TECHNICAL NOTE

Cradle-to-Grave Carbon Impacts of a Kitchen Cabinet

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Abstract

Kitchen cabinets are manufactured using many materials components including wood, glass, and steel. In this streamlined LCA. This paper focuses on the carbon impacts for producing kitchen cabinets and the end-of-life (EoL) impacts when the cabinets are removed from service and landfilled, combusted, and reused. One kitchen cabinet across its entire life cycle results in a net positive A1-C4 GWP_{TOTAL} of 23.06 kg CO_2e when the cabinet is landfilled, 72.39 kg CO_2e when it is combusted, and 72.11 kg CO_2e when it is reused. In each EoL scenario, the biogenic carbon content of the cabinet is −56.45 kg CO_2. When Module D is included, an additional benefit of −14 kg CO_2e is added under the combustion EoL scenario and −65 kg CO_2e is added when the material is reused. When module D is included, the net GWP_{TOTAL} under the combustion and reuse scenarios were 58 kg CO_2e and 7 kg CO_2e, respectively.

This study aims to fill some of these data gaps by conducting a cradle-to-grave LCA of kitchen cabinets. This study was commissioned by the Composite Panel Association (CPA), with participation by the Kitchen Cabinet Manufactures Association (KCMA). The goal of this case study was to get a better understanding of the carbon impacts of downstream products that use WCP, primarily particleboard and medium density fiberboard (MDF). Using kitchen cabinets as the product category, a streamlined cradle-to-grave LCA was performed to estimate the carbon impacts of three possible waste treatments: landfilling, combustion, and reuse.

As the need for reductions in embodied carbon impacts has been increasing in the face of a warming climate, so has the demand for reporting on the environmental impacts of materials used in construction. Embodied carbon is the sum of the cradle-to-gate upfront carbon emissions which include resource extraction, material transportation, and product manufacturing and does not include the carbon stored in wood products or changes in soil carbon pools (Lambert and Lewis, 2024). Embodied carbon is reported as global warming potential (GWP) measured in carbon dioxide equivalents (CO_2e) and presented as CO_2e_{FOSSIL}(ISO 2017).

The *biogenic carbon* that is part of the molecular composition of wood is derived from the carbon dioxide removed from the atmosphere by photosynthesis during tree growth (ISO 2017). The harvesting of trees transfers the carbon from the forest to the wood product. On average, the carbon content of wood is 50 percent (Bergman et al. 2014). For example, one kilogram of oven-dry wood typically contains about 0.5 kilograms (kg) of carbon, which is equivalent to 1.83 kg of CO_2 when oxidized. Biogenic carbon is commonly reported as $CO_2e_{BIOGENIC}$, and is stored in wood products during its service life and may be emitted to the atmosphere at the end of life (EoL). Release of the biogenic carbon can occur by combustion or by landfilling, through leaching and the release CO_2 and methane (CH_4) emissions. The rate at which carbon is released is highly dependent upon the EoL treatment (García and Freire 2014; Wang et al. 2018; Lao and Chang 2023). Landfills are considered carbon-locking, as they can permanently store carbon (up to 88 percent of the initial carbon content) (EPA 2020). These results arise when wood is compacted and sealed in the landfill to prevent water and oxygen from entering, preventing any anaerobic decomposition. From a sustainability perspective, recycling or reuse of wood products after their

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initial service life is preferable, but in most cases wood products, particularly wood composite panels (WCP), most likely end up in the landfill or are used for energy recovery, after their extended use (Ximenes et al. 2018).

Life Cycle Assessment (LCA) is used as a method to quantify and document the environmental impacts of materials across their entire life cycle—from raw material extraction and production to use, disposal, and/or recycling. By systematically evaluating inputs such as energy and resources, and outputs like emissions and waste, LCA provides a transparent, science-based method for comparing materials and identifying opportunities to reduce environmental burdens. LCAs are becoming increasingly more important as they are used by all industries to inform product and process design and for builders and architects as they seek to minimize energy consumption and carbon releases in all aspects of construction. Going forward, the need for credible, scientific, and impartial LCA-based information will be greater than ever. One cannot assume wood products will continue to enjoy environmental superiority without continued advancement in environmental and product performance, from cradle to grave.

WCPs are well known for their environmentally-friendly attributes of being renewable and produced using waste wood from primary wood products contributing to an environmentally friendly wood source (Puettmann 2024a, 2024b; Puettmann 2022). However, although the environmental impacts of WCP production have been well-documented (Puettmann 2024a, 2024b), less information exists on the EoL treatment impacts for these products. A review of EoL practices for WCP details existing data and assumptions for service lifetimes, waste treatment options, embodied carbon impacts, and carbon storage benefits (Puettmann and Sahoo 2023). The authors note that few LCA studies on WCP include EoL impacts due to key data gaps such as landfill carbon dynamics specifically for engineered wood products. In addition, data are also limited on specific waste treatments for end-use products manufactured from WCP, such as kitchen cabinets (Puettmann and Sahoo 2023).

This study aims to fill some of these data gaps by conducting a cradle-to-grave LCA of kitchen cabinets. This study was commissioned by the Composite Panel Association (CPA), with participation by the Kitchen Cabinet Manufactures Association (KCMA). The goal of this case study was to get a better understanding of the carbon impacts of downstream products that use WCP, primarily particleboard and medium density fiberboard (MDF). Using kitchen cabinets as the product category, a streamlined cradle-to-grave LCA was performed to estimate the carbon impacts of three possible waste treatments: landfilling, combustion, and reuse.

Materials and Methods

Kitchen cabinet materials

This project was initiated with a global literature review on the EoL carbon impacts of WCP methodologies, biogenic carbon emissions factors for WCP, and carbon stored in WCP when WCP are landfilled (Puettmann and Sahoo 2023). One of the main takeaways from the literature review was the lack of information on product category use and the expected service life of various product categories. Furthermore, the fate of these product categories after use is not well-understood.

