



**Product Category Rules (PCR)
For Asphalt Mixtures:
Annex 1
Prescribed Upstream (Secondary) Data
Sources**

Annex Version 2.1

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1. Overview of prescribed background (secondary) data sources

In choosing the datasets, the first priority was transparency. To meet this transparency goal, the prescribed datasets must be publicly available at no cost. This was in response to public agencies who would request and use the Environmental Product Declarations (EPDs) published under this PCR. Cost and a lack of transparency of data sources have been noted as barriers to adoption of other existing EPD programs.

This annex will be updated as new data becomes available to fill existing data gaps.

Further Explanation — Choice of Data Sources

Data sources prescribed are publicly available and freely accessible to ensure transparency. Use of the prescribed data source will improve comparability among EPDs developed using this PCR by limiting variability due to differences in the upstream data within the system boundary.

1.1. Prioritization of data for upstream processes

Section 7.1.9.2 of the PCR for Asphalt Mixtures assigns the following prioritization hierarchy for selection of upstream data associated with production of commodities and raw materials:

- The first priority is valid facility-specific or product-specific EPDs with impact categories modeled according to TRACI 2.1 for the specific inputs associated with the EPD.
 - o Facility-specific and product-specific EPDs for upstream materials and processes do not need to be listed in this Annex to be used for EPDs.
- The second priority is either of the following:
 - o Valid industry average EPDs with impact categories modeled according to TRACI 2.1 as prescribed in this Annex.
 - o Freely available public datasets as prescribed in this Annex, including critically reviewed LCA studies that are compliant with ISO 14040/14044 that have been published to the USLCI.

Thus, any of the generic datasets prescribed in this Annex (LCAs that have been published to the USLCI and industry average EPDs) may be replaced with valid facility-specific or product-specific EPDs.

1.2. Process for adding new data to Annex 1

Data selection criteria for this Annex are described in the Upstream/Background Inventory Data section beginning on page 22 of the underlying LCA by Mukherjee (2021). In general, the following criteria will be used for selection of generic datasets to be incorporated into this Annex.

- Uniformity in use of life cycle inventories
- Transparency of life cycle inventories
- Geography and regionalization

- Data gaps
- Dependence on life cycle inventory data from allied industries

Organizations who are interested in adding new datasets to this Annex or updating existing datasets should contact NAPA directly at epd@asphaltpavement.org for further information.

2. Secondary data sources for upstream production of raw materials (A1)

The prescribed background (upstream) inventories for raw material extraction and manufacturing provided in this section.

2.1. Asphalt binder

2.1.1. Asphalt binder, refined from crude oil

The following inventories are available from Wildnauer et al. (2019) as a North American average:

- Asphalt binder, no additives, consumption mix, at terminal, from crude oil.
- Asphalt binder, 0.5% polyphosphoric acid (PPA) (by weight of asphalt binder), consumption mix, at terminal, from crude oil. This inventory may be used for PPA up to 1.0% (by weight of asphalt binder).
- Asphalt binder, 3.5% styrene-butadiene-styrene (SBS) (by weight of asphalt binder), consumption mix, at terminal, from crude oil. This inventory uses styrene-butadiene-rubber (SBR) as a proxy for SBS and is suitable for asphalt binder that contains SBR or SBS in increments of 0-3.5%, 3.5-5.5%, 5.5-7.5%, and 7.5-10.0% per Mukherjee (2021).
- Asphalt binder, 8% ground tire rubber (GTR) (by weight of asphalt binder), consumption mix, at terminal, from crude oil. This inventory is only valid for terminal blended rubber modified asphalt up to 10% by weight of asphalt binder. It shall not be used for wet process GTR techniques including asphalt-rubber, McDonald process, or continuous process, and shall not be used for dry process GTR techniques. However, despite the data gap for the dry process, the energy used in the mixing plant to produce the rubber modified asphalt is included in the overall energy use values.

2.1.2. Bio-based asphalt binder

There are no available background inventories for bio-based asphalt. Bio-based asphalt is considered a data gap.

2.1.3. Emulsified asphalt

There are no available background inventories for emulsified asphalt. Emulsified asphalt is considered a data gap.

2.1.4. Cutback asphalt

There are no available background inventories for cutback asphalt. Cutback asphalt is considered a data gap.

2.1.5. Natural asphalt binder

Natural asphalt binder, such as gilsonite and Trinidad Lake asphalt, are typically used as binder modifiers. See Table 1.

2.2. Aggregates

2.2.1. Crushed stone, sand, and gravel

The inventory developed by Mukherjee (2021) for coarse aggregate from crushed stone shall be used for crushed stone, sand, and gravel. This inventory was derived from data published by Marceau et al. (2007).

2.2.2. Recycled aggregates

The inventory developed by Mukherjee (2021) for coarse aggregate from crushed stone shall be used as a proxy for recycled aggregates that do not contain asphalt binder, such as recycled concrete aggregate and glass cullet. This inventory was derived from Marceau et al. (2007).

