

Generic Wool Carpet

Product Selection and Description

In BEES, wool carpet with a 25-year life is studied. The mass of 0.09 m² (1 ft²) of wool broadloom carpet or carpet tile is approximately 40 oz (1.13 kg). Four different product combinations are included in the BEES database.

Flow Diagram

The flow diagram below shows the major elements of the production of this product, as it is currently modeled for BEES.

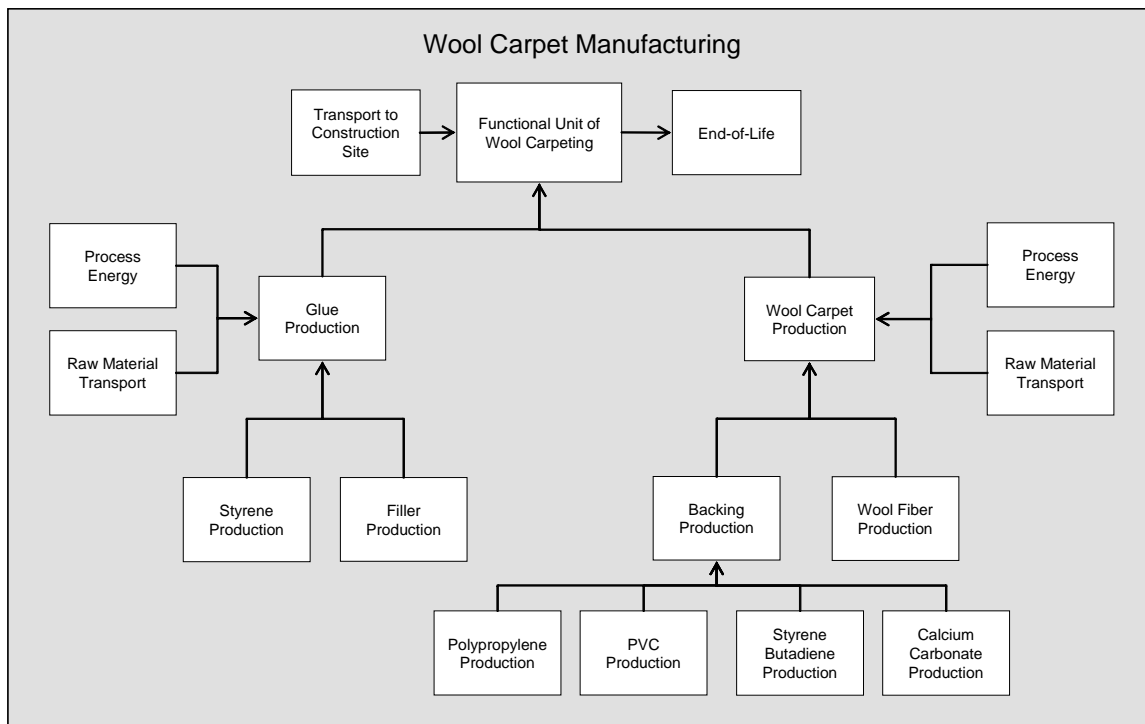


Figure 1: Wool Carpet System Boundaries

Raw Materials

Wool carpeting consists of a mix of wool for the facing, a polymer for the backing, and a styrene butadiene/limestone mix that is used to adhere the facing to the backing. The difference between the tile and broadloom carpets is the polymer that makes up the backing, as shown below.

Table 1: Wool Carpet Constituents

Constituent	Material	g/m² (oz/ft²)
Broadloom		
Face Fiber	Wool	1 571 (5.11)
Backing	Polypropylene	139 (0.45)
	Styrene butadiene latex	254 (0.83)
	CaCO ₃ filler	750 (2.44)
Tile		
Face Fiber	Wool	1 517 (4.94)
Backing	Virgin PVC	133 (0.43)
	Styrene butadiene latex	244 (0.79)
	CaCO ₃ filler	724 (2.36)

Data for wool production comes from the U.S. LCI Database. Production data for the remaining materials in the carpet comes from the U.S. LCI Database and 2010 American Chemistry Council data.¹

Raw wool is greasy and carries debris that needs to be washed off in a process called “scouring.” The amount of washed wool per kg of raw wool is 80 %, as shown in the table below along with mass fractions for other raw wool constituents reported by the Wool Research Organization of New Zealand (WRONZ).

Table 2: Raw Wool Constituents

Constituent	Mass Fraction (%)
Clean fiber (ready to be carded and spun)	80
Grease	6
Suint salts	6
Dirt	8

Grease is recovered at an average rate of 40 %.² The scoured fiber is then dried, carded, and spun. The table below lists the main inflows and outflows for the production of wool yarn from raw wool as reported by WRONZ.³

¹ Franklin Associates, a Division of ERG, for the Plastics Division of the American Chemistry Council: *Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors* (Prairie Village, KS, 2010).

