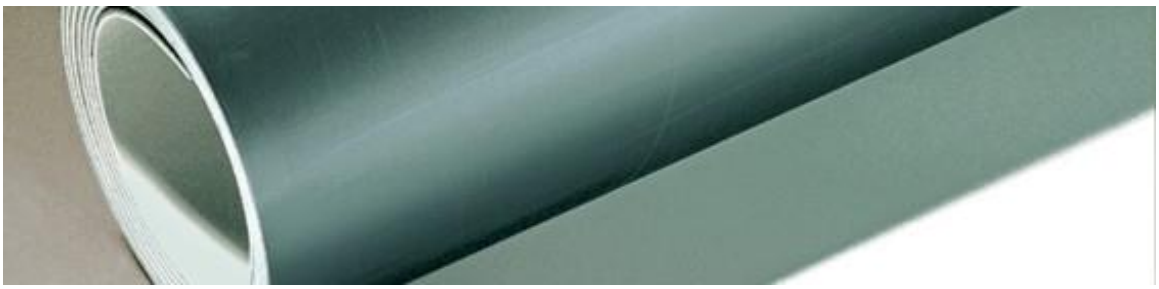
Environmental Product Declaration

According to ISO 14025 and ISO 21930

White, single-ply polyester reinforced PVC roofing membrane, with a finished nominal thickness of:
- 1.016 mm (40 mils);
- 1.219 mm (48 mils); and
- 1.524 mm (60 mils).

Chemical Fabrics and Film Association (CFFA), Vinyl Roofing Division



ASTM International Certified Environmental Product Declaration

This document is a Type III environmental product declaration for various thicknesses of white, single-ply polyester reinforced (SPPR) PVC roofing membranes (40, 48 and 60 mils), as produced by the Chemical Fabrics and Film Association (CFFA), Vinyl Roofing Division member companies. This declaration has been prepared in accordance with ISO 14025 and ISO 21930, the governing single-ply roofing product category rules and ASTM international's EPD program operator rules.

The intent of this document is to further the development of environmentally compatible and more sustainable construction methods by providing comprehensive environmental information related to potential impacts of PVC roofing membranes in accordance with international standards.

Environmental Product Declaration Summary

Owner of the EPD	**Chemical Fabrics and Film Association (CFFA)** Vinyl Roofing Division- Head office 1300 Sumner Ave. Cleveland, Ohio 44115-2851 Link (URL): www.chemicalfabricsandfilm.com/roofing.html Both LCI and meta-data were provided by four of CFFA member companies for the reference year 2010. These companies represent over 95% of CFFA member production of SPPR PVC roofing membranes. It is estimated that the production CFFA members represents about 85% of the U.S market by volume. CFFA provided additional product performance and scenario parameter values in the completion of this EPD. The owner of the declaration is liable for the underlying information and evidence.
CFFA Member Manufacturers Names and Addresses	**Canadian General-Tower Limited** 52 Middleton Road, Cambridge, Ontario, Canada N1R 5T6 Member Link (URL): www.cgtower.com **Duro-Last Roofing** 525 Morley Drive, Saginaw, MI 48601 Member Link (URL): www.duro-last.com **FiberTite Roofing Systems** 225 N. Industrial Dr, Bristol, TN 37620

	Member Link (URL): www.seamancorp.com **Flex Membrane International Corp.** 2670 Leiscz's Bridge Road Suite 400 Leesport, PA 19533 Member Link (URL): www.flexroofingsystems.com **Sika Corporation- Roofing** 100 Dan Road, Canton, MA 02021 Member Link (URL): www.sarnafilus.com
Product Group	Single Ply Roofing Membranes
Product Name	White, SPPR PVC roofing membrane, with a finished nominal thickness of: • 1.016 mm (40 mils) • 1.219 mm (48 mils) • 1.524 mm (60 mils)
Product Definition	Single Ply Roofing Membranes are defined as thermoplastic or thermoset membranes of compounded synthetic materials manufactured in a factory for use in roofing [1].
Product Category Rule (PCR)	ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Single Ply Roofing Membranes, November 2013 [1].
Certification Period	8.15.2014 - 8.15.2019
Declared Unit	1 m^2 installed white, SPPR PVC roofing membrane, with a finished nominal thickness of: • 1.016 mm (40 mils) • 1.219 mm (48 mils) • 1.524 mm (60 mils)
ASTM Declaration Number	EPD-009

