into consideration in those schemes. For example, the proposed 5-star energy efficiency rating by the Australian Building Codes Board for housing does not take into account the whole-of-life impacts of different materials. The use of life-cycle-assessment tools could ensure that a true comparison between materials is made. When whole-of-life factors are taken into account, wood products generally have a much lower energy footprint than alternative products [e.g. 7 and 18].

Table 1. Embodied energy values (renewable and non-renewable components) of a range of wood products in Australia and overseas

Product type	Embodied energy total (MJ/kg)	Embodied energy renewable component (MJ/kg)	Non-renewable component (MJ/kg)	Reference
Australian softwood timber	14.3	6.3[1]	8[1]	Pullen [4]
	18.1	12.2[1]	5.9[1]	Mclennan [7]
North American softwood	15.7	5.8[2]	9.9[2]	Cocotas and Cheung [19]
	6.3	2.9[2]	3.4[2]	Forintek [20]
	9.2	4.3[1]	4.9[1]	Puettmann and Wilson [21]
Finnish structural softwood	15.0	13.1	1.9	Derived from Hakkinen [22]
Australian particleboard	10	1.5[1]	8.5[1]	Pullen and Varley [3]
Australian Laminated particleboard	13	1.5[1]	11.5[1]	Pullen [4]
North American plywood	11.5[3]	4.8	6.7	Forintek [20]
	8.9	4.2[1]	4.7[1]	Derived from Puettmann and Wilson [21]

1. Average of two mills
2. Includes green and dry mill energy requirements
3. Including adhesive energy

Current green building rating schemes often assess different building products on uneven environmental grounds. In the US for instance, the LEED scheme (Leadership in Energy and Environmental Design http://www.usgbc.org/), favour biomass materials that are rapidly renewable, have low VOCs, have a high recycled content and are FSC-certified. However, the requirement for certification (FSC) is not replicated for other materials, even though they may face similar or worse problems as a result of the extraction of their feedstock. This applies for example to steel (through the extraction of non-renewable primary material resources such as ores, coal and limestone), concrete and cement (quarrying of non-renewable primary material resources) [23] and bamboo. Bamboo products obtain a high score in the LEED scheme due to their rapid renewable nature, but the various environmental issues associated with the establishment of bamboo plantations [24] are not taken into account. LCAs are normally used to quantify the environmental impacts of materials, products or processes from the raw materials through production, use and disposal. The adoption of a LCA approach in building rating schemes would address those concerns and more closely reflect the true environmental impacts of building materials.

2.2 Disposal of wood and paper products

2.2.1. Wood and paper products in landfills

The fate of wood products at the end of their service life significantly influences the whole-of-life environmental impact of the product. However, LCA studies often do not include disposal in their scope (eg. CORRIM project), resulting in incomplete assessments. The greenhouse footprint of building products is impacted considerably by their disposal pathway. In the case of wood and paper products placed in landfills, the rate and extent of decomposition of the products are the main parameters governing their greenhouse impact.

The current default decay rates for wood and paper products in landfills commonly adopted in national greenhouse inventories and used in waste policy (eg to determine potential greenhouse benefits of diverting wood from landfill) are based on laboratory experiments conducted under highly optimised conditions. For example, the data used in the estimation of greenhouse gas emissions from wood and paper products in landfills in the US [25] are based on the results of laboratory experiments in which specific paper products and tree branches were degraded anaerobically [26]. The underlying assumption was that the results could be extrapolated to a wide range of paper products, solid wood (softwoods and hardwoods) and medium-density fibreboard (MDF). This assumption is not appropriate since the structure and composition of solid wood and panel products is inherently different from that of tree branches, and different types of paper products vary considerably in their composition. Bogner [27] observed that methane generation data from laboratory-based experiments under optimised conditions often overestimate observed methane production in landfills. Recent field-scale research conducted in Australia [15] suggests that decomposition of wood products is minimal after 30 years of burial in landfills.

The Greenhouse Footprint project aims to conduct further excavations in Sydney to verify previous results from Gardner et al [15]. The planned research includes chemical analyses of paper products recovered, which were not carried out previously. The principles and methodologies adopted in the planned research are those agreed during a recent workshop on the decomposition of forest products in landfills [28].

2.2.2. LCA of disposal options in NSW

In addition to research on the decomposition of wood and paper products in landfills, the Greenhouse Footprint project will include an analysis of the greenhouse impact of alternative pathways for redundant wood and paper products, such as recycling and use for energy. There has been considerable debate about the utilisation options for redundant wood products and paper, but a proper LCA has not yet been carried out to compare the available options in NSW. Morris [29] conducted two LCAs in San Luis Obispo County and Washington State in the USA to evaluate the environmental burdens associated with collection and management of municipal solid waste. The study included a range of paper products, which accounted for 57% of the collected recyclables. The projects compared curbside collection for recycling versus landfilling or incineration with energy recovery. In both projects, recycling was the best option in terms of reducing energy consumption and impacts of solid waste management on all public health and environmental impact categories, regardless on whether the methane was recovered or not. For products whose reciclability is lower than those included in the study (due to practical and/or market reasons), the results may not have been as clear cut.

The Greenhouse Footprint project will conduct an economic analysis to compare the cost-effectiveness of various disposal options, including more recent technologies, such as the use of pyrolysis at a commercial scale. This research, coupled with the LCA outlined above, will provide a valuable contribution to waste management strategies in NSW.

2.3. Carbon trading in NSW

There are currently a number of both mandatory and voluntary carbon trading initiatives in Australia. The biggest and world's first mandatory scheme is the New South Wales Greenhouse Gas Abatement Scheme (NSWGGAS [30]). It imposes mandatory greenhouse gas emission benchmarks on NSW electricity retailers, aimed at reducing per capita emissions from electricity generation (the 2006 penalty is $11 per tonne of additional carbon dioxide emitted). The price currently paid for greenhouse abatement certificates under the NSWGGAS is about $13.50 per tonne of carbon dioxide. Under the current rules of the Scheme, carbon sequestration in forests can be traded as abatement certificates. Eligible forestry projects must have been established on cleared land since 1990, and the sequestered carbon must be stored for 100 years. Continuing long-term carbon storage in wood products is not currently recognised in the NSWGGAS. Carbon storage in wood products is a more secure way of locking up the carbon than retaining it in permanent forests, as forests may be periodically affected by fire, diseases or natural mortality. As the majority of wood products in Australia and NSW are disposed of in landfills, from a long-term carbon storage perspective it is critical to know what percentage of the carbon in those products will be released as methane over time. Although initial results suggest decomposition is minimal in landfills in Sydney [15], further research is planned to conduct similar analyses on wood and paper products recovered during more excavations in old landfill sites in NSW.

3. CONCLUSIONS

This paper has described the significance of some of the issues associated with the greenhouse impact of the use of wood products in NSW. The greenhouse impact of the use of different building products is significantly affected by the renewable and non-renewable energy required for their extraction, transport, manufacture and installation. This information is currently not widely available for wood products. It is envisaged that the planned research will assist in the choice of greenhouse-friendly products for different building applications, with the aim to achieve lower greenhouse gas emissions. The research will also provide direct input into current waste disposal strategies in NSW, in terms of their greenhouse impacts and cost-effectiveness.

4. ACKNOWLEDGMENTS

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