CHAPTER

11

Recycling of Lumber

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11.1 INTRODUCTION

Wood from sustainably managed forests can play important roles both as material and as fuel in a transition to a low-carbon society. Wood is widely used as an energy source and as a physical and structural material in diverse applications, including furniture and joinery, pulp and paper, and construction material. There is large potential to improve resource efficiency and thereby reduce greenhouse gas (GHG) emissions through efficient management of post-use wood materials (IPCC, 2007). This chapter explores post-use management of wood products from resource efficiency and climate perspectives. Primary energy and GHG balances are important metrics to understand the resource efficiency of climate change mitigation strategies involving post-use wood products. This chapter describes the mechanisms through which post-use management of recovered wood materials can affect primary energy use and GHG impacts of wood products. To further understand the implications of different post-use management options for wood products, we then explore several quantitative case-studies.

11.2 BACKGROUND

In contrast to materials such as steel and concrete, which are manufactured through technological processes in factories, wood is produced through natural biological processes occurring in growing trees. By dry weight, wood has an elemental composition of about 50% carbon, 44% oxygen, 6% hydrogen, and trace amounts of several minerals (Pettersen, 1984). These elements return to the environment when a wood product is burned or decayed at the end of its service life. Carbon, oxygen and hydrogen generally return in the form of CO_2 and H_2O. The elements thus become bioavailable for other trees to use in their growth, leading to continual cycling of materials.

The lifecycle of wood products begins with forest management activities, e.g. seedling cultivation, tree planting and forest thinning. This is followed by harvesting and processing

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of logs into lumber, and the manufacture, use and end-of-life management of the finished wood products. In addition to the principal flows of round wood and primary wood products, considerable coproducts are generated, e.g. residues from silviculture, harvesting, primary processing when logs are sawn into lumber, and in secondary processing to make products such as doors and windows (Gustavsson and Sathre, 2011). The use of wood as material or fuel has feedback mechanisms that affect total energy use and GHG emissions. Relatively little energy is needed for the manufacture and processing of wood-based materials compared to non-wood alternatives such as concrete and steel (Gustavsson and Sathre, 2006; Perez-Garcia et al., 2005; IPCC, 2007). Typically, wood-based products use mainly biomass residues for processing energy and have lower climate impacts than non-wood alternatives (Gustavsson et al., 2006).

Post-use management options for wood products include reuse, recycling, energy recovery and landfilling with or without the capture of landfill gas (LFG). Reuse of end-of-life products involves the further use of a recovered product in a similar application without reprocessing, while recycling entails reprocessing it to produce a new type of product. For example, large wood frames may be reused in similar structural applications or be remilled (and recycled) into wood flooring. Recovered wood products may be used in different applications, including as raw material for production of particleboard, oriented strand board, medium density fiberboard and animal bedding and mulches. In some areas, deposition in landfills is the most common fate for post-use wood material. For example, in North America demolition waste including wood material is typically disposed in landfills (Salazar and Meil, 2009). This, however, is prohibited in the EU and in some states in the United States (Defra, 2012). While landfilling has typically been the default baseline from which recycling benefits may be measured, in many European countries the default practice may now be to burn untreated wood in conventional energy plants and treated wood in specific incineration plants.

End-of-life management is the single most significant variable for the full lifecycle energy and carbon profiles of wood products (Gustavsson and Sathre, 2009; Sathre and O'Connor, 2010). Post-use wood products contain significant amounts of energy stored in chemical bonds that can be recovered and used to substitute fossil fuels, avoiding fossil emissions (Gustavsson et al., 2006). Currently, woody biomass provides 9% of the global total primary energy, which is more than the share from all other renewable energy sources or nuclear energy (FAO, 2010; IEA, 2009). The share of woody biomass in the global energy mix is projected to double in the coming decades (Mead, 2005). Energy recovery from post-use wood will be an increasingly important component of these renewable energy sources.