EPD Information			
Program Operator		ASTM International	
Declaration Holder		Chemical Fabrics and Film Association (CFFA), Vinyl Roofing Division	
Product group Single Ply Roofing Membranes	**Date of Issue** 08.15.2014	**Period of Validity** 5 years	**Declaration Number** EPD- 009
Declaration Type A "Cradle-to-building with end-of-life (EOL) stage" EPD for three thicknesses of white, CFFA SPPR PVC roofing membrane (40, 48 and 60 mils). Activity stages covered include the product, construction and EOL stages (modules A1 to A5 and C1 to C4). The declaration is intended for use in Business-to-Business (B-to-B) communication.			
Applicable Countries United States and Canada			
Product Applicability and Characteristics The declared CFFA SPPR PVC roofing membrane thicknesses (40, 48 and 60 mils) are designed for low-slope and steep slope roofing applications. The membrane has an internal polyester reinforcement to provide the tear resistance required for mechanically-attached roof systems.			
Content of the Declaration The declaration follows Section 11, Content of the EPD, ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Single Ply Roofing Membranes, November 2013.			
This EPD was independently verified by ASTM in accordance with ISO 14025: **Internal** **External** **X**		Timothy Brooke ASTM International 100 Barr Harbor Drive West Conshohocken, PA 19428 tbrooke@astm.org	
EPD Project Report Information			
EPD Project Report		A Cradle-to-building with EOL stage Life Cycle Assessment for three thicknesses of white, SPPR PVC Roofing Membrane (40, 48 and 60 mils), June 2014	
Prepared by		Lindita Bushi and Jamie Meil Athena Sustainable Materials Institute 119 Ross Avenue, Suite 100 Ottawa, Ontario, K1Y 0N6, Canada lindita.bushi@athenasmi.org jamie.meil@athenasmi.org	

This EPD project report was independently verified by in accordance with ISO 14025 and the reference PCR:	Thomas P. Gloria, Ph. D. Industrial Ecology Consultants 35 Bracebridge Rd. Newton, MA 02459-1728 direct: 617.553.4929 mobile: 857.636.0585 email: t.gloria@industrial-ecology.com
PCR Information	
Program Operator	ASTM International
Reference PCR	ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Single Ply Roofing Membranes
Date of Issue	November 2013
PCR review was conducted by:	François Charron-Doucet Quantis International Email: francois.charron@quantis-intl.com

1 PRODUCT IDENTIFICATION

1.1 PRODUCT DEFINITION

This EPD refers to three thicknesses of white, single-ply polyester reinforced PVC roofing membrane as produced by CFFA members. The declared product is:

- White, SPPR PVC roofing membrane, with a finished nominal thickness of;

  - 1.016 mm (40 mils),
  - 1.219 mm (48 mils), and
  - 1.524 mm (60 mils).

Single Ply Roofing Membranes are defined as thermoplastic or thermoset membranes of compounded synthetic materials manufactured in a factory for use in roofing [1].

A white, SPPR PVC roofing membrane consists of two plies or layers of PVC material with a polyester reinforcement scrim between the layers. The top ply has special additives to make the membrane UV stable, plasticizers to make it flexible, and pigments for color. The bottom ply is typically darker in color containing fewer pigments by weight, but otherwise contains a similar mix of plasticizers, stabilizers, fillers and fire retardant additives.

Figure 1 White, SPPR PVC roofing membrane

1.2 PRODUCT STANDARD

The three declared CFFA SPPR PVC roofing membrane thicknesses (40, 48 and 60 mils) meet the ASTM D4434 [2] or ASTM D6754 [12].

1.3 TECHNICAL DATA

Table 1 summarizes key technical data for 40, 48 and 60 mils, white, SPPR PVC roofing membrane thicknesses. All three declared product thicknesses meet or exceed ASTM D4434 or ASTM D6754 specifications [2], [12].

Table 1: Weighted average technical data of declared thicknesses

Technical data	Units	Value /Test Results		
		40 mils	48 mils	60 mils
Specific density	kg/m^2	1.136	1.458	1.799
Color	N/A	white	white	white
Total Recycled Content (%)- (both pre-and post-consumer)	%	5%	5%	5%
Thickness	mm	1.016	1.219	1.524

1.4 PACKAGING

Product packaging materials, such as cardboard, polyethylene sheet, paperboard, steel and polypropylene banding are all used for the three membrane thicknesses.

2. PRODUCT APPLICATION

The three declared CFFA SPPR PVC roofing membrane thicknesses are designed for low-slope and steep slope roofing applications. The membrane has an internal polyester scrim reinforcement to provide the tear resistance required for mechanically-fastened roof systems.

Depending on the application, PVC roofing membranes can be installed using mechanical fasteners, bonding adhesives or loosely laid under ballast materials (e.g., gravel, pavers, vegetation, etc.).

“Mechanically fastened” is the most common installation method and is the basis for the installation scenario in this EPD. “Bonded” and “loosely laid under ballast” roof systems are mentioned for distinction between the individual roofing systems only. These latter two options were not considered in the installation scenario for this EPD.

3. DECLARED UNIT

The declared units are:

1 m^2 installed of white, SPPR PVC roofing membrane, with a finished nominal thickness of:
- 1.016 mm (40 mils);
- 1.219 mm (48 mils); and
- 1.524 mm (60 mils).

The color “white” in the context of the declared unit is expressed as roofing membrane having a reflectance, emittance and a combined solar reflectance index (SRI) meeting or

exceeding the cool roofing requirements of USGBC's LEED program, Green Globes, ENERGY STAR and California Title 24.

4 MATERIAL CONTENT

4.1 WEIGHTED AVERAGE PRODUCT FORMULATION

Table 2, 3 and 4 below present the weighted average generic formulation by input material for the three declared thicknesses as derived from the CFFA participating plants' unique formulations for both the face and back plies, including the input of polyester scrim reinforcement. The formulation data indicates that the top ply is heavier than the bottom ply and that, by weight, the reinforcing scrim accounts for over 7% of the overall mass of the product. PVC resin and plasticizers account for over 77% of the total mass of inputs.