KCMA members participated in this study by providing primary production data via surveys. Surveys requested the total kitchen cabinets produced in 2023 and the input materials, resources, and energy used. Cabinet manufacturers as part of this LCA represent a range of production from both small custom cabinet manufacturers to larger flat packed cabinet producers. Producers were primarily from the north central region of the United States (US). Disposal scenarios for kitchen cabinets at the end of service used assumptions provided by the EPA's Advancing Sustainable Materials Management Report (EPA 2020).

Kitchen cabinets represent both wall (above counter) and base (below counter) cabinet types (Fig. 1). They can be made from MDF, particleboard, plywood, solid wood, or a mix of each (Table 1). A kitchen cabinet can be sold with or without drawers, shelves, or doors. Doors can be made of wood, glass, or mirrors. Cabinets can be finished or not finished (Table 1, Fig. 1). The mass of a cabinet varies widely depending on the wood product used, size of cabinet, and type of cabinet. Based on survey results, the average cabinet mass was 36 kg oven dry (functional unit) with a minimum of 20 kg and a maximum of 52 kg. Wood mass in each cabinet represented 86 percent of the total cabinet mass (excluding dowels), with non-wood components composing the remaining 14 percent. Of the total wood used, plywood and MDF were the most represented in an average kitchen cabinet, representing 32 and 28%, respectively. Particleboard and solid wood represented 24 and 16% of the total wood used, respectively (Table 1).

Cabinets in general represent approximately 15 percent of the downstream use of MDF and particleboard (CPA 2024). Particleboard and MDF have been reported to have a life expectancy of 100 years when used in cabinetry (Puettmann and Sahoo 2023). Although there is very little data on the service life of individual product categories,

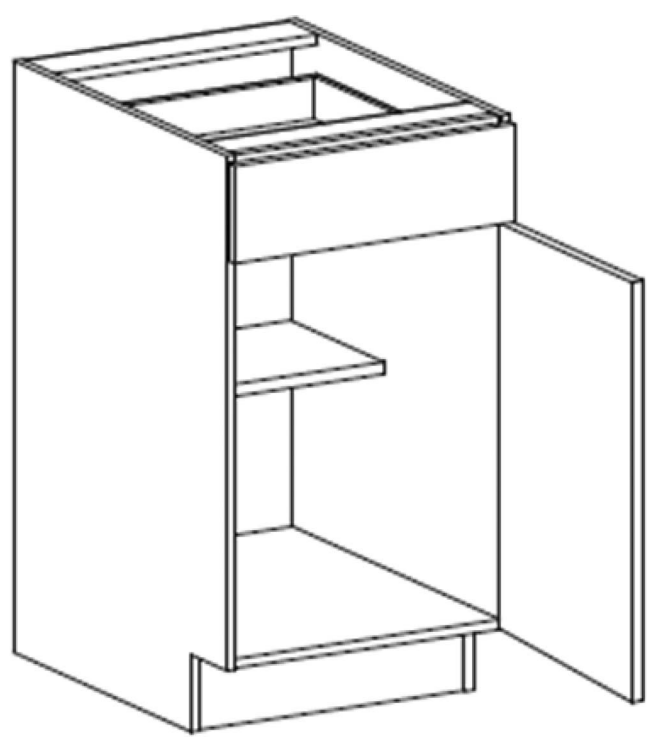

Figure 1.—Average base cabinet with drawer, shelf, and door.

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Table 1.—Bill of materials for one kitchen cabinet, based on weighted average production.

Product	Volume (m^3)	Mass (kg)	Percent of total wood or total non-wood mass	Percent of total cabinet mass
Medium Density Fiberboard	0.0113	8.67	28.16%	24.15%
Plywood (veneer core)	0.0162	7.59	24.67%	21.14%
Particleboard	0.0107	7.46	24.23%	20.78%
Solid wood (hardwood lumber)	0.0079	4.89	15.88%	13.62%
Plywood (composite core)	0.0046	2.18	7.07%	6.07%
Total Wood in Cabinet	0.0508	30.79	100%	85.77%
Coatings	—	2.078	40.69%	5.79%
Dowels	—	1.617	31.66%	4.50%
Metal hinges/slides	—	0.921	18.04%	2.57%
Adhesives	—	0.261	5.12%	0.73%
Paper overlay	—	0.096	1.87%	0.27%
Plastic clips/guides	—	0.093	1.82%	0.26%
Edge banding	—	0.025	0.48%	0.07%
Mirrors	—	0.015	0.29%	0.04%
Glass	—	0.001	0.02%	0.00%
Total Other Components		5.106	100%	14.23%
Total Cabinet		35.89		100%

we were conservative and assumed kitchen cabinets would be removed from service around 25 years. In addition, the authors could only find 25 years of US cabinet production available (Freedonia Group 2024). The authors would like to note that the service life of the cabinet is only used for carbon accounting for cabinets in service.

System boundary

Information modules included in this LCA are shown in Table 2 and Figure 2. The LCA is divided into modules A1-A3 (capturing the production stage) and A4 (transportation to customers). Additional modules included are the C2-C4 EoL stages and additional benefits or reuse, energy recovery, and recycling potential in Module D.

Due to data gaps, the impact associated with A5, B1-B7, and C1 (Sahoo et al. 2021) are assumed to be minor and are therefore excluded (Table 2).

A1 – This module includes upstream production of resources and materials used in cabinet manufacturing. This includes but is not limited to forestry operations and other resource extraction processes, and the manufacturing of wood products (Hubbard et al. 2020; Puettmann 2024a, 2024b; Roseburg Forest Products 2018), mirrors, glass inserts, metals, plastics, and adhesives. The participating manufacturers reported annual material consumption for cabinet manufacturing (Table 1). Wood products represented nearly 86 percent of the mass of cabinet.

A2 – Transportation of all resources and materials to cabinet manufacturing facilities is included in this module. Transportation of all wood and non-wood components to cabinet manufacturers (A2) required on average 440 kilometers (km) of road transport and 24,856 km of water transport.

