Generic Latex Paint Products

Product Selection and Description

Conventional paints are generally classified into two basic categories: water-based (in which the solvent is water) and oil-based (in which the solvent is an organic liquid, usually derived from petrochemicals). Oil-based paints are sometimes referred to as solvent-based. Paints essentially consist of a resin or binder, pigments, and a carrier in which these are dissolved or suspended. Once the paint is applied to a surface, the carrier evaporates, leaving behind a solid coating. In oil-based paints the carrier is a solvent consisting of volatile organic compounds (VOC), which can adversely affect indoor air quality and the environment. As a result, government regulations and consumer demand are forcing continuing changes in paint formulations. These changes have led to formulations containing more paint solids and less solvent, and a shift away from oil-based paints to waterborne or latex paints.

BEES considers three neutral-colored, latex-based paint alternatives for interior use: virgin latex paint plus two types of latex paint that contain leftover household paint, or post-consumer (PC) paint--consolidated and reprocessed. Because they do not use solvents as the primary carrier, latex paints emit far fewer volatile organic compounds (VOC) upon application. They also do not require solvents for cleaning of the tools and equipment after use. Water with a coalescing agent is the carrier for latex paints. The coalescing agent is typically a glycol or glycol ether. The binder is synthetic latex made from polyvinyl acetate and/or acrylic polymers and copolymers. Titanium dioxide is the primary pigment used to impart hiding properties in white or light-colored paints. A range of pigment extenders may be added. Other additives include surfactants, defoamers, preservatives, and fungicides.

Consolidated paint facilities are often located at or near county or city recycling and Household Hazardous Waste (HHW) facilities. These facilities generally have relatively small-scale operations in which paint meeting a certain quality is blended and repackaged and sold or given away to the public. In larger consolidating operations, some virgin materials are added to the paint. Reprocessed paint is generally produced in a larger-scale facility and varies by producer and PC paint content; reprocessed paint can contain 50 % to over 90 % PC paint.

The three latex paint alternatives are applied the same way. The surface to be painted is first primed and then painted with two coats of paint. One coat of paint is then applied every 4 years. In reality, the three paint options vary in quality, but for BEES they are assumed to be of the same quality, with one gal covering 37.2 m^2 (400 ft^2).

Flow Diagram

The flow diagram shown below shows the major elements of the production of these products as they are currently modeled for BEES.