Table 2: Weighted Average Generic Formulation for 1 m^2 of 40 mils, white, SPPR PVC roofing membrane

No.	Raw material input	Quantity (in kg)	% of total by weight
Both face & back ply			
1	PVC Resin	0.556	46.9%
2	Plasticizer	0.352	29.7%
3	Pigment	0.045	3.8%
4	Fire retardant	0.042	3.5%
5	Stabilizer	0.024	2.0%
6	Fillers	0.032	2.7%
7	Processing aids, oils and lubricants	0.007	0.6%
8	Biocide	0.0013	0.1%
9	Adhesives	0.0035	0.3%
Polyester fabric (scrim reinforcement)		0.123	10.3%
Total weight (Input)		**1.184**	**100%**

Table 3: Weighted Average Generic Formulation for 1 m^2 of 48 mils, white, SPPR PVC roofing membrane

No.	Raw material input	Quantity (in kg)	% of total by weight
Both face & back ply			
1	PVC Resin	0.713	47%
2	Plasticizer	0.455	30%
3	Pigment	0.067	4.4%
4	Fire retardant	0.055	3.6%
5	Stabilizer	0.030	2.0%

No.	Raw material input	Quantity (in kg)	% of total by weight
6	Fillers	0.040	2.6%
7	Processing aids, oils and lubricants	0.021	1.4%
8	Biocide	0.0018	0.1%
9	Adhesives	0.0039	0.3%
Polyester fabric (scrim reinforcement)		0.133	8.7%
Total weight (Input)		**1.519**	**100%**

Table 4: Weighted Average Generic Formulation for 1 m^2 of 60 mils, white, SPPR PVC roofing membrane

No.	Raw material input	Quantity (in kg)	% of total by weight
Both face & back ply			
1	PVC Resin	0.901	48.9%
2	Plasticizer	0.571	31.0%
3	Pigment	0.074	4.0%
4	Fire retardant	0.069	3.8%
5	Stabilizer	0.038	2.1%
6	Fillers	0.050	2.7%
7	Processing aids, oils and lubricants	0.011	0.6%
8	Biocide	0.0020	0.1%
9	Adhesives	0.0037	0.2%
Polyester fabric (scrim reinforcement)		0.122	6.6%
Total weight (Input)		**1.842**	**100%**

4.2 EXPLANATION OF MATERIALS

PVC resin

PVC is essentially derived from two simple ingredients: fossil fuel and salt. Petroleum or natural gas is processed to make ethylene, and salt is subjected to electrolysis to separate out the natural element chlorine. Ethylene and chlorine are combined to produce ethylene dichloride (EDC), which is further processed vinyl chloride monomer (VCM) gas. In the next step, known as polymerization, the VCM molecule forms chains, converting the gas into a fine, white powder “vinyl resin”, which becomes the basis for the next process – compounding. During compounding, vinyl resin is blended with additives such as stabilizers for durability, pigments for color, fire retardant, etc.

Plasticizer

Plasticizer is the second main component of the membrane. They contribute to the flexibility of the membrane. Plasticizer consists of phthalate esters and Ketone Ethylene Ester (KEE).

Scrim reinforcement

Scrim reinforcement is the third main component of the membrane. It's a polyester fibre (PET) with a weighted average density of 4.0 oz./sq. yd.

Pigment Titanium dioxide.

Fire retardant Antimony trioxide and alumina trihydrate.

Stabilizer Organic Based Stabilizer (OBS). OBS stabilizers contain no heavy metals—lead, barium, zinc, tin, or cadmium.

Fillers Calcium Carbonate and synthetic amorphous silica (95%)

Processing aids, oils, lubricants and solvents

Epoxidized Soybean Oil (ESO), waxes, epoxy resins, thermoplastic, organic acids and fatty acid esters.

Biocide Complex organic chemical compounds, antimicrobial additives for plastics.

Adhesives Acrylic resins and aromatic diisocyanate.

Note: Not all listed chemicals above are contained in each company specific membrane. For example three out of four CFFA member companies use calcium carbonate as filler; one company uses synthetic amorphous silica (95%).

5 Product Stage

5.1 PRODUCT STAGE

The product stage includes the following modules [1];

A1 Raw material supply
A2 Transport to the manufacturer,
A3 Manufacturing

Figure 2 shows the product stage system boundary for the three declared product systems

The Product Stage includes the following processes [1]:

• Extraction and processing of raw materials, including fuels used in product production;

• Average and/or specific transportation of raw materials (including recycled materials) from the extraction site or source to manufacturing site (including any recovered materials from the source to be recycled in the process), inclusive of empty backhauls;

• Manufacturing of the product;

• Packaging with product ready for shipment;

• Average or specific transportation from manufacturing site to recycling/reuse/landfill for pre-consumer wastes and unutilized by-products from manufacturing, including empty backhauls; and

• Recycling/reuse of pre-consumer wastes and by-products from production.