A3 – Cabinet manufacturing required electricity and energy usage. The average weighted mass of one cabinet is 36 kg, with 86 percent of the mass coming from wood products and 14 percent coming from other materials (e.g., glass, metals, coatings, etc.).

A4 – Transportation from cabinet manufacturers to retailers required 0.54 kg of cardboard per cabinet for packaging and 1,491 km of transport by truck.

C2-C4 – EoL treatment starts with waste transportation (C2) and ends with waste processing and disposal (C3/C4).

Table 2.—Description of system boundary modules.

A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4	D
Extraction and up-stream production	Transport to factory	Manufacturing	Transport to site	Installation	Use, Maintenance, Repair, Replacement, Refurbishment, Operational Energy and water use	Deconstruction	Transport	Waste Processing	Disposal	Reuse, Recycle, \& Recovery benefits
X	X	X	X	MND*	MND*	MND*	X	X	X	X

* MND = Module Not Declared and Excluded from this LCA.

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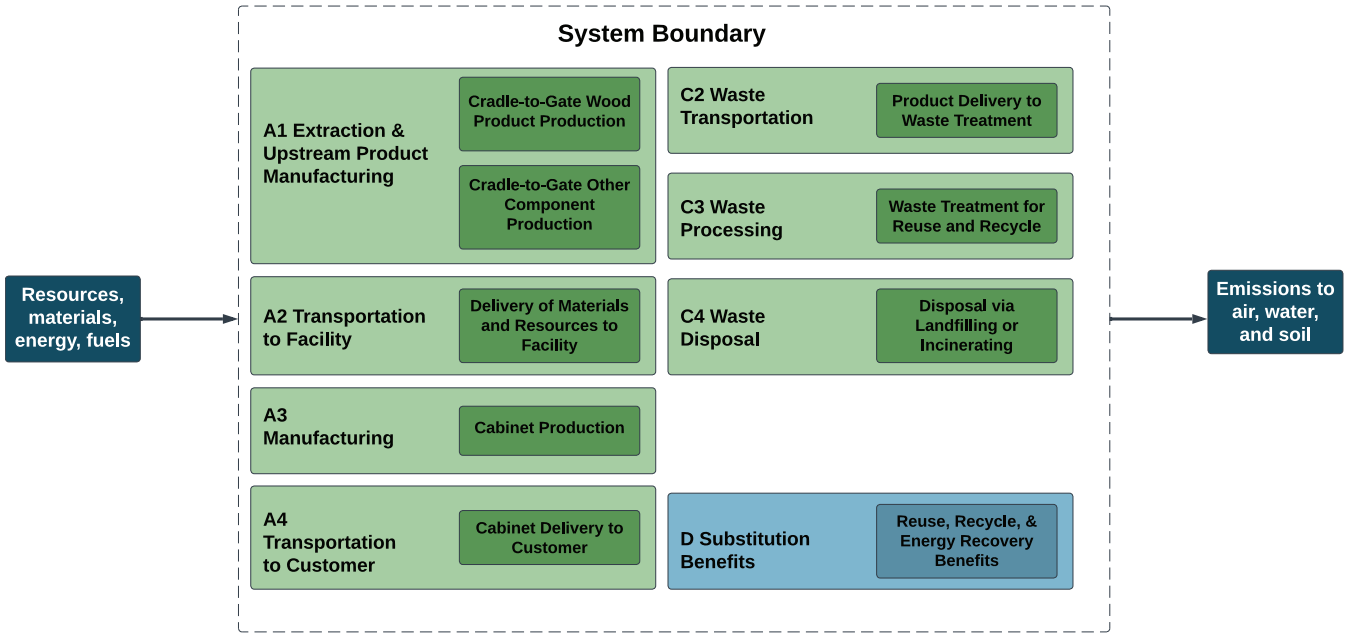

Figure 2.—Cradle-to-grave (A1-A3, A4, C2-C4 + Module D) system boundary for cabinet manufacturing.

Waste transportation required 32 km of truck transportation in each EoL scenario (EPA 2023a).

D – Substitution Benefit – The impacts of displacing a wood cabinet made from virgin materials with a reused wood cabinet are estimated by subtracting the impacts of manufacturing a wood cabinet from the GWP_{FOSSIL} in the reuse EoL scenario. The impacts of displacing electricity from the average grid mix with a combusted cabinet are also estimated by subtracting the impacts of electricity production from the GWP_{FOSSIL} in the combustion EoL scenario. This assumes the best-case substitution.

Carbon accounting

Embodied carbon.—Embodied carbon (GWP_{FOSSIL}) accounts for the greenhouse gas emissions released within the defined system boundary and is the sum of the upfront carbon emissions resulting from resource extraction, material transportation, and product manufacturing, but does not include the carbon stored in the product or changes soil carbon pools. Embodied carbon is reported as GWP_{FOSSIL} in carbon dioxide equivalents (CO_2e) and calculated using the US Environmental Protection Agency's (EPA) TRACI 2.1 v1.08 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts) (Bare 2012).

Biogenic carbon.—Biogenic carbon is the carbon derived from biomass. Trees absorb CO_2 through the process of photosynthesis, incorporating it into plant tissue as carbon. This biogenic carbon is emitted as $CO_{2BIOGENIC}$ and biogenic methane ($CH_{4BIOGENIC}$) when trees or biomass are combusted or decayed. During the production of wood products, biogenic carbon is emitted if wood biomass is combusted for energy during manufacturing or if forest residues are burned after a harvest. These emissions are captured in the A1 and C4 modules of this LCA.

Biogenic carbon or stored carbon is the carbon stored in a wood product used to manufacture a kitchen cabinet. Wood on average is 50 percent carbon. This carbon remains in the product, locked up, and only potentially gets released at the end of the product's life. At the end of the kitchen cabinet's life, biogenic carbon emissions can be released partially or all back into the atmosphere depending upon the EoL treatment.