² The non-recovered grease exits the system (e.g., as sludge from water effluent treatment).

³ These requirements also include processes such as dyeing and blending which take place at this stage.

Table 3: Wool Yarn Production Requirements

<i>Flow</i>	<i>Amount per kg (per lb) wool yarn</i>
Input	
Natural Gas	5.375 MJ (3.29 kWh)
Electricity	0.70 MJ (0.43 kWh)
Lubricant	0.063 kg (0.31 lb)
Water	37.5 L (21.79 gal)
Output	
Wool yarn ⁴	1 kg (4.85 lb)
Water emissions due to scouring:	4.125 g (0.02 lb)
Biochemical Oxygen Demand	11.625 g (0.06 lb)
Chemical Oxygen Demand	

Most of the required energy is used at the scouring step. Since grease is a co-product of the scouring process, a mass-based allocation is used to determine how much of the energy entering this process is due exclusively to the production of washed wool. One-fourth of the required energy is used for drying. Lubricant is added for blending, carding, and spinning, and some lubricant is incorporated into the wool. Approximately 6 % of the wool is lost during the blending, carding, and spinning processes of yarn production; this waste is accounted for in the BEES data for the manufacturing life-cycle stage.

Manufacturing

Energy Requirements and Emissions.

Wool yarn production into carpet fiber requires additional steps including bleaching, dyeing, and finishing. The inputs to the bleaching process, provided in the table below, are based on a Best Available Techniques document for the textile industry.⁵ No energy data are available for bleaching, and information for dyeing and finishing is not sufficient to permit inclusion in the BEES model.

Table 4: Wool Yarn Bleaching Inputs

<i>Input</i>	<i>kg/kg (= lb/lb) Wool Yarn</i>
Stabilizer	0.030
Sodium Tri-Polyphosphate	0.015
Hydrogen Peroxide (35%)	0.200
Formic Acid (85%)	0.002
Sodium Hydrosulphite	0.008

⁴ Accounts for the loss due to the 80 % mass fraction of clean fiber in raw wool.

⁵ European Commission, Integrated Pollution Prevention and Control (IPPC): Best Available Techniques for the Textile Industry (July 2003), p.135.

For both wool carpet types, the wool must be “tufted” to produce the carpet face. The face yarn is attached, using a primary coating and tufting needles, to the carpet backing. The energy requirements for this process step are provided in the following table.

Table 5: Energy Requirements for Wool Carpet Tufting

<i>Energy Carrier</i>	<i>MJ/m² (kWh/ft²)</i>
Electricity	1.79 (0.05)
Natural Gas (industrial boiler)	8.13 (0.21)
Total	9.92 (0.26)

Emissions associated with the manufacturing process arise from the production of electricity and the combustion of natural gas, and are based on the U.S. LCI Database.

Solid Wastes. Nearly 0.01 kg (0.02 lb) of waste is generated from the production of 0.09 m² (1 ft²) of wool broadloom and tile carpeting. The waste is assumed to be disposed of in a landfill.

Transportation. Truck transport of raw materials to the manufacturing plant is assumed to require 402 km (250 mi) by truck, with the exception of wool, which is transported 1 600 km (1000 mi).

Transportation

The distance for transport of wool broadloom carpet and wool carpet tile by heavy-duty truck to the building site is modeled as a variable of the BEES system.

Installation

Wool broadloom carpet and wool carpet tile both are installed using either standard latex glue or a low-VOC latex glue. For the tile, a typical glue application is 0.13 kg/m² (0.03 lb/ft²) of glue per unit installed tile. For the broadloom carpet, 0.13 kg/m² (0.14 lb/ft²) is applied.

No glue is assumed to be wasted during the installation process, but 5.7 % of the broadloom carpet and 2 % of the wool tile are assumed to be lost as waste; this waste is accounted for in the BEES data for the manufacturing life-cycle stage. All waste is assumed to be disposed of in a landfill.

Use

With a life of 25 years, the carpet is installed twice over a 50-year period. As with all BEES products, the environmental burdens from replacement are included in the inventory data. VOC off-gassing from the carpet and its installation adhesives are included in the BEES modeling.

End of Life

At end of life, the wool broadloom carpet and carpet tile are assumed to be disposed of in a landfill.

References

Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO. Found at: <http://www.nrel.gov/lci/database>.

PRé Consultants: *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

European Commission, Integrated Pollution Prevention and Control (IPPC): *Best Available Techniques for the Textile Industry* (July 2003).

Franklin Associates, a Division of ERG, for the Plastics Division of the American Chemistry Council: *Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors* (Prairie Village, KS, 2010).