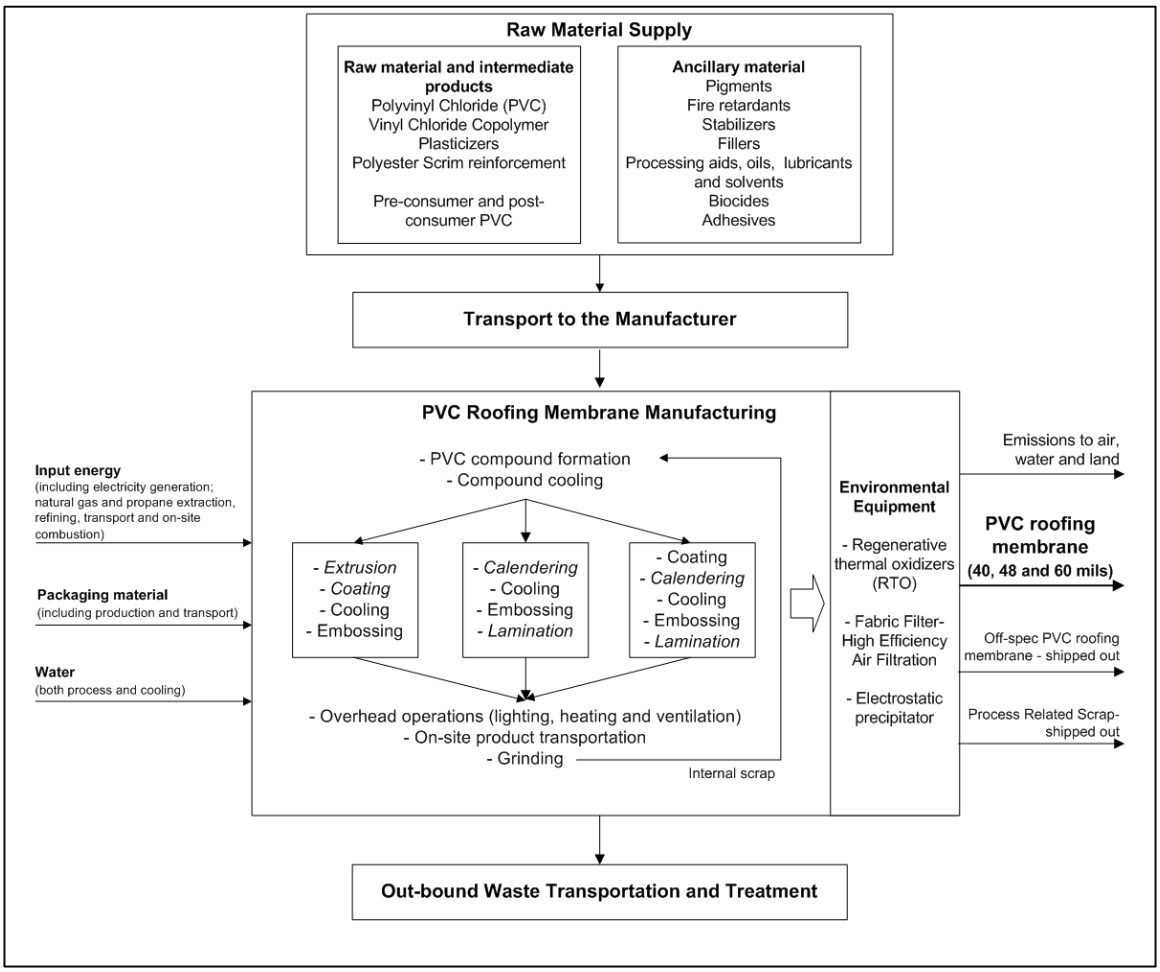


Figure 2 Product stage (module A1 to A3) system boundary

The capital goods & infrastructure, production equipment, delivery vehicles, lab equipment, personnel-related activities and energy & water use related to company management and sales have been excluded in the scope of the study. CFFA member manufacturing plants are located in the East and the Mid-West of the United States and

Ontario, Canada. The plants vary in size, but have similar PVC compound batch mixing, polyester scrim reinforcement and finished product density and pollution abatement equipment to control emissions to air. CFFA member plants either use an extrusion coating process or calendaring/ lamination process to produce membrane. Some PVC roofing manufacturers apply an acrylic finish to the top-ply for added UV protection and improved reflectance. Some of the plants also knit their own polyester scrim while others purchase their scrim from third-party suppliers.
Each facility has its own unique PVC roofing formulation for both the top and back plies and may use slightly lighter or heavier scrim reinforcement to achieve customized performance and durability characteristics. Generally, water use is limited to non-contact process cooling water; all plants operate a cooling tower. Furthermore, some of the facilities operate regrind equipment to recycle internal off-spec PVC materials or process pre- and post-consumer recovered PVC roofing.

Table 5 summarizes the weighted average transportation for all material inputs and waste outputs for the production of 1m^2 of white, SPPR PVC roof membranes on a ton-km and mode basis.

Table 5: Weighted average product stage- Transport data- per 1 m^2 of SPPR PVC membrane (40, 48 and 60 mils)

Transportation mode	Units	Quantity		
		40 mils	48 mils	60 mils
Rail	tkm	0.849	1.091	1.377
Road	tkm	0.401	0.510	0.570
Barge	tkm	0.194	0.250	0.315
Ocean freighter	tkm	0.410	0.535	0.679

6 Construction Process Stage

6.1 CONSTRUCTION PROCESS STAGE

The construction stage scenario includes the following modules:

A4 Average transportation of product from manufacturing site to the building site, (including empty backhauls);

A5 Product installation at the building site,
(including production and transportation of ancillary materials, energy use required for installation, waste generation and final disposal).