The biogenic carbon removal for wood deposited in landfills was calculated in accordance with ISO 13391-1, in which 10 percent of the initially stored biogenic carbon is assumed to be emitted as landfill gas, and the remaining 90 percent is stored long-term (ISO 2025a). We assumed for simplicity that all landfill emissions would be instantaneous, but in reality biogenic emission timing is highly dependent on the landfill management practices. There is no biogenic carbon removal credit for reused or combusted wood, as any biogenic carbon stored in these products leaves the system boundary. The $GWP_{BIOGENIC}$ result is deducted from the embodied carbon (GWP_{FOSSIL}) and reported as a net carbon emission (GWP_{TOTAL}).

Carbon flows.—Carbon flows are based on the mass of kitchen cabinets (Equation 1) as reported by manufacturers.

$$\begin{aligned} &\textit{Carbon flow } (mt\ CO_2) \\ &\quad = \textit{Kitchen production } (mt) * \frac{50\%}{100} * \frac{44}{12} \end{aligned} \tag{1}$$

— Cabinet production in oven dry mass (wood component only)
— mt = metric tons
— Estimated wood carbon content of panel = 50%
— Molecular weight of CO_2 = 44/12

Carbon pools are the cumulative carbon from current and previous year shipments (Equations 2 and 3). The kitchen cabinet carbon pool begins in 2001 (yr 1) and ends after 25 years of production (2025) and is calculated based on Equation 2. The assumption is that there are no removals from the carbon pools.

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$$Yr\ t\ Carbon\ pool,\ X_t = X_{t-1} + Carbon\ flow_t \quad (2)$$

— X = carbon pool (CO_2)
— t = year
— *Carbon flow* = Equation 1 (carbon as CO_2 in current year's production)

$$Cumulative\ Carbon\ pool\ (mt\ CO_2) = Carbon\ flow_{yr1} + Carbon\ flow_{yr2} \ldots + Carbon\ flow_{yrx} \quad (3)$$

End of life.—After the product is removed from service there are several possible outcomes for the fate of a kitchen cabinet. It can be disposed of via landfill, combusted with or without energy recovery, or reused. The results presented include a 100 percent landfill scenario, a 100 percent combustion scenario, and a 100 percent reuse scenario. An average of the three EoL treatments based on 67% landfill, 16% combustion, and 17% reuse is also shown (EPA 2020).

For C2 Transportation, we assumed an average waste transport distance of 32 km (EPA 2023a). For C3 Waste Processing, the emissions generated during product refurbishment in the reuse scenario are taken from EPA WARM data for lumber (EPA 2023a). The C4 Disposal is assumed to occur at a municipal landfill in the landfilling scenario, and at a waste-to-energy combustion facility in the combustion scenario. C4 includes all fossil emissions generated at each of these facilities during disposal.

Assumptions for C2 & C4:

— C2 Transportation: 32 km, for hauling to landfill, combustion, and reuse facilities
— C3 Waste Processing: repairs in the reuse scenario to produce a refurbished cabinet
— C4 Disposal: municipal landfill and combustion emissions

The GWP_{FOSSIL} for landfilled cabinets was estimated by applying the EPA's WARM emission factors for landfilling to each material component of a kitchen cabinet (EPA 2023a, 2023b). WARM calculates the emissions associated with landfilling biogenic materials by estimating the proportion of a material's biogenic carbon permanently stored in the landfill, the proportion emitted as CH_4, and the proportion emitted as biogenic CO_2.

Example for Landfilling Solid Wood:

Solid wood input of 0.087 kg (Table 1) × 0.17 kg CO_2e/kg wood (WARM emission factor) = GWP_{FOSSIL} of 0.01 kg CO_2e.

Combining each material's GWP_{FOSSIL} yielded the total GWP_{FOSSIL} for landfilling waste cabinets.

Calculations GWP_{FOSSIL} under the combustion and reuse scenarios were also taken from WARM tool, following the same calculation set-up as landfilled cabinets.

Substitution benefits—Module D

To account for environmental benefits, we assumed the best-case substitution benefits of displacing a new cabinet or average grid electricity for the reuse or combustion with energy recovery EoL scenarios. Per ISO 21930, substitution benefits are reported in Module D as the difference between output flows for reused materials or recovered fuels and the input flows of the displaced virgin materials (ISO 2017). It is assumed that recycling/reusing one kitchen cabinet can displace the A1-A3 impacts of producing one kitchen cabinet made from virgin raw materials, which is reported in this study to be 22.28 kg CO_2e per cabinet. Thus, the substitution benefit for recycling/reusing one cabinet is calculated by subtracting 22.28 kg CO_2e from the cradle-to-grave GWP_{FOSSIL}.

For cabinets that are combusted, it is assumed that combusting with energy recovery displaces fossil-generated electricity from the US average electrical grid. The EPA WARM tool reports that 5.36 kWh of electricity is generated from combusting 1 kg of wood; assuming their reported combustion system efficiency of 17.8 percent, the substitution benefit of displacing fossil electricity is calculated by multiplying the energy content of wood and the combustion system efficiency by the GWP_{FOSSIL} emission factor for 1 kWh of electricity from the US average grid, yielding a substitution benefit of −0.46 kg CO_2e per kg wood.

Results and Discussion

The embodied carbon for disposing of one cabinet after its service life in each EoL scenario are presented in Figures 3-6. The landfill scenario had a higher C3/C4 GWP_{FOSSIL} (1.70 kg CO_2e) (Fig. 3) than the combustion (Fig. 4) and reuse scenarios (Fig. 5) (0.28 and 0 kg CO_2e, respectively), due to the methane emissions generated in the landfill. When biogenic materials such as wood are subjected to the anaerobic conditions of landfills, a portion of the stored biogenic carbon degrades and is released as $CH_{4BIOGENIC}$, a strong greenhouse gas with a higher radiative efficiency and shorter atmospheric residence time than CO_2 (EPA 2023c). In the case of construction lumber and MDF, 1 percent of the initial biogenic carbon content is assumed to be emitted as CH_4 (EPA 2023d). Despite this low proportion, landfilling these wood products still results in higher C3/C4 embodied carbon impacts compared to combusting or recycling wood. The reuse scenario has the lowest A1-C4 + D GWP_{TOTAL}, due to the large substitution impacts of displacing A1-A3 production of a new cabinet. The average scenario has the second lowest A1-C4 + D GWP_{TOTAL}, since 16% of the cabinet mass is reused in this scenario, offsetting the higher A1-C4 + D impacts of the landfilled and combusted cabinet mass (Fig. 6).