Post-use wood products are a potentially important resource in many countries, and Falk and McKeever (2004) observed that up to 90% of solid post-use wood may be recovered. Incomplete data make it difficult to know precisely how much is currently recovered in different countries (Defra, 2012), although a detailed inventory compiled the sources and quantities of recovered wood in 20 countries in the EU (COST Action E31, 2007). About 30 Mt of solid wood was recovered annually in these countries together, corresponding to about 13% of their annual round wood use. Falk and McKeever (2004) reported that 62.5 Mt of solid wood waste was generated in the United States in 2002, most of which was landfilled. They observed that 43% of the generated solid wood waste was suitable for recovery and reuse. Post-use wood may be recovered from construction and demolition sites, municipal and industrial waste, furniture and joinery manufacture, packaging and pallets. Other sources of recovered wood include post-use railroad ties and utility poles, which are often treated with chemical preservative. Incomplete data make it difficult to estimate how much recovered wood is used globally as bioenergy or as raw material. In the EU, 9.1 and 9.7 Mt of recovered wood were used as bioenergy and as raw material in 2007, respectively (Mantau et al., 2010). The share of recovered wood used as bioenergy or as raw material varies significantly among EU countries. For example, 90% of recovered wood in Sweden is used as bioenergy, while 70% of recovered wood in France is used as raw material for further wood processing (Mantau et al., 2010). Typically, post-use wooden materials are transported to material sorting or recycling sites where they are sorted according to size and quality, screened for contaminants, cleaned and designated for different end-use markets. Sorted clean and large wooden materials are typically used in higher value-added applications while small wood may be used for low-value purposes (CWC, 1997).

Few lifecycle studies provide comprehensive analysis of the implications of different end-of-life management options for wood products. Salazar and Meil (2009) assessed the energy and carbon balances of typical and wood-intensive buildings and explored scenarios where end-of-life wood materials are either disposed in landfill with recovery of LFG or recovered of energy by combustion, replacing fossil gas and coal for electricity production. The results show that diverting the post-use wood materials from the landfill for combustion significantly improved the energy and carbon balances of the buildings. Petersen and Solberg (2002) analyzed the lifecycle GHG emissions and cost-efficiency of structural beams made with steel or glue laminated (glulam) wood, including the impacts of different end-of-life management scenarios for the demolished wood and steel. They found that the greatest GHG and energy benefits are achieved when the wood is burned for energy to replace fossil fuels. Landfilling the wood resulted in large atmospheric GHG emissions due to the gradual anaerobic decomposition of the wood, releasing methane. They concluded that the differences in impacts between the glulam wood beam and steel beam depend strongly on how the post-use materials are managed.

Dodoo et al. (2009) analyzed the effects of post-use material management on the lifecycle carbon balance of wood- and concrete-frame buildings. The analysis included scenarios where demolished wooden material is used for energy to replace fossil fuels and demolished steel and concrete are recycled to replace virgin raw materials. They found that replacing fossil fuel with the recovered wooden material gives the greatest carbon benefit in the post-use phase of the buildings. Sathre and Gustavsson (2006) analyzed the effects of different post-use management options on the energy and carbon balances of wood lumber. Post-use options included reuse as lumber, reprocessing as particleboard, pulping to form paper products and burning for energy recovery. They compared energy and carbon balances of products made of recovered wood to the balances of products obtained from virgin wood fiber or from non-wood material. They found that several mechanisms affect the energy and carbon balances of recovery wood: direct effects due to different properties and logistics of virgin and recovered materials, substitution effects due to the reduced demand for non-wood materials when wood is reused, and land use effects due to alternative possible land uses when less timber harvest is needed because of wood recovery. They concluded that land use effects have the greatest impact on energy and carbon balances, followed by substitution effects, while direct effects are relatively minor.

Studies on solid waste management scenarios have also included the impacts of post-use wood products. Carpenter et al. (2013) assessed the environmental impacts of different end-of-life management options for construction and demolition waste in a lifecycle perspective. They analyzed scenarios where wood waste is either combusted with and without energy recovery or disposed in landfill with and without LFG recovery. They found that all the impact categories were significantly lower when the wood waste is combusted with energy recovery, compared to the other scenarios. Bolin and Smith (2011a,b) explored the environmental implications of landfilling or energy recovery of preservative treated wood. The impacts analyzed include energy use, GHG emissions, acidification, eutrophication, smog and ecological toxicity. The authors found that energy recovery of the preservative-treated wood results in lower impacts for all categories except for eutrophication and water use. They concluded that appropriate combustion of preservative-treated wood for energy recovery should be permitted. Jambeck et al. (2007) compared the environmental and economic tradeoffs associated with scenarios where treated wood waste is landfilled or combusted for electricity production in a waste-to-energy facility. The ash from the wood combustion was assumed to be landfilled. The economic analysis considered the cost of waste collection, transport, treatment and disposal, and the revenue generated from the sale of electricity for the combustion for energy scenario.