6.2 PRODUCT TRANSPORT TO BUILDING SITE

Table 6 shows the average product transportation distance and mode to building site.

Table 6: A4 module, Product transport to building site scenario

TRANSPORTATION MODE	UNITS	ONE-WAY DISTANCE
Road (to local distributor) (combination truck, average fuel mix)	km	800
Road (to building site) (single unit truck, diesel powered)	km	25

6.3 INSTALLATION AT THE BUILDING SITE

The following installation methods are considered for the three declared CFFA roofing membrane thicknesses (see Table 7):

Table 7: Installation systems

DECLARED PRODUCT	INSTALLATION	SEAM WELDING
40 mil	mechanically fastened	hot-air welding
48 mil	mechanically fastened	hot-air welding
60 mil	mechanically fastened	hot-air welding

For the mechanical fastened installation system, the PVC roofing membranes are rolled out on a suitable substrate (clean, even, solid, on insulation or cover board as required), aligned and fastened with approved fastening systems to the supporting structure according to the manufacturer's specification.

Usually, the fastening is carried out along the membrane overlap (seam area). After installation of the fasteners, seam overlaps are welded for waterproofing. Fasteners may also be placed in the field of the membrane. With mechanical fastening of the roofing membranes, the complete roof build-up (including thermal insulation, vapor control layer, etc.) is secured to the underlying structure.

Table 8 summarizes the installation scenario data for $1m^2$ of installed CFFA PVC roofing membrane considered in this EPD.

Table 8: A5 module, Installation scenario data per 1 m^2 of installed membrane

BUILDING INSTALLATION SCENARIO[1)]	QUANTITY	UNITS
Fasteners[2)] (5" screw and seam plates)	0.1105	kg
Electricity for seam welding	0.0206	kWh
Electricity for securing the screws	0.0146	kWh
Seam area	0.05	m^2
Material loss	1	%
Waste transport to landfill (including packaging waste)	75	km

Notes:
[1)] This scenario is based on industry generic technical data.
[2)] Each fastener is typically used to hold down 7.5 sq. ft. (0.7 m^2) of PVC roofing membrane, so a fastener usage of 1.5 fasteners per m^2 (=10.76/7.5) is used in the LCA.

7 End of Life Stage

The End-of-Life Stage includes the following scenario modules:

C1 De-Construction/ Demolition,

C2 Transport to waste processing and/or disposal,

C3 Waste processing for reuse, recovery and/or recycling,

C4 Disposal

Table 9 shows the End-of-Life (EOL) scenario data (module C1-C4) per 1m^2 of installed CFFA PVC roofing membrane.

Table 9: C1-C4 modules, EOL scenario data per 1 m^2 of installed membrane

END-OF LIFE	QUANTITY AND UNITS	C2. TRANSPORT (IN KM)	
		TRUCK	BARGE
C1. Deconstruction/demolition- Electricity (in kWh)	0.0024	N/A	
C1. Deconstruction/demolition- Diesel (in MJ)	0.421	N/A	
C3. Material recycling back to the PVC roofing system[2)]	2%	27	1354
C3. Material recycling back to the other PVC products[1)2)]	9%	27	1354
C3. Incinerated for energy recovery	0%	N/A	

END-OF LIFE	QUANTITY AND UNITS	C2. TRANSPORT (IN KM)	
		TRUCK	BARGE
C3. Reuse	0%	N/A	
C4. Landfilled	89%	75	
Total	**100%**	N/A	

Notes:
[1)] Examples: Commercial PVC flooring, PVC expansion joint material for the concrete industry.
[2)] Based on the average 2010 CFFA LCI transportation data.

8 LIFE CYCLE ASSESSMENT

8.1 SYSTEM BOUNDARY

Figure 3 shows the life-cycle stages and individual modules that are included within the LCA system boundary of this EPD. In Figure 3, an "X" indicates the module is included in the system boundary, while "MND" indicates the "module is not declared" and therefore is excluded from the system boundary.

Product stage			Construction process stage		Use stage							End-of-life stage			
Raw Material supply	Transport	Manufacturing	Transport	Construction- Installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X

Figure 3 Life Cycle Stages and Modules

8.2 CUT OFF RULES, DATA QUALITY REQUIREMENTS AND ALLOCATION RULES

Cut-off rules, as specified in ASTM SPRM PCR: 2013, section 7.2, were applied [1]. All input/output data reported by the participating CFFA member PVC manufacturing plants were included in the LCI modelling. None of the reported flow data were excluded based on the cut-off criteria.

All data quality requirements as per the ASTM SPRM PCR: 2013, sections 7.1 and 7.3 were met [1].

