Regulatory Evolution (US)

Name	PU Foams (factory)			Spray Polyurethane Foams (field)			Key Properties				
	PIR Board/ Bunstock	Appliance	Metal Panels	HP-SPF	LP-SPF two-component	OCF - one component foam	ODP (CFC eq)	GWP[1] (CO_2 eq)	lambda (W/m°K)	boiling point (°C)	flammable
Generation 1											
CFC-11	✓	✓	✓	✓			1	4660	0.01	23.7	no
CFC-12					✓	✓	1	10200	0.011	-29.8	no
Generation 2											
HCFC-141b	✓	✓	✓	✓			0.11	782	0.010	32.2	no
HCFC-142b							0.065	1980	0.013	-9.8	no
HCFC-22	✓				✓	✓	0.055	1760	0.011	-40.8	no
Generation 3											
HFC-245fa		✓	✓	✓			0	858	0.013	15.3	no
HFC-365mfc				✓ [2]			0	804	0.011	40.2	yes
HFC-134a					✓	✓	0	1300	0.014	-26.2	no
Generation 4											
HFO-1233zd		✓	under devl.	under devl.			0	1	0.010	19	no
HFO-1336mzz-Z		under devl.	under devl.	under devl.			0	2	0.011	33	no
HFO-1234ze					under devl.[3]	✓	0	<1	0.010	-19	no
Other Options											
pentanes	✓	✓	✓				0	<25	0.015	49	YES[4]
CO_2 (from water)			✓	Gen 3 additive			0	1	0.087[5]	-71	no
methyl formate				Gen 3 additive[6]			0	<25	0.0107	31.5	YES

(1) IPCC 5th Assessment Report 2013

(2) Beginning January 2013; often blended with HFC-227ea

(3) Challenges with extended shelf-life for two-component low-pressure SPF

(4) High flammability poses safety hazard for field applied products like HP-SPF and LP-SPF

(5) Rapidly diffuses from within closed-cell foam without diffusion barrier (e.g., metal facings) resulting in low R-value and dimensional stability issues (shrinkage)

(6) Not a stand-alone blowing agent for HP-SPF; typically blended with other blowing agents to reduce flammability

Spray Polyurethane Foam Life Cycle Assessment Summary

For Residential Insulation and Commercial Roofing

Spray Polyurethane Foam Saves Energy and Reduces Environmental Impact

Life cycle assessment shows SPF insulation significantly reduces energy and environmental impact when evaluated over the entire life cycle.

The Spray Polyurethane Foam Alliance (SPFA) completed a Life Cycle Assessment (LCA) of open and closed-cell spray polyurethane foam (SPF) insulation in buildings to quantify cradle-to-end of life energy and environmental impacts across the entire life cycle. The LCA was conducted to assure builders, designers, and consumers that the products are indeed part of a responsible and effective energy and environmental construction solution.

SPFA conducted two studies to complete this LCA effectively: one focused on embodied energy and the environmental impact of manufacturing SPF products, and the second focused on the energy use phase of SPF products. The first study was performed in accordance with ISO 14040/44. The second study followed recognized whole building energy modeling methods to estimate the use-phase impact of SPF in residential and commercial buildings and was also independently validated. Together, these results create a picture of the overall energy and environmental impact of SPF products.

As part of the LCA, SPFA evaluated the impact of three SPF products (low- and medium-density wall foams and medium-density roof foam) in residential and commercial buildings. A formal independent critical review was conducted in accordance with the ISO 14040 series of LCA standards, plus further technical input and review included broad participation of SPFA members and industry representatives

A complete 48-page report containing *details of the SPF Life Cycle Assessment can be obtained from the Spray Polyurethane Foam Alliance website at www.sprayfoam.org.*

Founded in 1987 originally as the Polyurethane Foam Contractors Division, the Spray Polyurethane Foam Alliance (SPFA) is the voice as well as the educational and technical resource for the spray polyurethane foam industry.