Rivela et al. (2006) analyzed the system-wide environmental impacts and trade-offs associated with the use of recovered wood for particleboard production or for bioenergy. When the recovered wood is recycled into particleboard, energy is assumed to come from natural gas; when the recovered wood is used for bioenergy, particleboard is assumed to be produced from virgin wood. Merrild and Christensen (2009) analyzed the energy and global warming impacts of recycling wood into particleboard or producing particleboard from virgin wood. They found that recycling post-use wood into particleboard results in significant energy and GHG savings compared to the particleboard production from virgin wood, primarily because of the avoided energy for drying virgin wood. The study did not include impacts from upstream activities and processes, e.g. the fate of the forest if virgin wood is not harvested.

11.3 KEY ISSUES IN POST-USE MANAGEMENT OF WOOD

11.3.1 Post-use Wood in Integrated lifecycle Flows

Post-use wood products can be managed as part of an integrated flow of material and energy within and between the forestry, manufacturing, construction, energy and waste management sectors (see Figure 11.1). This integration, which valorizes the post-use materials, can bring energetic, economic and environmental advantages (Sathre and Gustavsson, 2009). Recovery and recycling of wood from demolished buildings is becoming increasingly common. The percentage of end-of-life wood materials that is recoverable is variable, and depends on the practical limitations linked to the building design and whether material recovery is facilitated through deconstruction. A high recovery percentage of demolition wood could be achieved in future as the value of wood as an energy source is more widely recognized, and as more buildings are designed and constructed in ways that facilitate deconstruction to allow greater recycling and reuse of building materials (Kibert, 2003). This may involve the "design for disassembly" of buildings to facilitate the removal of wood products with minimal damage, to maintain their potential for further re-use as a material. Such optimization of end-of-life product recovery and recycling systems may become increasingly important, to gain additional value from the wood as a

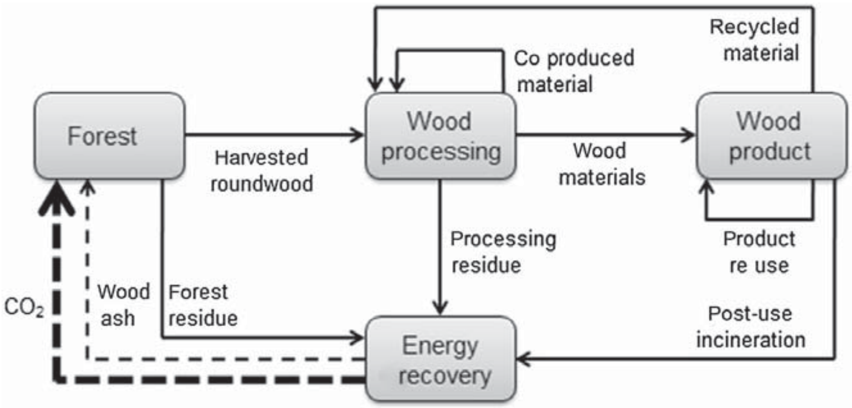

FIGURE 11.1 Schematic diagram of system-wide integrated material flows of wood products.

material before it is ultimately burned to recover its feedstock energy.

