How will timber buildings help New Zealand meet Kyoto Protocol commitments?

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Forestry is a cornerstone of the New Zealand government's approach to meeting its commitments to the Kyoto Protocol. It is well known that trees, as they grow, absorb carbon from the atmosphere, some of which is retained in wood and wood products, and that carbon absorbed by new forests can be used to offset emissions of carbon dioxide (CO_2) from burning of fossil fuels.

An increasing volume of carbon retained in timber buildings or other wood products might also be used to offset emissions of carbon dioxide from burning of fossil fuels, except that this is not permitted under the Kyoto Protocol accounting system.

The tangible benefit of using more wood in buildings is the reduced CO_2 emissions resulting from the smaller amount of fossil fuel energy required to manufacture wood compared with that needed to manufacture more energy intensive materials.

What are the requirements of the Kyoto Protocol for New Zealand?

For signature countries to meet their obligations with the Kyoto Protocol, net national emissions for developed countries must be reduced in the first five-year commitment period (2008-2012), relative to 1990. The exact reductions vary from country to country with an average of about 5%, but New Zealand is only required to reduce emissions to 1990 levels. For New Zealand, the two main greenhouse gases are carbon dioxide (CO_2) which is mainly produced from burning of fossil fuel and methane (CH_4) from agricultural activities, in roughly equal proportions. Only CO_2 is considered here.

New Zealand carbon dioxide emissions have been increasing steadily over recent years, with the bulk of the increase from burning of liquid fuels in the transportation sector. In 1990, total emissions of CO_2 were about 62 million tonnes per year, which have now increased to about 77 million tonnes per year. The government hopes that by 2008 this increase of 15 million tonnes per year will be reduced by about 5 million tonnes per year through various policy incentives for reducing fossil fuel use, and further offset by an average of 21 million tonnes per year of CO_2 absorbed in forests, giving New Zealand an average credit surplus of 11 million tonnes per year over the first commitment period, which can be sold on the international market.

For the five years of the commitment period, these target numbers become a cumulative increase of 75 million tonnes of carbon dioxide since 1990, a reduction of 25 million tonnes through policy incentives, 105 million tonnes per year of CO_2 absorbed in forests, giving a credit surplus of 55 million tonnes[1].

Why is forestry so important?

Globally, the contribution of forestry to the Kyoto Protocol is very small, but forestry is extremely important for New Zealand because the Kyoto Protocol allows increases in the carbon pool in a country's forests to be counted to offset carbon dioxide emissions from any other sources.

Before we go on, it is essential to use the correct terminology in this discussion. A growing tree on a previously non-forested site is called a carbon "sink" because it absorbs carbon dioxide from the atmosphere. After a tree is cut down it becomes a carbon "source" as the carbon is released to the atmosphere in the form of carbon dioxide when the wood is burned or decays or is eaten by bugs. A standing tree contains a "pool" or "reservoir" of carbon in the chemical structure of its wood. The carbon pool in a whole forest depends on the sums of the sinks and sources from all the trees in the forest, which is difficult to quantify. To measure the increase or decrease of the carbon pool in a forest it is easiest to compare carbon inventories at the beginning and end of the period, rather than trying to calculate continuous flows of carbon into and out of the system[2].

Which forests are counted?

The year 1990 is an important year in Kyoto accounting. For any new forests planted on farmland since 1990, their absorbed carbon during the first commitment period will be counted as a carbon sink. Forests which were existing in

1990 are not counted unless the forest is actually removed during the commitment period, in which case the loss of carbon will be counted as a carbon source.

How do forests store carbon?

Growing trees absorb carbon from the atmosphere. In the process of photosynthesis, the leaves of growing trees absorb carbon dioxide from the atmosphere with the help of solar energy. Much of the absorbed carbon is converted to wood, which has a complex chemical structure consisting of about 50% carbon.

In order to use forestry to offset fossil fuel emissions, it is necessary to maintain both new and existing forests in perpetuity, and also to continue to plant new forests on non-forested land. There are three major considerations:

1. All existing forests must remain in place because the carbon pool in these forests is part of the Kyoto inventory. The size of this pool will fluctuate about a steady state condition, depending on the type of forest, sometimes being a carbon sink and sometimes a carbon source. Carbon is stored in all forests including native forests and shrublands. Unmanaged mature natural forests (preservation forests) reach a steady state so that the carbon being absorbed each year is roughly equal to the carbon emitted through natural processes of decay and degradation of wood, leaves and soil. The forest will have fluctuations in the size of the carbon pool due to natural causes including variations in climate, natural hazards and pests. A managed plantation forest will have fluctuations due to logging and replanting of parts of the forest estate with the whole forest sometimes being a carbon sink and sometimes a carbon source depending on tree demographics and the management regime. The use of plantation forestry for carbon storage requires that all logged areas be replanted. An unmanaged natural forest will tend to have a higher carbon density (tonnes per square metre) than a managed forest[2].

2. The planting of new forests on farmland must be continued every year in order to continually increase the total carbon pool, and offset carbon dioxide emissions from burning of fossil fuel. This new planting will require a continuing supply of land suitable for afforestation, which may become increasingly difficult to find as the required land areas become very large. The government may need to offer incentives for private planting of new forests if reliance on forestry carbon credits is to continue into the future.