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Spray Polyurethane Foam Life Cycle Assessment Summary

The Life Cycle Approach: An Essential and Holistic Product Evaluation

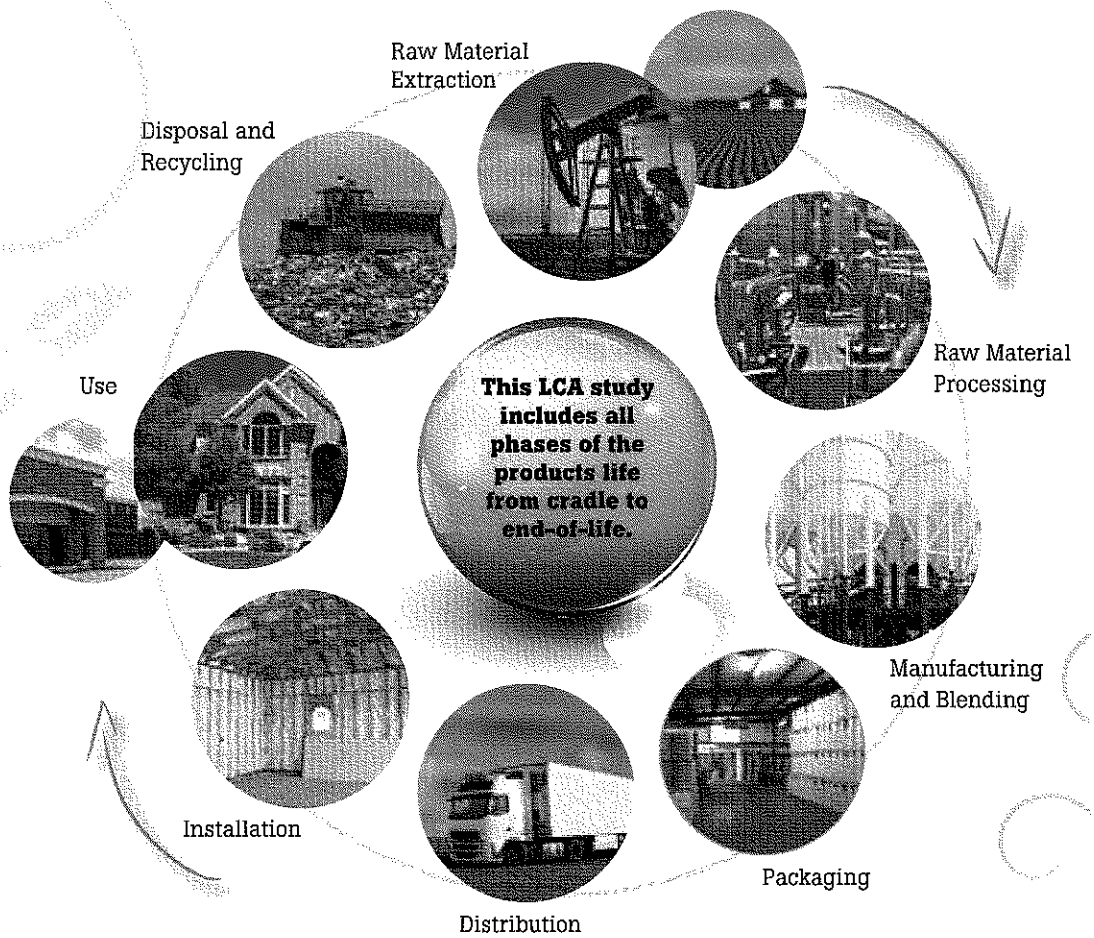
What is Spray Polyurethane Foam (SPF)?

Spray Polyurethane Foam (SPF) insulation is rigid, lightweight, flexible, wind resistant, and effective in extreme temperatures and weather conditions. When applied, SPF adheres immediately and expands from 20 to 120 times of its liquid volume.

SPF insulations offer more consistent insulation performance (R-value) and other advantages over alternative insulation systems, due to SPF's ability to provide an integral air barrier, and in the case of close-cell spray foam, water vapor resistance. SPF products also offer good acoustic performance.