11.3.2 Wood Cascading

Additional use of recovered wood material, such as reusing as lumber, reprocessing as particleboard or pulping to form paper products, can improve the environmental performance of the material. Wood products are well suited for material cascading, which has been suggested as a strategy to increase the efficiency of resource use (Haberl and Geissler, 2000). Cascading is the sequential use of a resource for different purposes as the resource quality degrades over time. The cascade concept includes four dimensions of resource economy: resource quality, utilization time, salvageability and consumption rate (Sirkin and ten Houten, 1994). In terms of these four characteristics, optimal utilization of wood resources is achieved by matching the resource quality to the task being performed, so as not to use a high-grade resource when a lower-grade one will suffice; increasing the total utility gained from a resource through prolonging the time during which it is used for various purposes; upgrading a resource through salvaging and reprocessing, where appropriate, for additional higher-grade uses; and balancing the usage rate of a resource with the capacity of forest land to regenerate lost resource quality. Effective cascading use of post-use wood materials may further improve resource efficiency. In some cases, particularly when forest resources are limited, it will be beneficial to employ a more complex cascade chain involving multiple material uses before final burning (Sathre and Gustavsson, 2006). The advantages of such wood cascading depend strongly on the relative quantities of wood products entering service and new wood biomass produced by forests. When forest biomass production is limited, cascading may be beneficial by allowing greater usage from the limited primary biomass production. However, when the biomass production is larger than the amount of wood products made and used, the benefits of material cascading are questionable. At least two conditions can be imagined in which post-use wood cascading, besides energy recovery, could be beneficial: (1) total use of woody biomass increases significantly and the primary harvest is limited, and (2) designation of more forest land as protected reserves to increase biodiversity benefits, together with a limited primary harvest. In the future, if more material and energy services are provided by biomass and fewer by fossil resources, wood cascading is likely to become more important by allowing more intensive use of limited biomass resources.

Reprocessing of recovered wood in a cascade chain may require altered levels of specific energy use for material processing. There are differences in processing energy required because of the different physical properties of virgin and recovered wood, mainly the lower moisture content of recovered wood. Slightly more energy is needed to saw or chip the dry recovered wood, which is harder than green wood. Substantially less energy is required to kiln-dry the recovered wood than the green wood during production of lumber or particleboard. Drying has the largest single demand for energy in the manufacture of lumber and particleboard made from green wood (FAO, 1990). Moisture content, through its effect on heating value, is also important in the comparison of biofuels, e.g. dry recovered wood versus green, freshly harvested biofuel.

11.3.3 Chemical Preservatives

As a biologically produced material, wood is part of natural material cycles and can be decomposed by a variety of organisms such as fungi and insects. To prevent the deterioration of wood products while still in service, some wood is treated with chemical wood preservatives that kill decay organisms. Two main categories of chemical treatments exist: oil-borne preservatives such as creosote and pentachlorophenol, and water-borne preservatives such as copper- and boron-based solutions (Lebow, 2010). Regulations in many countries define the allowable uses of different types of preservatives, which differ between, e.g. residential and industrial applications. The landscape of chemical wood preservatives has changed significantly in the last decades toward safer materials, and continues to change. The use of arsenic in wood preservative solutions, such as the once common chromated copper arsenate (CCA), has been phased out, particularly in residential applications. In the European Union, the Biocidal Products Directive (98/8/EC) covers many common wood preservatives including CCA and creosote, leading to increasing restrictions on their use. Nevertheless, significant quantities of chemically treated wood are currently in service and will require post-use management in the coming years. Opportunities for recycling of preservative treated wood are more limited than for untreated wood (Felton and de Groot, 1996). Particular concerns include worker exposure to emissions from recycling processes, and interference by preservatives with the bonding of adhesives. Energy recovery from treated wood is also restricted, although treated wood can be incinerated under suitable combustion conditions with flue gas cleaning and appropriate ash disposal (Townsend et al., 2008).