Although the WARM tool offers many strengths when calculating EoL impacts, there are several limitations that inhibit a comprehensive EoL assessment for WCP. Though there are many different types of materials included in WARM, there are only two types of construction wood products available. MDF is the only WCP offered by WARM, which we have used as a proxy for all WCP included in kitchen cabinets due to the lack of existing data on other WCP. However, WCP vary in their resin content, wood content, and product density (Puettmann 2024a, 2024b), all of which can impact landfill biodegradation since resin inhibits degradation. Notably, MDF has a higher resin (10%) (Puettmann 2024a) content than the other types of WCP used in this study's cabinets (particleboard (8%) and plywood (3%)), so the landfill emissions for the particleboard and plywood portions of the cabinet (48% of the total cabinet mass) may be underestimated. Conversely, the laboratory landfill experiments that provided data for WARM's emission factors have been demonstrated to overestimate landfill emissions for WCP such as MDF (Puettmann and Sahoo 2023). Due to the

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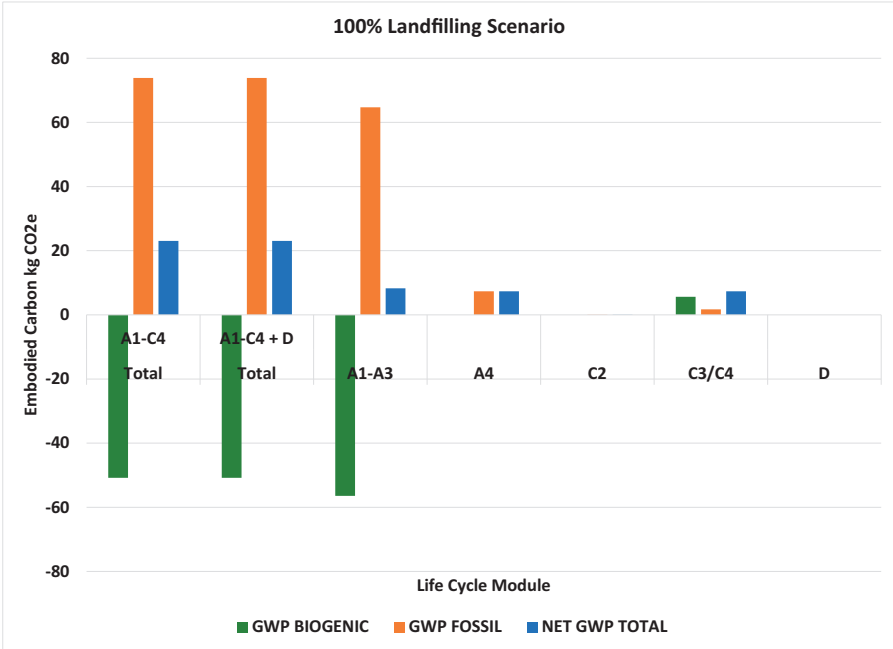

Figure 3.—Cradle-to-Grave (A1-C4, D) Embodied Carbon, Biogenic carbon, and Net Carbon Results as kg CO_2e for One Kitchen Cabinet Under the 100% Landfilling End-of-Life Scenario. Note: C2 values are not zero, but not visible at this scale.

lack of detailed data on landfill emissions for different WCP, it is unknown what the combined impact of these limitations is, and whether or not MDF is a suitable proxy for other WCP when landfilled.

Case Study—25 years of cabinet production and use

To estimate the potential embodied carbon impacts, carbon storage benefits, and substitution benefits of the US kitchen cabinet industry, 25 years of cabinet production were modeled. The annual US consumption of kitchen cabinets was reported from 2001-2023 (Freedonia Group 2024). In order to capture 25 years of service life, future demand for 2024 and 2025 were estimated based on a projected annual increase in demand of 1 percent (Freedonia Group 2024). Based on Freedonia Group research (2024) we assumed that 10 percent of this reported demand was for non-wood kitchen cabinets, so 10 percent of the

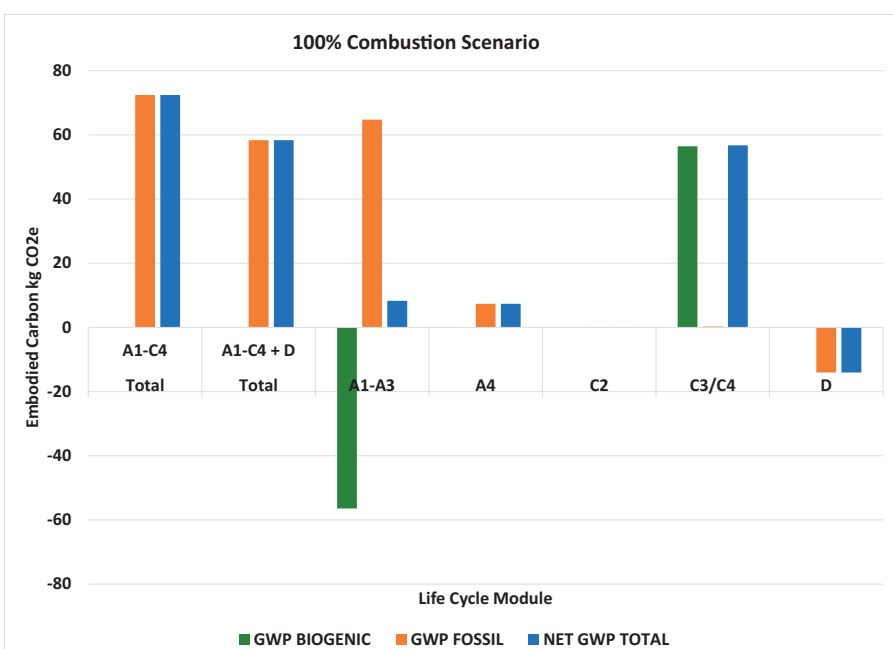

Figure 4.—Cradle-to-Grave (A1-C4, D) Embodied Carbon, Biogenic carbon, and Net Carbon Results as kg CO_2e for One Kitchen Cabinet Under the 100% Combustion End-of-Life Scenario. Note: C2 values and C3/C4 fossil are not zero, but not visible at this scale.