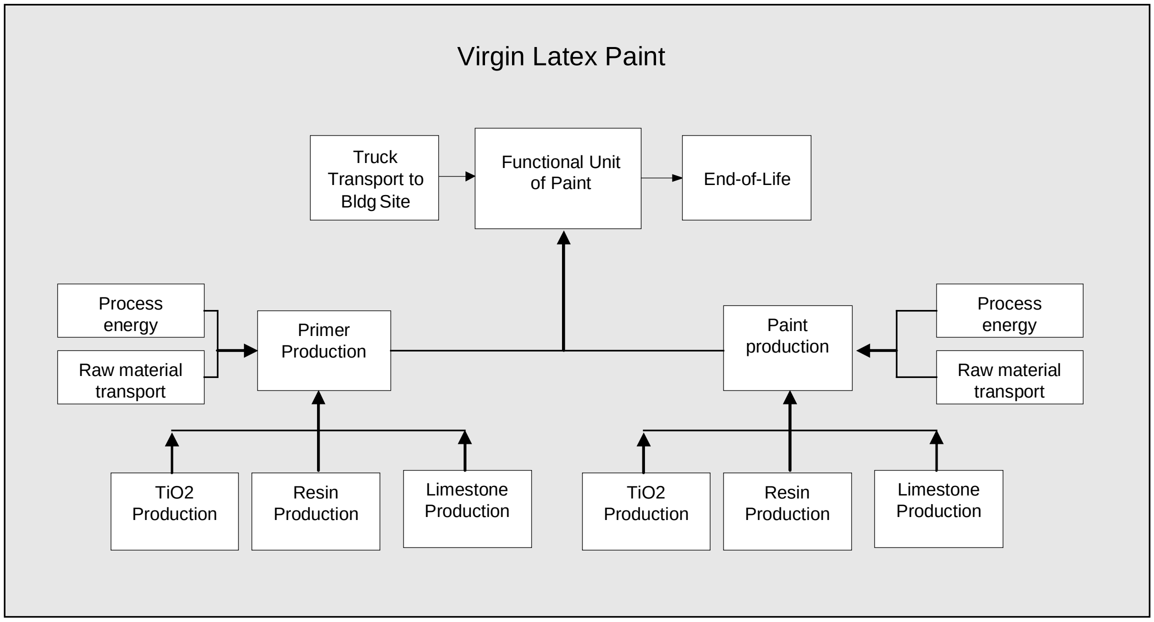

Figure 1: Virgin Interior Latex Paint System Boundaries

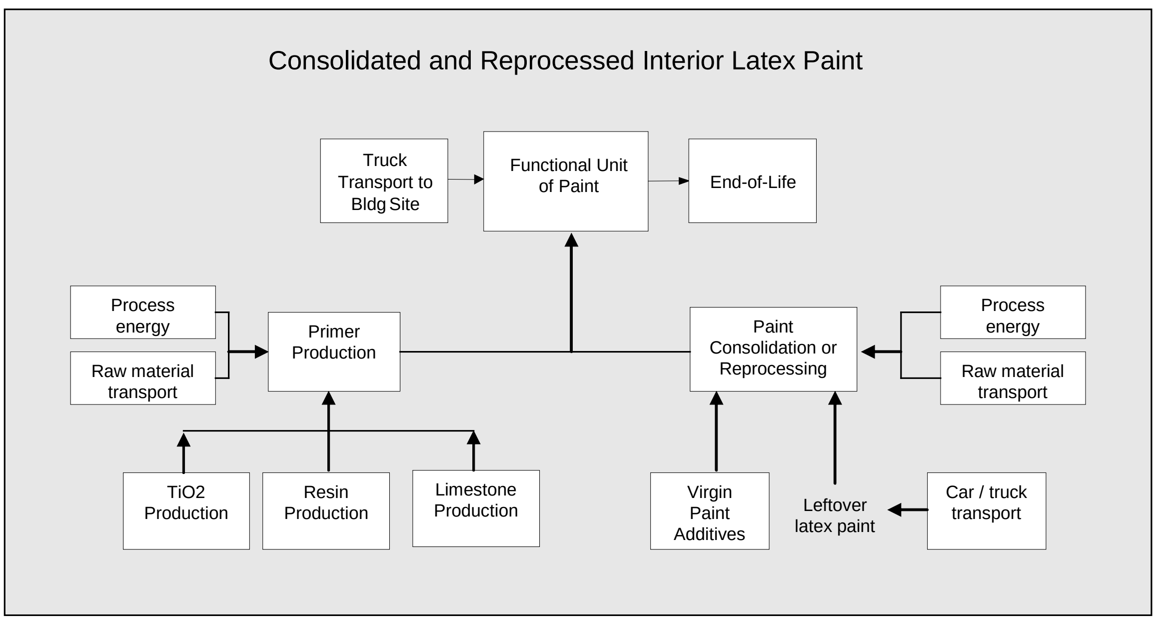

Figure 2: Consolidated and Reprocessed Interior Latex Paint System Boundaries

Raw Materials

Virgin latex paint. The major virgin latex paint constituents are resins (binder), titanium dioxide (pigment), limestone (extender), and water (thinner), which are mixed together until they form an emulsion. The average composition of the virgin latex paint/primer system modeled in BEES is listed in the Table below.

Constituent	*Paint Mass Fraction (%)*	*Primer Mass Fraction (%)*
Resin	25	25
Titanium dioxide	12.5	7.5
Limestone	12.5	7.5
Water	50	60

The data for titanium dioxide is 1990s European production data from the SimaPro database. Limestone data comes from the U.S. LCI Database. The Table below displays the market shares for the resins used for interior latex paint and primer as well as the components of each type of resin as they are modeled in BEES. The production of the monomers used in the resins is based on elements of the SimaPro database.