11.3.4 Nutrient Cycling

Wood has very small quantities of mineral elements such as Ca, Mg, K and P, although tree leaves and needles typically have higher concentrations of these elements. To avoid loss of these nutrients from forest ecosystems over the long term, ashes from combusted biomass can be applied to growing forests to ensure that nutrient cycles are closed (Stupak et al., 2007). In the absence of ash recycling, the continued export of nutrients contained in the biomass could lead to nutrient deficiency and reduced forest production. In Sweden, for example, the National Board of Forestry has published recommendations regarding the appropriate manner in which ash recycling should be done (Swedish National Board of Forestry, 2002). The dosage of ash application is calculated in such a way as to balance the removal of nutrients in wood, bark and foliage with the return of nutrients in ash. Quality standards are specified for ashes, including minimum content of Ca, Mg, K and P. To avoid the long-term build-up of heavy metals and other contaminants that can be concentrated in the ash, maximum content of trace elements including several heavy metals is also specified. Before wood ashes are applied to the forest, they must be stabilized to slow their dissolution and avoid damage to sensitive flora and fauna. Stabilization can take place both chemically and physically, with the goal that the ashes dissolve slowly over a period of 5–25 years in the field. Ash processing can be done in centralized facilities, or can be done with mobile equipment at the locations where the ash is produced. Ashes can be spread in the forest using ground equipment such as converted tractors, or by helicopter.

11.4 CASE STUDY SCENARIOS

Here, several case-study scenarios are explored and analyzed to quantify the primary energy use and GHG implications of different end-of-life management options for recovered wood.

11.4.1 Case Study Method: Primary Energy Use and GHG Balances

This case study is based on a four-story wood-frame building with 16 apartments and a total heated floor area of 1190 m^2, located in Växjö, Sweden. Further details of the characteristics of the building are reported in Persson (1998) and in Dodoo et al. (2012). The mass of major materials contained in the building is shown in Table 11.1.

TABLE 11.1 Mass of Major Materials Contained in the Building

Material	Mass (t)
Lumber	59
Particleboard	18
Plywood	21
Concrete	223
Steel	16
Plasterboard	89

A method developed by Gustavsson et al. (2006) is used to calculate the primary energy and GHG balances of the scenarios studied. The primary energy used to extract, process, transport and assemble the materials is calculated, and the lower heating values of the logging and processing residues and of the recovered demolition wood used as fuel. The GHG emissions from fossil fuel combustion and cement process reactions are calculated, as well as the potential emissions avoided by replacing fossil fuel with recovered biofuels, and the carbon stock changes in materials and forests. The recovery and use of LFG from landfilled wood products is considered in scenarios involving landfilling. The LFG emission is estimated based on the default IPCC methodology (IPCC, 2006). Recoverable forest residues at harvest are based on data from Lehtonen et al. (2004) and Sathre and Gustavsson (2006). We assume 70% recovery of available harvest residues, and 100% of processing and construction residues. The recovery percentage of post-use wood varies with scenario. The assumed lower heating values for the recovered biomass are 4.25 kWh/kg dry biomass for bark and harvest residues, 4.62 kWh/kg dry biomass for processing residues and 5.17 kWh/kg dry biomass for recovered post-use wood (Gustavsson and Sathre, 2006). The amount of diesel fuel used for biomass recovery, expressed in terms of the heating value of the biomass, is assumed to be 1% for processing residues and post-use wood and 5% for harvest residues (Gustavsson and Sathre, 2006). Specific final energy for building material production is based on Swedish conditions (Björklund and Tillman, 1997; Sathre and Gustavsson, 2006). Electricity is assumed to be produced in coal-fired condensing plants with a conversion efficiency of 40% and distribution loss of 2%. Conversion efficiency is assumed to be unchanged when recovered biofuels replace coal.

The biogenic carbon storage sequestered or released from wood materials is not included in the inventory as the wood is assumed to come from sustainably managed forestry, where carbon flows out of the forest are balanced at the landscape level by carbon uptake by growing trees.

11.4.2 Particleboard Production from Recovered Lumber or Virgin Wood

We analyze the primary energy and GHG implications of producing particleboard from either recovered lumber or virgin wood. Figure 11.2 summarizes the scenarios. The analysis considers particleboard in a 100-year lifecycle perspective and assumes that the particleboard is combusted for energy at the end of its service life. In *Scenario A*, 90% of the lumber in the case-study building, corresponding to 53.1 t, is assumed to be recovered and used as raw material for the particleboard production. In *Scenario B*, particleboard production is from virgin wood, and biomass residues are obtained from forest management and processing activities for the virgin wood. The fuel used to recover and transport the wood material is assumed to be diesel and is calculated with data from Sathre and Gustavsson (2006).When recovered lumber is reprocessed as particleboard (*Scenario A*), the forest is assumed to either remain unharvested and continue to grow by either 0% or 20% over the 100-year lifecycle, or to be harvested at year 0 and used to displace coal. When the forest is harvested to produce particleboard (*Scenario B*), the recovered lumber is combusted, substituting coal. An estimated 9% more electricity and 60% less thermal energy are needed for particleboard production with recovered lumber compared to the particleboard made from virgin wood (Sathre and Gustavsson, 2006).