Temporal scope – Primary data collected from CFFA members for their operational activities (gate-to-gate manufacturing and product formulations) are representative for the year 2010. Additional life cycle inventory data necessary to model and account for base and intermediate material flows as well as energy use, etc. were from US LCI database or the ecoinvent v.2.2 database, 2014. Both databases required adjustment to either fill known data gaps or reflect a N. American system boundary. CFFA members, in consultation with the LCA practitioner, developed all downstream scenario information based on typical practices in 2013.

Geographic scope – based on the United States and Canada system boundaries for all processes and product systems. The United States and Canada background data were the preferred source, but when not available European data (adjusted for the United States and Canada system boundary) were used as a proxy. All downstream activity stages (scenarios) were based on prevailing the United States and Canada practices.

Technology scope – prevailing typical or average technology as employed in North America.

Similarly, the ASTM SPRM PCR:2013, Section 5 allocation rules, based on the requirements and guidance of ISO 14044:2006, Clause 4.3.4, were followed. Mass allocation was used to partition shared processes across all products and co-products within CFFA member manufacturing facilities. An ISO conforming “system expansion” method was used to model closed-loop recycling within the plant as well as to account for both the input of pre- and post-consumer scrap entering the product system and output off-spec PVC roofing membrane and process related scrap leaving the product system.

8.3 RESULTS OF THE LIFE CYCLE ASSESSMENT

Tables 10 to 12 summarize the “cradle-to-building with EOL stage” LCA results for the three declared CFFA white, single-ply polyester reinforced PVC roofing membrane thicknesses (40, 48 and 60 mils) on an absolute basis. Life cycle stages included cover the product stage (cradle-to-gate, modules A1 to A3), construction process (product transportation and onsite effects, modules A4 and A5) and EOL stages (deconstruction, transportation, waste processing and disposal, modules C1 to C4). As required in ASTM SPRM PCR:2013, Section 8, the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental

Impacts (TRACI), version 2.1, 2012 impact categories are used as they provide a North American context for the mandatory category indicators to be included in this EPD. These are relative expressions only and do not predict category impact end-points, the exceeding of thresholds, safety margins or risks. Total primary and sub-set energy consumption were compiled using a cumulative energy demand model. Material resource consumption and generated waste reflect cumulative life cycle inventory flow information.

Table 10: LCA results- 40 mils, 1 m^2 of installed membrane - absolute basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	kg CO_2 eq.	4.28	0.28	0.11	4.67
Acidification potential	kg SO_2 eq.	0.04	0.001	0.001	0.04
Eutrophication potential	kg N eq.	0.07	0.001	0.009	0.08
Smog creation potential	kg O_3 eq.	0.42	0.03	0.01	0.45
Ozone depletion potential	kg CFC-11 eq.	4.4E-07	7.6E-09	6.2E-09	4.6E-07
Total primary energy consumption					
Nonrenewable fossil	MJ	77.1	3.9	0.7	81.6
Nonrenewable nuclear	MJ	7.1	0.3	0.011	7.5
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	0.9	0.05	0.001	1.0
Renewable (biomass)	MJ	0.7	0.01	0.0001	0.7
Material resources consumption					
Nonrenewable materials	kg	0.926	0.121	1.3E-05	1.047
Renewable materials	kg	0.202	1.6E-03	5.2E-05	0.204
Fresh water	l	66.7	1.4	0.1	68.1
Waste generated					
Non-hazardous	kg	2.1E-02	0.011	1.011	1.044
Hazardous	kg	4.8E-04	0	0	4.8E-04

Table 11: LCA results- 48 mils, 1 m^2 of installed membrane- absolute basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	kg CO_2 eq.	5.41	0.31	0.13	5.85
Acidification potential	kg SO_2 eq.	0.06	0.002	0.001	0.06
Eutrophication potential	kg N eq.	0.09	0.001	0.012	0.10

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Smog creation potential	kg O_3 eq.	0.62	0.03	0.01	0.66
Ozone depletion potential	kg CFC-11 eq.	5.7E-07	7.6E-09	6.2E-09	5.9E-07
Total primary energy consumption					
Nonrenewable fossil	MJ	98.0	4.2	0.7	102.9
Nonrenewable nuclear	MJ	9.0	0.3	0.012	9.3
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	1.2	0.05	0.001	1.2
Renewable (biomass)	MJ	1.2	0.01	0.0001	1.2
Material resources consumption					
Nonrenewable materials	kg	1.198	0.121	1.3E-05	1.320
Renewable materials	kg	0.278	1.6E-03	5.5E-05	0.279
Fresh water	l	86.0	1.4	0.1	87.5
Waste generated					
Non-hazardous	kg	2.6E-02	0.015	1.298	1.339
Hazardous	kg	6.0E-04	0	0	6.0E-04

Table 12: LCA results- 60 mils, 1 m^2 of installed membrane- absolute basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	kg CO_2 eq.	6.44	0.34	0.15	6.93
Acidification potential	kg SO_2 eq.	0.07	0.002	0.001	0.07
Eutrophication potential	kg N eq.	0.11	0.001	0.015	0.13
Smog creation potential	kg O_3 eq.	0.64	0.04	0.01	0.69
Ozone depletion potential	kg CFC-11 eq.	7.1E-07	7.6E-09	6.2E-09	7.2E-07
Total primary energy consumption					
Nonrenewable fossil	MJ	117.9	4.6	0.7	123.2
Nonrenewable nuclear	MJ	10.5	0.3	0.012	10.9
Renewable (solar, wind, hydroelectric, and geothermal)	MJ	1.4	0.05	0.001	1.5
Renewable (biomass)	MJ	1.1	0.01	0.0001	1.1
Material resources consumption					
Nonrenewable materials	kg	1.450	0.121	1.3E-05	1.572
Renewable materials	kg	0.305	1.6E-03	5.7E-05	0.307