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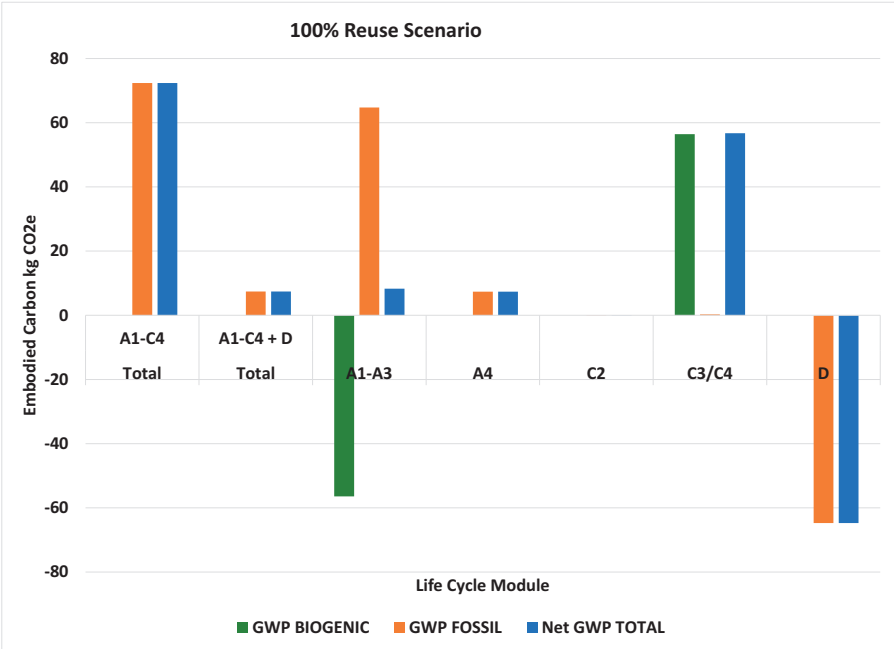

Figure 5.—Cradle-to-Grave (A1-C4, D) Embodied Carbon, Biogenic carbon, and Net Carbon Results as kg CO_2e for One Kitchen Cabinet Under the 100% Reuse End-of-Life Scenario. Note: C2 values and C3/C4 fossil are not zero, but not visible at this scale.

kitchen cabinets were deducted from the annual demand. The total number of units consumed in the 25-year time period (2001-2025) was 1.42 billion wood-based kitchen cabinets, which was calculated by summing each year's demand (Fig. 7).

Using the LCA survey data for kitchen cabinets, the production (A1-A4) and end-of-life (C2-C4) impacts were modeled for 1.42 billion cabinets for 25 years. Under the average scenario, the resulting A1-C4 GWP_{TOTAL} was 56 million MT CO_2e, whereas the cabinets stored −48 million MT CO_2e (Fig. 8). When the substitution benefits are accounted for under module D (A1-C4 + D), they yielded benefits of a net positive GWP_{TOTAL} of 37 million MT CO_2e under the average scenario (Fig. 8).

The LCA input data was based on surveys from a small sample of kitchen cabinet producers. The authors chose not to weigh the results based on the small sample size that was not an adequate representation of the U.S kitchen cabinet

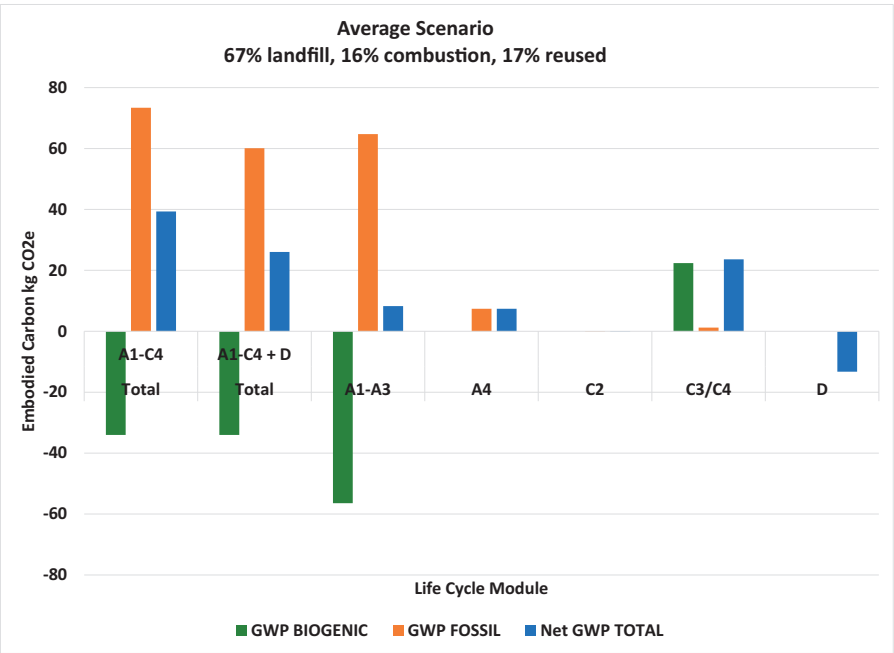

Figure 6.—Cradle-to-Grave (A1-C4, D) Embodied Carbon, Biogenic carbon, and Net Carbon Results as kg CO_2e for One Kitchen Cabinet Under the Average End-of-Life Scenario.