3. Any deforestation resulting from clearing of new or existing forest land will have a serious negative impact on New Zealand's carbon credit balance. The carbon pool of a forest is lost if the land is converted to agriculture or other non-forest uses. The government is assuming the liability for any deforestation (unless it exceeds a very high level), so they may decide to discourage forest owners from converting forest land to agricultural or other non-forest uses, as is already happening in some areas.

In summary, in order to obtain a benefit from the carbon pool in forests, it is not only necessary to make new plantings every year, but also necessary to ensure that existing forest cover remains in place in perpetuity, either managed for timber production or as a protected forest[2].

Who gets the benefits from carbon stored in New Zealand forests?

The government has nationalised the carbon credits from nearly all plantation forestry in New Zealand, so that the benefits of carbon storage flow to the government rather than to the owners of the trees. This has caused great concern in the forest industry because of the enormous potential value of the carbon credits in the first commitment period. The price of carbon credits will change as they are traded on international markets, but the current price on the European futures market is about 10 Euros ($NZ 20) per tonne, so New Zealand's estimated surplus of 55 million tonnes over the first five-year period has a potential value of $1.1 billion. The government is making attempts to recognise the significant contribution of the forestry sector by supporting a wide range of initiatives in education, promotion, biosecurity, infrastructure and market development, using a very small percentage of the projected income.

Although the expected benefits are huge in the first commitment period, demographic changes in New Zealand plantation forests may result in the forest estate becoming a net source rather than a sink in the third and some subsequent periods[2], which could be of great concern to future governments and forest owners.

What are the benefits of using more wood in buildings?

The most obvious apparent benefit of using more timber as a building material is the increase in the pool of carbon in wood and wood products, but this is of no benefit to the government because this pool is not a carbon "sink" in the Kyoto Protocol.

In terms of the Kyoto Protocol, the only significant benefit of using more wood as a building material is the reduction in CO_2 emissions which comes from manufacturing wood rather than more energy intensive materials such as steel, concrete and aluminium. Wood requires much less energy to process than other materials because it is a natural material already embodying a large amount of solar energy. This reduction in fossil fuel consumption is not in itself tradable, but is could contribute to an increased surplus of carbon credits which are able to be traded on the international market.

How much carbon is stored in New Zealand buildings?

It is misleading to ask "how much carbon is stored in New Zealand buildings?" The question has two meanings because of the ambiguity of the word "stored". The first meaning is "how large is the annual sink of carbon in new buildings?" and the second meaning is "how big is the pool of carbon in existing buildings?"

In answer to the first question, a study at Victoria University of Wellington[3] has given estimates for the embodied energy and resulting carbon dioxide emissions for different materials. A follow-up study at University of Canterbury[4] converted these material-specific estimates into quantities for different types of buildings, showing that the carbon sink for wood and wood products in new New Zealand buildings is roughly half a million tonnes of carbon dioxide each year. Similar results are available for new house construction in the United States[5]. Timber in buildings contains carbon, which remains for the life of the building, which may be 50 years or more. This pool of carbon is not a cumulative benefit because when timber buildings are finally demolished, and the wood decays or is burned, the carbon finds its way back into the atmosphere as CO_2.

The answer to the second question will change over time because of variations in the carbon sink resulting from new buildings and the carbon source resulting from demolition or other disposal of old buildings. In a steady state economy the number of new buildings being built could approximately equal the number being demolished in which case the carbon pool would remain roughly constant. The size of the wood carbon pool in existing New Zealand buildings has not been quantified.

Some authors state that there will be benefits if wood is used in long-life products, but it is the size of the pool, not the life of products which is most important[2]. If the Kyoto accounting system counted the pool of wood products, the total size of the pool would be more important than the flow of carbon through the pool, ie wood ownership would be more important than wood consumption.

How much fossil fuel energy is used to manufacture the materials in New Zealand buildings?

It is difficult to estimate how much fossil fuel energy is used to manufacture the materials in New Zealand buildings. The University studies mentioned above estimate that the total fossil fuel energy used to construct new buildings during the 1990s was about 32 PJ per year, about 7% of New Zealand's total fossil fuel energy consumption at that time. The amount of energy will be considerably greater in the current building boom period.

How much carbon dioxide is emitted to the atmosphere in the construction of New Zealand buildings?

The main greenhouse gas emitted to the atmosphere in the manufacture of materials and buildings is carbon dioxide resulting from burning of fossil fuel to provide heat or electricity for processing of materials. There is also a small amount of carbon dioxide released to the atmosphere during the manufacture of cement from limestone. The total CO_2 emissions associated with construction of buildings in New Zealand is over 2 million tonnes each year[4]. This number would be higher if we did not have a high proportion of electricity generated by renewable sources such as hydro electricity. Any increased use of renewable sources of energy such as wind power, or burning of wood or wood waste as fuel for electricity generation or heat will directly reduce the amount of fossil fuel being burned, leading to a benefit in the Kyoto system. Energy used for heating, cooling and lighting of buildings also results in carbon dioxide emissions over the life of the building.