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Fresh water	l	103.6	1.4	0.1	105.0
Waste generated					
Non-hazardous	kg	3.3E-02	0.018	1.601	1.652
Hazardous	kg	7.6E-04	0	0	7.6E-04

Tables 13 to 15 present a contribution analysis (in %) for the three selected CFFA PVC roofing membrane thicknesses (40, 48 and 60 mils). These tables show the contribution of the product, construction and EOL activity stages to the total results on a percent basis.

Table 13: Contribution analysis results- 40 mils, 1 m^2 of installed membrane - percent basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	%	91.6	6.0	2.3	100
Acidification potential	%	95.6	3.0	1.4	100
Eutrophication potential	%	86.2	1.5	12.3	100
Smog creation potential	%	91.6	5.7	2.8	100
Ozone depletion potential	%	97.0	1.7	1.3	100
Total primary energy consumption					
Nonrenewable fossil	%	94.5	4.7	0.8	100
Nonrenewable nuclear	%	95.4	4.4	0.1	100
Renewable (solar, wind, hydroelectric, and geothermal)	%	94.4	5.5	0.1	100
Renewable (biomass)	%	98.9	1.1	0.0	100
Material resources consumption					
Nonrenewable materials	%	88.4	11.6	0	100
Renewable materials	%	99.2	0.8	0	100
Fresh water	%	97.9	2.0	0.1	100
Waste generated					
Non-hazardous	%	2.0	1.1	96.9	100
Hazardous	%	100	0	0	100

Table 14: Contribution analysis results- 48 mils, 1 m2 of installed membrane - percent basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	%	92.5	5.3	2.2	100
Acidification potential	%	96.3	2.6	1.1	100
Eutrophication potential	%	86.6	1.3	12.1	100
Smog creation potential	%	93.5	4.6	2.0	100
Ozone depletion potential	%	97.6	1.3	1.1	100
Total primary energy consumption					
Nonrenewable fossil	%	95.2	4.1	0.7	100
Nonrenewable nuclear	%	96.3	3.6	0.1	100
Renewable (solar, wind, hydroelectric, and geothermal)	%	95.5	4.4	0.1	100
Renewable (biomass)	%	99.4	0.6	0.0	100
Material resources consumption					
Nonrenewable materials	%	90.8	9.2	0	100
Renewable materials	%	99.4	0.6	0	100
Fresh water	%	98.4	1.5	0.1	100
Waste generated					
Non-hazardous	%	2.0	1.1	96.9	100
Hazardous	%	100	0	0	100

Table 15: Contribution analysis results- 60 mils, 1 m^2 of installed membrane - percent basis

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Global warming potential	%	92.9	4.9	2.2	100
Acidification potential	%	96.4	2.5	1.1	100
Eutrophication potential	%	86.9	1.1	11.9	100
Smog creation potential	%	93.0	5.1	1.9	100
Ozone depletion potential	%	98.1	1.1	0.9	100
Total primary energy consumption					
Nonrenewable fossil	%	95.6	3.8	0.6	100

Category Indicator	Unit	Product stage	Construction process stage	End-of life stage	Total
		A1-A3	A4-A5	C1-C4	
Nonrenewable nuclear	%	96.8	3.1	0.1	100
Renewable (solar, wind, hydroelectric, and geothermal)	%	96.2	3.7	0.1	100
Renewable (biomass)	%	99.3	0.7	0.0	100
Material resources consumption					
Nonrenewable materials	%	92.3	7.7	0	100
Renewable materials	%	99.4	0.5	0	100
Fresh water	%	98.6	1.3	0.1	100
Waste generated					
Non-hazardous	%	2.0	1.1	96.9	100
Hazardous	%	100	0	0	100

8.4 INTERPRETATION

The above life cycle impact assessment results represent a “cradle-to-building with EOL stage” EPD per installed square meter for each declared PVC roofing membrane thickness as manufactured by CFFA PVC roofing division members, which are then removed and processed at their respective end of life. Impacts during the building use stage, such as maintenance, repair, replacement and building operating energy impacts, have not been considered as these impacts would be particular to the building archetype, its expected life and climate location.

For each of the declared membrane thicknesses, the cradle-to-gate product stage dominates the category indicators, primary energy and resource consumption and waste generated results – ranging from 86% to 100% of the total effects. Except for non-renewable materials consumption, the construction process stage accounted for less than 6% of the overall effects. The end-of-life stage was generally found to be a minor contributor to the declared product impacts; however, it did account for 12% of the eutrophication potential and over 95% of the non-hazardous waste generated.

9 ADDITIONAL AND ENVIRONMENTAL INFORMATION

- *Cool Roofing*
  The three declared membrane thicknesses meet or exceed the cool roofing requirements of USGBC's LEED program, Green Globes, ENERGY STAR and California Title 24.