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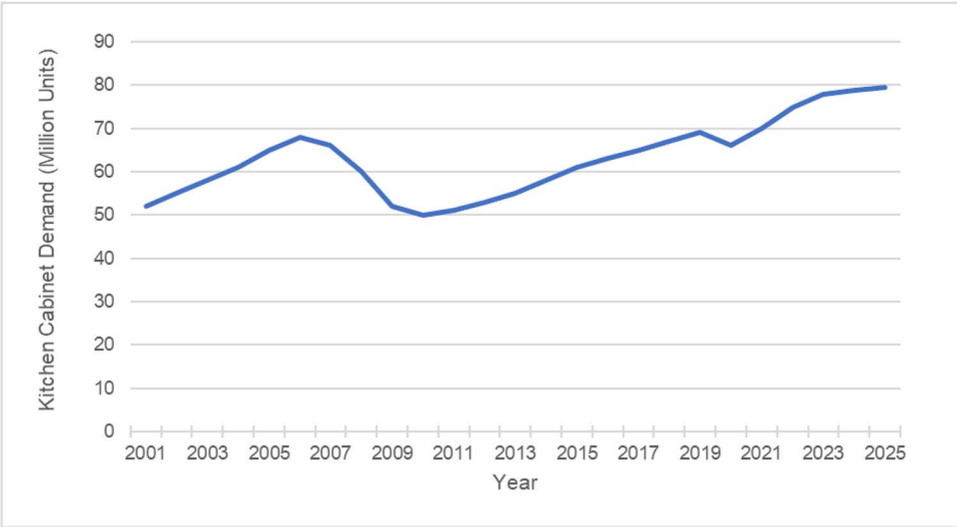

Figure 7.—Annual kitchen cabinet demand in millions of units in the United States from 2001–2025 (extrapolated fromFreedonia Group 2024).

industry. The primary goal of the study was to investigate the downstream use and EoL impacts of WCP used in kitchen cabinets (particleboard, plywood, and MDF).

The LCA results indicate that fossil fuel use during cabinet manufacturing (A3) was the driving factor for the high embodied carbon. It is the authors' opinion that if a wider range of producers were included, including custom and flat packed cabinets from large and small producers, the results would produce carbon impacts that are more reflective of an average kitchen cabinet.

Although our results show that the manufacturing and use of kitchen cabinets is not carbon negative, there are still benefits of using wood. For example, the cradle-to-gate embodied carbon of our wood cabinet illustrates a 45 percent lower value than that reported for a steel cabinet (Vytrolma UAB 2024). However, the authors would like to note that the wood kitchen cabinet and the steel cabinet might not have functional equivalencies. Under ISO 13391-3 (ISO 2025b) the displacement factor for using a wood cabinet versus a steel cabinet is 0.79 kg CO_2e/kg of wood cabinet. For the cabinet assessed in this study, this equals 24.32 kg CO_2e displaced.

Conclusions

This study provides a streamlined cradle-to-grave (A1-C4) LCA of kitchen cabinets produced in the United States. The primary goal of this LCA was to develop embodied carbon impacts for producing, using, and disposing of a

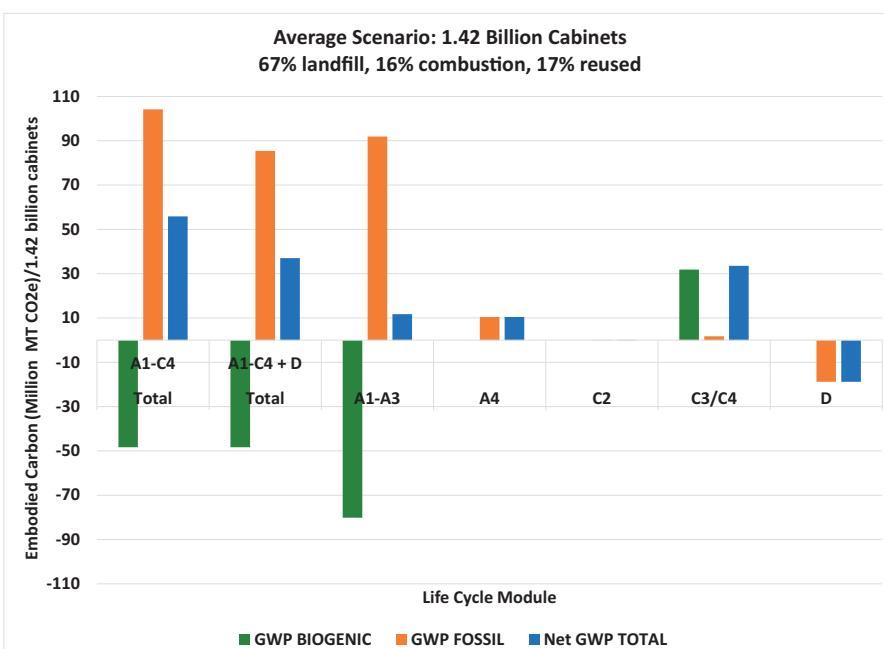

Figure 8.—Annual Cradle-to-Grave (A1-C4, D) Embodied Carbon, Biogenic carbon, and Net Carbon Results as kg CO_2e for 1.42 Billion Cabinets Produced Over 25 years, Under the Average End-of-Life Scenario.

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kitchen cabinet. The production, distribution, and waste treatment of one kitchen cabinet across its entire life cycle results in a net positive A1-C4 GWP_{TOTAL} of 23.06 kg CO_2e when the cabinet is landfilled, 72.39 kg CO_2e when it is combusted, and 72.11 kg CO_2e when it is reused. When module D is included, an additional benefit of −14 kg CO_2e and −65 kg CO_2e is added under the combustion and reuse scenarios, respectively, yielding a net GWP_{TOTAL} of 58 kg CO_2e and 7 kg CO_2e, respectively. The average EoL distribution scenario (67% landfill, 16% combustion, 17% reuse) added a module D benefit of −13 kg CO_2e, yielding a net GWP_{TOTAL} of 26 kg CO_2e.