The primary energy balances of all the scenarios are negative, meaning that more energy is available for external use than is used during

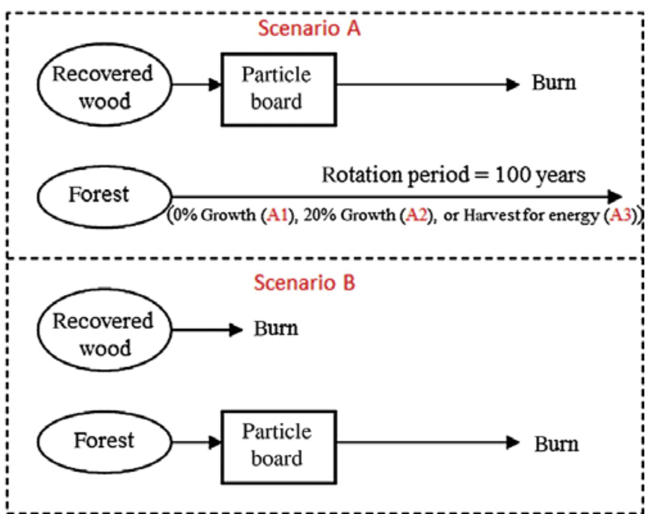

FIGURE 11.2 Comparison of two alternatives for producing particleboard. In *Scenario A* recovered lumber is used as raw material for particleboard, allowing the forest to be used for other purposes. In *Scenario B* the recovered lumber is burned, and the forest is harvested to produce particleboard.

TABLE 11.2 Primary Energy and GHG Implications of Scenarios where Particleboard is Produced from Recovered Lumber or Virgin Wood

Description	Primary Energy (MWh)	Greenhouse Gas (t CO_2e)
A1. RECOVERED LUMBER FOR PARTICLEBOARD, 0% FOREST GROWTH		
Material recovery and production	60	22
Heating value of residues	−215	
Substitution of fossil coal by residues		−85
Product carbon stock changes		0
Forest carbon stock changes		0
Total	−155	−63
A2. RECOVERED LUMBER FOR PARTICLEBOARD, 20% FOREST GROWTH		
Material recovery and production	60	22
Heating value of residues	−215	
Substitution of fossil coal by residues		−85
Product carbon stock changes		0
Forest carbon stock changes		−32
Total	−155	−95
A3. RECOVERED LUMBER FOR PARTICLEBOARD, HARVEST FOREST FOR ENERGY		
Material recovery and production	72	25
Heating value of residues	−477	
Substitution of fossil coal by residues		−189
Product carbon stock changes		0
Forest carbon stock changes		0
Total	−405	−164
B. VIRGIN WOOD FOR PARTICLEBOARD, BURN RECOVERED LUMBER		
Material recovery and production	74	26
Heating value of residues	−491	
Substitution of fossil coal by residues		−195
Product carbon stock changes		0
Forest carbon stock changes		0
Total	−417	−169

the product lifecycle (Table 11.2). The GHG balances are negative for all scenarios except when the forest remains standing without growth. The primary energy and GHG balances are lowest when virgin wood is used for particleboard and the recovered lumber is burned. The difference in primary energy and GHG balances is small between the scenario where the recovered lumber is used for particleboard and the forest for biofuel and the scenario where virgin wood is used for particleboard and the recovered lumber for biofuel. The difference in process energy between making particleboard from recovered lumber and virgin wood is small in relation to the total energy flow in the production systems.