- *Reference Service Life of the PVC roofing membranes*

  If exposed to the standard load, professionally installed and applied in accordance with the intended use in compliance with the generally accepted engineering standards, the PVC roofing membranes can reach a service life of 30 years or more [9].

- *Quality and Environmental Management Systems*
  CFFA member manufacturing plants follow either the ISO 9001 quality management system or other in-house quality control systems and one member follows the ISO 14001 environmental management system.

- *Health Protection Manufacture*
  The OSHA standards are applicable and followed.

  - U.S. Department of Labor, Occupational Safety & Health Administration (OSHA), 29 CFR, PART 1910 Occupational Safety and Health Standards.
  (https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910)

  No additional health protection measures extending beyond mandatory occupational safety measures for commercial operations are required.

- *Environmental Protection Manufacture*
  The CFFA member manufacturing plants comply with the regional (U.S and Canada) environmental protection requirements, monitor and report the emissions to air during the manufacturing process as per the following:

  - EPCRA Section 313 Toxic Release Inventory Reporting (U.S)
  (http://www.ecy.wa.gov/epcra/section313.html)
  - The Canadian National Pollutant Release Inventory (NPRI) Reporting
  (http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1)

  The two following process-specific emissions to air are measured at the stack after environmental control devices are utilized (see Table 16):

  - Total Particulate Matter (PM)
  - Non-methane volatile organic compounds (NMVOCs)

- *Environmental Equipment at the Manufacturing Plants*
  Table 16 summarizes the environmental abatement equipment installed at the CFFA member manufacturing plants.

Table 16: Summary of Environmental Equipment

No.	Environmental Equipment	Process controlled	Emissions controlled
1	Regenerative Thermo Oxidizer (RTO) – without energy recovery	Extrusion, coating, adhesive coating process; print the top-film finishing (coating)	VOCs
2	Fabric Filter – High Efficiency Air Filtration	Extrusion process; back and face compound mixing; PVC compound formation	Particulates total; PM_{10}, $PM_{2.5}$
3	Electrostatic precipitator	Spread coat process; Lamination	Particulates, oils; aerosol plasticizer

Cooling Water Towers
All CFFA member plants operate cooling towers of various types and sizes. The weighted average capacity of cooling towers indicated a capacity of 3.89E+06 BTU/hrs; i.e., small air conditioning cooling towers.

10 DECLARATION TYPE

A "Cradle-to-building with EOL stage" EPD for three CFFA SPPR PVC roofing membrane thicknesses (40, 48 and 60 mils) covering the product, construction and EOL stages (modules A1 to A5 and C1 to C4) and is intended for use in Business-to-Business communication.

11 PRODUCT SPECIFIC DECLARATION

The three declared thicknesses (40, 48 and 60 mils), white, single-ply polyester reinforced PVC roofing membrane, fall under the description:

- *A specific product EPD, as an average from several manufacturers' plants*
(in this case, CFFA, Vinyl Roof Division member manufactures' plants as listed under "CFFA Member Manufacturers Names and Addresses", see pg. 2).

12 DECLARATION COMPARABILITY LIMITATION STATEMENT

The following ISO statement indicates the EPD comparability limitations and intent to avoid any market distortions or misinterpretation of EPDs based on the ASTM's SPRM PCR: 2013:

- *EPDs from different programs (using different PCR) may not be comparable.*
- *Declarations based on the ASTM SPRM PCR [1] are not comparative assertions; that is, no claim of environmental superiority may be inferred or implied.*

13 EPD Explanatory Material

For any explanatory material, in regard to this EPD, please contact the program operator.
ASTM International
Environmental Product Declarations
100 Barr Harbor Drive,
West Conshohocken,
PA 19428-2959, http://www.astm.org

14 REFERENCES

1. ASTM International, Product Category Rules For Preparing an Environmental Product Declaration For Single Ply Roofing Membranes, November 2013
2. ASTM D4434, Standard Specification for Poly (Vinyl Chloride) Sheet Roofing
3. Athena Sustainable Materials Institute, A Cradle-to-Gate Life Cycle Inventory of PVC Roofing Membrane Product, Prepared for Chemical Fabrics and Film Association, Inc., September, 2011
4. ISO 21930: 2007 Building construction – Sustainability in building construction – Environmental declaration of building products.
5. ISO 14025: 2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.
6. ISO 14044: 2006 Environmental management - Life cycle assessment - Requirements and guidelines.
7. ISO 14040: 2006 Environmental management - Life cycle assessment - Principles and framework.
8. EN 15804:2012 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.
9. IBU, EPD-BAU-20130188-IBCC-DE, PVC-P Dach- und Dichtungsbahnen, 26.09.2013, pg 4, section 2.12 reference service life.
10. Weidema, B 2001: Avoiding Co-Product Allocation in LCA, Journal of Industrial Ecology 4(3):11-33, 2001.
11. ASTM Program Operator for Product Category Rules (PCRs) and Environmental Product Declarations (EPDs), General Program Instructions, October 2012.
12. ASTM D6754 Standard Specification for Ketone Ethylene Ester Based Sheet Roofing