Table 2: Latex Paint Resin Constituents

Resin Type	*Market Share (%)*	*Constituents*	*Mass Fraction (%)*
Vinyl Acrylic	25	Vinyl Acetate	80 to 95
		Butyl Acrylate	5 to 20
Polyvinyl Acrylic	12.5	Polyvinyl Acrylic	100
Styrene Acrylic	12.5	Styrene	50
		Butyl Acrylate	50

Virgin latex paint is assumed to be sold in one-gal steel cans, which are included in the model. Steel data comes from life cycle inventories submitted by the American Iron and Steel Institute (AISI) and the International Iron and Steel Institute (IISI) and represents late 1990s worldwide production of steel.

Consolidated paint. A recent LCA study on leftover paint waste management[1] that surveyed paint consolidation plants all over the United States found the average percentage of virgin constituents to be approximately 1.5 %, with the remainder being leftover household paint. At 5.08 kg (11.2 lb) per gal this amounts to 0.08 kg (0.17 lb) of virgin additives, which are described above. Consolidated paint is usually repackaged in 19 L (5 gal) high density polyethylene (HDPE) plastic buckets, which are included in the BEES model. Data on HDPE comes from American Chemistry Council 2006 data developed for submission to the U.S. LCI Database.

Reprocessed paint. The leftover paint waste management study also surveyed paint reprocessing plants. Based on this survey, PC paint content ranged from 55 % to 93 %, with a weighted average of 76 %. Therefore, the quantity of virgin constituents was modeled as 24 %, amounting to 1.24 kg (2.74 lb) of virgin additives per gal of reprocessed paint, at an assumed density of 1.34 kg/L (11.2 lb/gal). These additives are described under the virgin latex paint raw materials section above. Reprocessed paint is packaged in both 19 L (5 gal) HDPE plastic buckets and 3.8 L (1 gal) steel containers; the BEES model assumes half the reprocessed paint is packaged in each option.

Manufacturing

Paint manufacture essentially consists of combining the ingredients, less some of the solvent, in a steel mixing vessel. In some cases the mixing is followed by a grinding operation to break up the dry ingredients, which tend to clump during mixing. Then, additional solvents or other liquids are added to achieve final viscosity, and

[1] Franklin Associates and Four Elements Consulting, LLC, “Life Cycle Assessment Results for Six "Pure" Methods for Managing Leftover Paint. Draft Report” (Paint Product Stewardship Initiative, 2006). For more information, go to http://www.productstewardship.us.

supplemental tinting is added. Finally, the paint is strained, put into cans, and packaged for shipping.

Virgin latex paint. The blending energy for virgin latex paint and the paint primer is assumed to be 4.5 MJ (1.25 kWh) of purchased electricity per gal of paint blended and 7.0 MJ (1.94 kWh) of additional energy per gal.[2] In the absence of data on the source of the additional energy required, it is assumed to be natural gas. Emissions associated with paint and paint primer manufacturing, such as particulates to the air, are based on U.S. EPA AP-42 emission factors.

Truck transportation of raw materials to the paint manufacturing site is assumed to average 402 km (250 mi) for limestone, 2400 km (1500 mi) for titanium dioxide, and 80 km (50 mi) for the resins.

Consolidated latex paint. Before PC paint undergoes consolidation, it is sorted from solvent based paints, contaminated paint, and other HHW materials that come to a HHW facility. Once the paint in good condition is separated from other types of paint and HHW, the paint cans are opened manually or electrically and paint is poured into a mixing vessel. The cans are sometimes crushed using electrical equipment. Water is often used to clean facilities, as are absorbents to soak up paint from the floor. Waste is minimized as often the emptied containers are recycled. The following Table provides consolidation plant sorting inputs and outputs.

Table 3: Consolidated Paint Sorting Data

Flow	***Units***	***Amount***
Inputs		
Water used	L/L (gal/gal)	0.22 (0.22)
Absorbent used to absorb paint on floor	kg/L (lb/gal)	0.0002 (0.002)
Electricity	J/L (kwh/gal)	31 0227 (0.327)
Natural gas process fuel	m3/L (ft3/gal)	0.0001 (0.010)
Diesel fuel (mobile equipment)	L/L (gal/gal)	0.0009 (0.001)
Natural gas (mobile equipment)	L/L (gal/gal)	0.0003 (0.0003)
Propane (mobile equipment)	L/L (gal/gal)	0.005 (0.005)
Gasoline (mobile equipment)	L/L (gal/gal)	0.0002 (0.0002)
used oil	L/L (gal/gal)	0.001 (0.001)
Outputs		
Waste	kg/L (lb/gal)	0.102 (0.850)

Next, the paint is blended and repackaged. The following Table provides the consolidation process energy and water requirements.