In each EoL scenario, the biogenic carbon content of the cabinet was −56.45 kg CO_2, which offsets 87 percent of the cabinet's A1-A3 embodied carbon emissions from production. When the displacement of steel cabinets is considered, the wood-based kitchen cabinet in this study displaces 0.79 kg CO_2e for every kg of wood cabinet manufactured. The EoL LCA research presented in this paper provides value by giving builders, designers, and architects scientific data to make informed decisions regarding material selection, with the goal of reducing embodied carbon from materials used to make finished products.

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Literature Cited

Bare, J. 2012. Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - Software Name and Version Number: TRACI version 2.1 - User's Manual. Washington, D.C.: U.S. EPA.

Bergman, R., M. Puettmann, A. Taylor, and K. Skog. 2014. The Carbon Impacts of Wood Products. *For. Prod. J.* 64(7–8): 220−231. https://doi.org/10.13073/FPJ-D-14-00047.

Composite Panel Association (CPA). 2024. Shipments and Downstream Market Report.

EPA. 2020. Advancing Sustainable Materials Management: 2018 Fact Sheet Assessing Trends in Materials Generation and Management in the United States. 25pp. https://www.epa.gov/sites/default/files/2020-11/documents/2018_ff_fact_sheet.pdf. Accessed November 29, 2025.

EPA. 2023a. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)—Construction Materials Chapters (p. 124). United States Environmental Protection Agency. 124pp. https://www.epa.gov/system/files/documents/2023-12/warm_construction_materials_v16_dec.pdf. Accessed November 29, 2025.

EPA. 2023b. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Containers, Packaging, and Non-Durable Good Materials Chapters. United States Environmental Protection Agency. 82pp. https://www.epa.gov/system/files/documents/2023-12/warm_containers_packaging_and_non-durable_goods_materials_v16_dec.pdf. Accessed November 29, 2025.

EPA. 2023c. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Background Chapters. United States Environmental Protection Agency. 61pp. https://www.epa.gov/system/files/documents/2023-12/warm-background_v16_dec.pdf. Accessed November 29, 2025.

EPA. 2023d. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)—Management Practices Chapters. United States Environmental Protection Agency. 128 pp. https://www.epa.gov/system/files/documents/2024-01/warm_management_practices_v16_dec.pdf. Accessed November 29, 2025.

Freedonia Group. 2024. US Kitchen Cabinets Market – Industry Research Report. https://www.freedoniagroup.com/industry-study/us-kitchen-cabinets. Accessed November 29, 2025.

García, R. and F. Freire. 2014. Carbon footprint of particleboard: a comparison between ISO/TS 14067, GHG Protocol, PAS 2050 and Climate Declaration. *J. Clean. Prod.* 66:199−209.

Hubbard, S. S., R.D. Bergman, K. Sahoo, and S.A. Bowe. 2020. A life cycle assessment of hardwood lumber production in the northeast and north Central United States. CORRIM Report. 45 pp. https://research.fs.usda.gov/treesearch/60571.

International Organization for Standardization (ISO). 2017. Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services. Second edition (ISO 21930:2017-07). 80 pp.

International Organization for Standardization (ISO). 2025a. Wood and wood-based products – Greenhouse gas dynamics – Part 1: Framework for value chain calculations. First edition (ISO 13391-1: 2025-04). 44 pp.

International Organization for Standardization ISO. 2025b. Wood and wood-based products – Greenhouse gas dynamics – Part 3: Displacement of greenhouse gas emissions. First edition (ISO 13391-3: 2025-04). 22 pp.

Lambert, M. and M. Lewis. 2024. Embodied Carbon 101. Carbon Leadership Forum. https://carbonleadershipforum.org/embodied-carbon-101-v2/.

Lao, W.L. and L. Chang. 2023. Greenhouse gas footprint assessment of wood-based panel production in China. *J. Clean, Prod.* 389:136064.

Puettmann, M. 2022. Carbon analysis of wood composite panels. *Forest Prod. J.* 72(2):112−115.

Puettmann, M. 2024a. Cradle-to-grave Life Cycle Assessment of North American Medium Density Fiberboard. CORRIM Report. 57 pp. https://corrim.org/wp-content/uploads/2024/07/MDF-Cradle-to-grave-LCA-Final.pdf. Accessed November 29, 2025.

Puettmann, M. 2024b. Cradle-to-grave Life Cycle Assessment of North American Particleboard. Composite Panel Association. CORRIM Report. 56 pp. https://corrim.org/wp-content/uploads/2024/07/PB-Cradle-to-grave-LCA-Final.pdf. Accessed November 29, 2025.

Puettmann, M. and K. Sahoo. 2023. Literature Review – End of life carbon accounting for wood composite panels. CORRIM Research Paper. 15 pp. https://corrim.org/wp-content/uploads/2025/11/CPA-EoL-review-white-paper.pdf. Accessed November 29, 2025.

Roseburg Forest Products. 2018. Hardwood Plywood [Environmental Product Declaration]. 9 pp. https://www.roseburg.com/wp-content/uploads/2021/01/EPD_-_SkyPly_Hardwood_Plywood-2.pdf. Accessed November 29, 2025.

Sahoo, K., Bergman, R., and Khatri, P. (2021). Cradle-to-Grave Life-Cycle Assessment of Cellulosic Fiberboard. Recent Progress in Materials, 3(4), 1 – 28.

Vytrolma UAB. 2024. Coated Steel Cabinets. [Environmental Product Declaration]. https://environdec.com/library/epd16005. 9 pp. Accessed December 1, 2025.

Wang, S., W. Wang, and H. Yang. 2018. Comparison of product carbon footprint protocols: case study on medium-density fiberboard in China. *Int. J. Environ. Res. Public Health.* 15(10):2060.

Ximenes, F.A., A.L. Cowie, and M.A. Barlaz. 2018. The decay of engineered wood products and paper excavated from landfills in Australia. *Waste Manag.* 74:312−322.

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