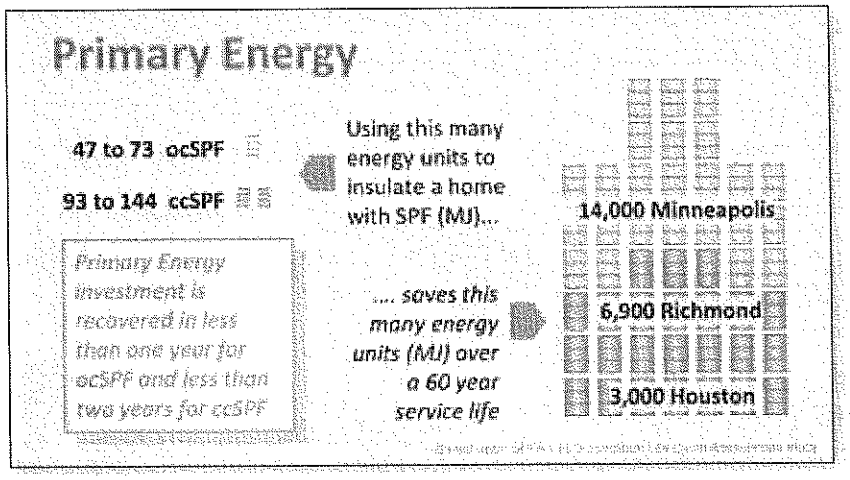
When SPF is created, a blowing agent is combined with liquid polyurethane raw materials, which creates a foamed material composed of small bubbles or cells. The two components join under pressure as they are sprayed on to building assemblies. As the mixture cures, the cells burst (ocSPF) or remain intact (ccSPF).

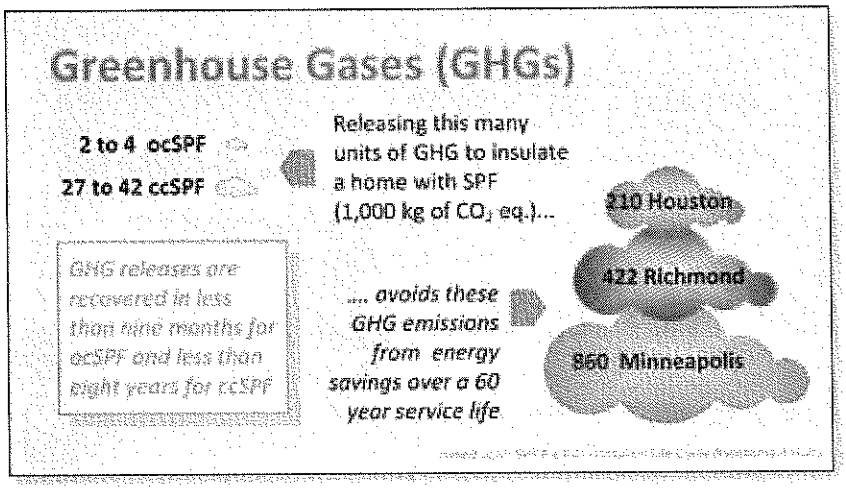
The life cycle approach to evaluating the energy and environmental impacts of products is critical in understanding these impacts and for developing environmental improvement strategies. For SPF insulation, the use phase energy savings and avoided environmental impacts result from a high R-value and reduced air infiltration. These positive impacts significantly offset the impacts associated with manufacturing SPF, which are quantified using a holistic life cycle assessment. Considering only single attributes (such as recycled or renewable material content), or only the impacts from the manufacturing phase of a product creates a limited and technically flawed perspective on the environmental impact of SPF.



SPF's Complete Life Cycle Results: Significant Energy Savings and Reduced Environmental Impacts

The LCA results show that spray foam products save significantly more energy and prevent more environmental impacts during the life of the insulation in a building compared to the relatively minor energy and environmental impacts associated with making the insulation.



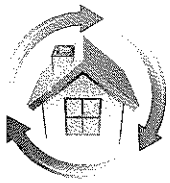


What is the difference between open and closed cell SPF?