Table 4: Consolidated Paint Processing Data

Flow	***Units***	***Amount***
Water used	L/L (gal/gal)	0.07 (0.07)
Electricity	J/L (kwh/gal)	55 092 (0.058)
Natural gas process fuel	m3/L (ft3/gal)	0.00001 (0.002)
Diesel fuel (mobile equipment)	L/L (gal/gal)	0.002 (0.002)
Propane (mobile equipment)	L/L (gal/gal)	0.007 (0.007)

The absorbent used to soak up paint from the facility floor is reported as cat litter, which is modeled as clay

[2] Based on the amount of purchased electricity reported in U.S. Department of Commerce, "2002 Census Report: Paint and Coating Manufacturing 2002," based on 1.3 billion gallons of all paints and coatings produced in 2002.

using the SimaPro database. All data on energy use and combustion in mobile equipment and boilers comes from the U.S. LCI Database.

The leftover paint waste management study found that about 60 % of the time, paint comes to a consolidation plant by truck from a HHW facility or a municipal solid waste transfer station. The remaining incoming paint comes directly from households via passenger vehicle. Based on the surveys, truck transportation is on average 161 km (100 mi) and car transport is on average 15 km (9.4 mi). The passenger vehicle mileage has been allocated to one-fourth its amount to account for the mass of other HHW drop-off items likely transported in the car plus driving for other errands during the same trip. The passenger vehicle is modeled as 50 % gasoline-powered car and 50 % sport utility vehicle, and gasoline usage and emissions data come from an EPA study on passenger vehicles.[3] Truck transportation data comes from the U.S. LCI Database.

Reprocessed latex paint. As with consolidated paint, before paint is reprocessed it must be sorted from other incoming materials. Once the PC latex paint appropriate for reprocessing is sorted from other paints and materials, it is blended with virgin materials and packaged for sale. The following tables provide the inputs and outputs from sorting and reprocessing.

Table 5: Reprocessed Paint Sorting and Processing Data

Flow	***Quantity per L (per gal)***
Inputs:	
Water used	0.565 L (0.565 gal)
Electricity	0.425 MJ (0.447 kWh)
Propane (mobile equipment)	0.0023 L (0.0023 gal)
Gasoline (mobile equipment)	0.0009 L (0.0009 gal)
Outputs:	
Waste	0.0083 kg (0.07 lb)

Paint reprocessing facilities mostly receive leftover paint via truck from collection sites including HHW facilities. Because there are fewer reprocessing facilities, trucks travel on average a greater distance than to consolidation facilities; this distance is about 885 km (550 mi) according to the leftover paint study.

Transportation

Transportation of virgin and reprocessed latex paint from the manufacturing facility to the building site via heavy-duty truck is modeled as a variable of the BEES system. Transportation of the consolidated paint, also a BEES variable, is accomplished by gasoline-powered car and sport utility vehicle, typically traveling a much shorter distance due to the high number of local paint consolidation facilities and markets.

Installation

At the beginning of the 50-year BEES use period, one coat of primer is applied under the two coats of paint. The raw materials section above provides the material constituents for primer.

Use

Every four years, the wall is assumed to be painted over with one additional coat, amounting to 12 additional coats over the 50-year use period. As with all BEES products, these “replacements” are accounted for in the model. All three paint options are assumed to have a VOC content of 150 g (5.29 oz) per liter and to release 20.5 g (0.05 lb) VOC per functional unit over 50 years.

[3] National Vehicle and Fuel Emissions Laboratory, “Annual Emissions and Fuel Consumption for an "Average" Passenger Car” and Annual Emissions and Fuel Consumption for an "Average" Light Truck (U.S. Environmental Protection Agency: EPA420-F-97-037, April 1997).

End of Life
At end of life, all the paint goes into the landfill with the wall on which it is applied.

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.

Industry Contacts

David Darling, National Paint & Coating Association (2005)