How will more timber buildings reduce carbon dioxide emissions?

The principal benefit from increased use of wood in New Zealand buildings is the reduction of energy required to manufacture building materials. The University of Canterbury study[4] has shown that a significant change in the New Zealand construction industry, resulting in the use of much more wood and wood products as substitutes for energy intensive materials, would assist compliance with the Kyoto Protocol by reducing carbon dioxide emissions associated with building materials

This scenario assumes no changes in the energy used for heating and cooling of buildings, which over the life of a building is larger than the energy needed to manufacture the materials. Research is needed into innovative methods of reducing the energy required for heating and cooling in timber and all other buildings, utilising passive solar architecture and other techniques.

Which buildings could be constructed with more wood?

Houses make up about half the new buildings constructed in New Zealand each year. Most New Zealand houses are built with a timber frame which is not usually visible in the finished building because it is clad on the exterior with bricks or other materials and lined on the inside with gypsum plaster or similar material. There are opportunities for using more wood in houses as cladding, for flooring, windows and other joinery. Many apartments, hotels, motels and hostel type buildings are made from reinforced concrete or steel framing where there are opportunities for using timber or timber products. Factories and industrial buildings are nearly all made with steel roof cladding on steel framed roof structures, with concrete floors and concrete or masonry walls. It is not possible to economically use wood for roof cladding or industrial floors, but there are possibilities for using engineered wood products for structural members. The main structures of office buildings in New Zealand are mostly reinforced concrete, with increasing use of structural steel. There is limited opportunity for low to medium rise office buildings to be built with timber, often combined with concrete or steel in composite construction.

An investigation into a possible upper limit on substitution levels[4] considered a postulated scenario where up to half of all apartment, hotel and motel buildings are constructed with light timber framing, ten percent of commercial office buildings are built with glulam or LVL frames, half of industrial buildings have a timber structure, and at least half of all new houses have increased use of timber in floors, windows and other components. Implementation of this scenario would decrease carbon dioxide emissions by up to half a million tonnes annually. This would be a significant contribution to the government's target reduction of 5 million tonnes of CO_2 emissions per year in the first commitment period. This scenario is unlikely to eventuate without strong incentives.

A recent report by BRANZ[6] investigated the potential for greater use of timber in government and private sector buildings in New Zealand, identifying up to half a million square metres of floor area of eligible projects each year, resulting in carbon dioxide emission savings of 64,000 tonnes per year.

Which wood products are used as building materials?

A wide range of wood products is suitable for building and construction. The main material is sawn timber, increasingly supplemented with manufactured products such as plywood and other panel products, also glued laminated timber (glulam), laminated veneer lumber (LVL) and medium density fibreboard (MDF). High performance wood structures include LVL and glulam beams, timber I-beams, high strength trusses, walls and frames designed for excellent strength, performance and reliability. In addition to structural applications, large quantities of wood and wood products are used for decorative panelling, shelving, furniture, cladding and other non-structural uses.

How much timber is likely to be used in New Zealand buildings?

The construction industry is a major New Zealand industry with strong traditions and well established procedures. There is strong competition between major materials, so changes occur slowly unless there are strong incentives. Some parts of the industry may be reluctant to use more timber following recent problems relating to weathertightness and wood quality, which have since been dealt with by government agencies. Most buildings are constructed with borrowed money, so the lending institutions and the insurance industry have to be comfortable with the security of their investments.

A significant increase in the use of timber in new buildings will not happen without a serious co-ordinated investment in education, research and promotional activities. Education of engineering, architecture and design students provides design skills and confidence in new materials for innovative future design of buildings and building products. Education is also needed to support the solid wood processing industry, to encourage economical production and design of innovative new products using New Zealand grown timber. Continuing education of professional engineers, architects and designers is also essential, along with promotional activities by industry.

All sectors of the construction industry obtain confidence from leading-edge research into building performance issues including wind, fire and earthquake resistance, noise control, thermal behaviour and durability. The industry needs design aids for many aspects of timber usage, including structural design, durability, passive solar architecture etc.

What are the other benefits of innovation in design and construction of more timber buildings?

In addition to benefits accruing from the carbon credits described above, greater use of timber in New Zealand buildings will be accompanied by reduced dependence on imported materials and fossil fuels, increased opportunities for adding value to renewable New Zealand resources, export potential for engineered wood products and prefabricated building components rather than logs, creation of new employment opportunities in various cities and regions, development of export markets using New Zealand design expertise and demonstration of the unique capabilities of New Zealand timber and timber products. A secondary benefit is that greater reliance on timber buildings could result in increased investment in plantation forestry, eventually leading to further increases in the Kyoto carbon pool.

Encouragement of teaching and research in engineering and architecture of timber products and buildings is essential if the nation is to reap the rewards of the massive financial investment in forestry over recent decades.

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Note:
Most of these references quantify carbon sinks and flows in tonnes of *carbon*, but these have been converted to tonnes of *carbon dioxide equivalent* in this document in line with current international convention.