2.2.3. Slag aggregate

There are no available background inventories for slag aggregates, such as blast furnace slag and steel slag. These materials are considered data gaps.

2.3. RAP and RAS

The inventory developed by Mukherjee (2021) for reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) processing shall be used for RAP and RAS. This inventory was derived from data published by Mukherjee (2017).

2.4. Additives

The available inventories for asphalt mixture additives and asphalt binder additives are provided in Table 1.

EPDs shall indicate data gaps for materials that are less than 1% of the total mass inputs for the asphalt mixture (excluding fuel) with no available background (upstream) datasets, as prescribed in Section 7.1.8 of the *PCR for Asphalt Mixtures*. When these materials comprise more than 1% (individually) or 5% (combined) of the total mass inputs for the asphalt mixture (excluding fuel), an EPD cannot be developed, as prescribed in Section 7.1.8 of the *PCR for Asphalt Mixtures*.

Table 1. Background inventories for asphalt mixture additives and asphalt binder additives

Type	Generic Examples	Background (Secondary) Inventory	Reference/Comment
Antistrip Agents	Hydrated lime	Quicklime, at plant	NREL (2021)
	Liquid Antistrips		
	Amidoamines	Data Gap	
	Imidazolines	Data Gap	
	Organo-silanes	Data Gap	
	Polyamines	Data Gap	
	Biopolymers	Data Gap	

Type	Generic Examples	Background (Secondary) Inventory	Reference/Comment
Binder Modifiers, Elastomers	Ground tire rubber	Asphalt binder, 8% ground tire rubber (GTR) (by weight of asphalt binder), consumption mix, at terminal, from crude oil	Wildnauer et al. (2019) / See Section 2.1.1 of this Annex
	Natural rubber	Data Gap	
	Polychloroprene latex	Data Gap	
	Reactive Ethylene Terpolymers	Data Gap	
	Styrene-butadiene-rubber (SBR)	Asphalt binder, 3.5% styrene-butadiene-styrene (SBS) (by weight of asphalt binder), consumption mix, at terminal, from crude oil	Wildnauer et al. (2019) / See Section 2.1.1 of this Annex
	Styrene-butadiene-styrene (SBS)	Asphalt binder, 3.5% styrene-butadiene-styrene (SBS) (by weight of asphalt binder), consumption mix, at terminal, from crude oil	Wildnauer et al. (2019) / See Section 2.1.1 of this Annex
Binder Modifiers, Extenders	Bio-based oils	Data Gap	
	Lignin	Data Gap	
	Petroleum Oils	Data Gap	
	Re-refined engine oil bottom (REOB), aka vacuum tower asphalt extender (VTAE)	Data Gap	
	Sulfur	Data Gap	
Binder Modifiers, Natural Asphalt	Gilsonite	Data Gap	
	Trinidad Lake Asphalt	Data Gap	
Binder Modifiers, Other	Biochar	Data Gap	
	Polyphosphoric acid (PPA)	Asphalt binder, 0.5% polyphosphoric acid (PPA) (by weight of asphalt binder), consumption mix, at terminal, from crude oil	Wildnauer et al. (2019) / See Section 2.1.1
Binder Modifiers, Plastics	Ethylene acrylate copolymer	Data Gap	
	Ethylene propylene copolymers (EPM)	Data Gap	

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Type	Generic Examples	Background (Secondary) Inventory	Reference/Comment
	Ethylene propylene diene (EPDM)	Data Gap	
	Ethylene-vinyl acetate (EVA)	Data Gap	
	Polyethylene	Data Gap	
	Polyolefins	Data Gap	
	Polypropylene	Data Gap	
	Recycled plastics	Data Gap	
Binder Modifiers, Recycling Agents	Aromatic extracts	Data Gap	
	Paraffinic oils	Data Gap	
	Tall oil-based products	Data Gap	
	Vegetable oil-based products	Data Gap	
Fibers, natural	Cellulose	Data Gap	
	Mineral	Data Gap	
	Rock wool	Data Gap	
Fibers, synthetic	Aramid	Data Gap	
	Fiberglass	Data Gap	
	Polyester	Data Gap	
	Polypropylene	Data Gap	
Mineral fillers	Baghouse fines	N/A	Cut-off rule
	Crusher fines	Coarse aggregate from crushed stone	Marceau et al. (2007)
	Fly ash	N/A	Cut-off rule
	Lime	Quicklime, at plant	NREL (2021)
	Portland cement	Portland cement, at plant	PCA (2021)
	Slag cement	Slag cement	Slag Cement Association (2015)
Pigments	Iron oxide	Data Gap	
	Titanium dioxide	Data Gap	
Recycled Plastic	Recycled plastic, dry method	Data Gap	
Warm Mix Additives, Chemical	Amine surfactants, emulsifiers, and other chemical additives	Data Gap	
Warm Mix Additives, Organic	Waxes and fatty acid amides	Data Gap	
Warm Mix Additives, Other	Zeolites (aluminosilicates)	Data Gap	
	Hybrid technologies (blends of chemical and water-based technologies)	Data Gap	

3. Secondary data sources for transportation (A2)

The following inventories are available from National Renewable Energy Laboratory (NREL, 2021):

3.1. Boat

- Transportation by barge, diesel powered.
- Transportation by ocean freighter, diesel powered.