11.4.3 A Complex Cascade Chain for Recovered Wood Products

Here we present a more complex material management scenario. Recovered lumber is used for building-frame construction and then recycled as particleboard before combustion with energy recovery (*Scenario C*). This is compared to a scenario where non-wood alternatives including reinforced concrete frame material and gypsum panelboard are used (*Scenario D*). Here we assume that the forest resources are limited, so the building must be constructed either with recovered lumber or alternate non-wood materials. When non-wood materials are used for construction, the recovered lumber is burned in place of coal. A schematic diagram of these scenarios is shown in Figure 11.3. The analysis is based on the same amount of recovered lumber and specific energy data and fuel cycle emission data, as in Section 11.4.2.

The primary energy and GHG balances are lowest when recovered lumber is used for the building frame (Table 11.3). This is due mainly to the fossil fuel used for the production of concrete and steel, compared to the reuse of the recovered lumber, which is assumed to require no additional processing energy. Significant amounts of biomass residues are recovered at the end of the lifecycle of wood product, in contrast to the non-wood alternative materials. The GHG balance is substantially higher for the reinforced concrete materials, owing to the calcination emission of CO_2 during cement production as well as greater fossil fuel use for manufacture of the non-wood materials.

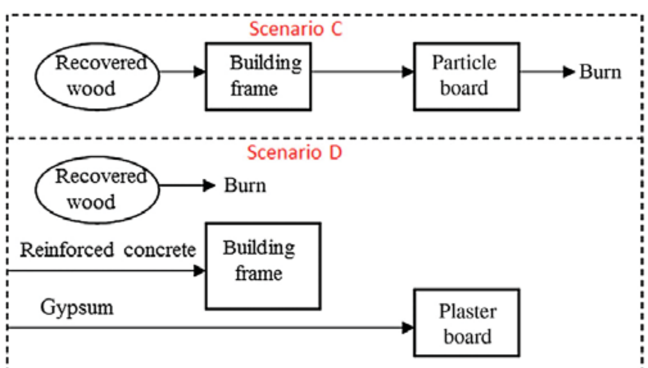

FIGURE 11.3 Comparison of two alternatives for providing building materials, assuming limited forest. In *Scenario C*, recovered lumber is used for building materials. In *Scenario D*, reinforced concrete and plasterboard are used for building materials and the recovered lumber is burned.

TABLE 11.3 Primary Energy and Greenhouse Gas Implications of Scenarios where Recovered Lumber or Non-wood Materials are Used for Building Frame and Panel Products

Description	Primary Energy (MWh)	Greenhouse Gas (t CO_2e)
C. RECOVERED LUMBER FOR PRODUCTS		
Material recovery and production	58	17
Heating value of residues	−233	
Substitution of fossil coal by residues		−92
Product carbon stock changes		0
Total	−175	−75
D. NON-WOOD MATERIALS FOR PRODUCTS, BURN RECOVERED WOOD		
Material recovery and production	171	68
Heating value of residues	−233	
Substitution of fossil coal by residues		−92
Product carbon stock changes		0
Total	−62	−24

11.5 SUMMARY

In this chapter we have explored the implications of end-of-life management options for wood products and have described several mechanisms through which post-use management of recovered wood materials can affect the lifecycle resource efficiency and climate performance of wood products. This analysis shows how efficient management of post-use wood products can contribute to a sustainable, resource-efficient, low-carbon society. Recovering energy from post-use wood material gives significant primary energy and GHG benefits. These benefits of post-use wood materials may be further optimized when wood is cascaded, in which post-use wood is reused and recycled for use in a sequence of applications and afterward burned to recover the heat content. The benefits of additional material use in complex cascade chains, however, depend largely on the relative abundance of primary forest resources.

Lifecycle and system perspectives of wood products are needed, so that all the lifecycle phases—acquisition of raw material, manufacture, use and end-of-life—are considered and optimized as a whole, including the energy and material chains from natural resources to final services. Primary energy and GHG balances are important metrics when analyzing the resource efficiency and climate mitigation effectiveness of post-use wood management options. Primary energy use largely determines natural resource efficiency and steers the environmental impacts of material production. More so than with other common materials, appropriate post-use management of wood products is important because in addition to its structural use as a physical material, wood can also be used as a sustainable bioenergy source. The increased use of wood products from sustainably managed forests can play an important role in our transition to a low-carbon economy, and post-use management is a critical phase of the wood product lifecycle that should be thoughtfully optimized.

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