3.2. Pipeline

- Transportation by pipeline, natural gas powered.

3.3. Train

- Transportation by train, diesel powered.

3.4. Truck

- Transportation by combination truck, diesel powered.
- Transportation by combination truck, gasoline powered.
- Transportation by refuse truck, diesel powered.
- Transportation by refuse truck, gasoline powered.

4. Secondary data sources for asphalt mixture production (A3)

4.1. Electricity consumption

The inventory data for consumption-based electricity is available from the National Energy Technology Laboratory (NETL, 2019) at the balancing authority level for plants located in the U.S.

The inventory data for consumption-based electricity is available from Ecoinvent (Ecoinvent, 2021) for plants located in Canada.

4.2. Fuel combustion

4.2.1. Boilers, burners, and other process heating equipment

The available inventories for on-site combustion of fuel for process heating equipment are provided in Table 2. These inventories shall be used for processes including the primary and secondary burner, hot oil heater, and ancillary heating sources such as on-site asphalt-rubber blending plants.

Table 2. Background inventories for fuel consumption by process heating equipment

Fuel type	Inventory	Reference
Biodiesel	Soy biodiesel, production, at plant with combustion emissions data reported from Miller (2008)	NREL (2021) and Miller (2008)
Brown grease (aka grease trap oil, FOG)	Soy biodiesel, production, at plant with combustion emissions data reported from Miller (2008)	NREL (2021) and Miller (2008)

Fuel type	Inventory	Reference
Coal, anthracite	Anthracite coal, combusted in industrial boiler	NREL (2021)
Coal, bituminous	Bituminous coal, combusted in industrial boiler	NREL (2021)
Coal, lignite	Lignite coal, combusted in industrial boiler	NREL (2021)
Diesel	Diesel, combusted in industrial boiler	NREL (2021)
Landfill gas	Natural gas, combusted in industrial boiler (proxy)	NREL (2021)
Liquid natural gas (LNG)	Natural gas, combusted in industrial boiler	NREL (2021)
Liquified petroleum gas (LPG) (aka propane)	Liquified petroleum gas, combusted in industrial boiler	NREL (2021)
Natural gas	Natural gas, combusted in industrial boiler	NREL (2021)
Recycled fuel oil (aka used oil)	Recycled fuel oil, combusted in industrial boiler	Mukherjee (2021)
Residual fuel oil	Residual fuel oil, combusted in industrial boiler	NREL (2021)
Renewable diesel	Diesel, combusted in industrial boiler (proxy)	NREL (2021)
Renewable natural gas (RNG)	Natural gas, combusted in industrial boiler	NREL (2021)
Yellow grease (aka recycled vegetable oil)	Soy biodiesel, production, at plant with combustion emissions data reported from Miller (2008)	NREL (2021) and Miller (2008)

4.2.2. Internal combustion engines

The available inventories for on-site combustion of fuel for internal combustion engines are provided in Table 3. These inventories shall be used for equipment such as loaders, generators, skid steers, compressors, and other equipment that uses an internal combustion engine.

Table 3. Background inventories for fuel consumption by internal combustion engines

Fuel type	Inventory	Reference
Biodiesel	Soy biodiesel, production, at plant with combustion emissions data reported from Miller (2008)	NREL (2021) and Miller (2008)
Compressed natural gas (CNG)	Compressed natural gas equipment operation, industry average, >56 kW and <560 kW	NREL (2021)

Fuel type	Inventory	Reference
	Compressed natural gas equipment operation, industry average, >19 kw and <56 kW	NREL (2021)
Diesel fuel	Diesel, combusted in industrial equipment	NREL (2021)
Gasoline	Gasoline, combusted in industrial equipment	NREL (2021)
Liquid natural gas (LNG)	Natural gas, combusted in industrial equipment	NREL (2021)
Liquified petroleum gas (LPG) (aka propane)	Propane, combusted in equipment	NREL (2021)
Renewable diesel	Diesel, combusted in industrial equipment	NREL (2021)

4.2.3. End-of-life for waste materials and byproducts

Waste materials and by-products generated as a result of asphalt mixture production should use the U.S. Environmental Protection Agency’s Waste Reduction Model (WARM) inventory for “MSW, landfilling of asphalt concrete” with plant-specific transport distances as discussed by Mukherjee (2021).

5. References

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