Closed-cell spray polyurethane foam (ccSPF) *is also known as medium-density spray foam. The material weighs about 2 pounds per cubic foot with an R-value of 6.0 to 6.8 per inch. It can be used as cavity insulation or continuous exterior insulation for walls, floors and ceilings. SPF used on exterior sides of low-slope roofing has a density of about 3 pounds per cubic foot and provides similar R-values as medium density SPF.*

Open-cell spray polyurethane foam (ocSPF) *is also known as low-density spray foam. The material weighs about ½-pound per cubic foot with an R-value of 3.6-4.5 per inch and can be used for interior, above-grade insulation and acoustic applications.*

For all environmental categories studied, embodied environmental impacts from manufacturing are minimal when compared to environmental impacts avoided during insulation use over a 60-year period.



The table below shows the ratio of energy and GHG avoided to the embodied amounts used to make the SPF insulation. It also shows the years of use (payback) required to recover the embodied impacts. The table includes LCA results for all three SPF types used for residential insulation and low-slope roofs in commercial buildings.

Application	SPF Type	Ratio & Payback	Houston		Richmond		Minneapolis	
			Energy	GHG	Energy	GHG	Energy	GHG
Residential Insulation	Low Density Open-Cell	Avoided/Embodied	64	92	128	164	194	248
		Payback (Yr)	0.9	0.7	0.5	0.4	0.3	0.2
	Medium Density Closed-Cell	Avoided/Embodied	32	7.6	64	13.6	98	21
		Payback (Yr)	1.9	7.9	0.9	4.4	0.6	2.9
Commercial Roofing	Roofing R4 --> R20	Avoided/Embodied	55	15	56	15	66	17
		Payback (Yr)	1.1	4	1.1	4.1	0.9	3.6
	Roofing R12 --> R20	Avoided/Embodied	30	8.2	28	7.5	29	7.3
		Payback (Yr)	2	7.3	2.1	8.0	2.1	8.3

This LCA Project was funded by SPFA, with additional funding support from the following SPFA Supplier Members.

American Chemistry Council
Center for the Polyurethanes Industry
EPA RIN 2060-AS18

The American Chemistry Council's Center for the Polyurethanes Industry (CPI) represents the manufacturers of chemicals and materials used in the manufacture of polyurethanes. The building and construction market is the largest end use market for polyurethanes in the United States. Polyurethanes are used in the manufacturer of many building products, including energy-efficient foam insulation.

The U.S. Environmental Protection Agency (EPA) is proposing to change the listing status of certain blowing agents with high global warming potential (GWP), including those used in the manufacturer of certain foam insulation, under the Significant New Alternatives Policy (SNAP) Program. Blowing agents serve highly targeted uses in the manufacturer of foam insulation; and therefore, the elimination of certain end uses should be done only after careful consideration of the factors involving the availability of commercially viable alternatives.

The following non-exhaustive list contains factors that should be considered in determining whether replacement blowing agents are available for foam insulation end uses:

- There are no "drop in" replacements for blowing agents in foam insulation. Insulation manufacturers use proprietary blends of chemicals that differ from generic product formulations used in the development of blowing agents. Substituting an alternative blowing agent within a specific foam insulation product requires reformulation of that product.
- Reformulation requires insulation manufacturers to test the new materials. The material property tests include thermal performance and fire protection, and are time- and resource-intensive. Some material tests and standard certifications may be required to meet building codes. Other tests and standards certifications may be optional, but are performed to meet market demands or industry best practice.
- Certain foam insulation, like spray polyurethane foam (SPF) insulation, is manufactured onsite or "field-applied." As a result, the reformulation process for SPF requires manufacturers to test products under a number of environmental conditions (i.e., a wide range of air and substrate temperatures and humidity conditions).
- Some SPF products require additional testing considerations. Two-component low-pressure SPF is delivered in pre-pressurized drums or kits. These drums or kits must be tested for shelf-life stability. As with any product testing, setbacks or complications uncovered during the testing process may require the insulation manufacturer to start the reformulation process over.
- GWP should not be used as the sole selection criteria for blowing agents used in foam insulation, which could lead to the selection of alternative technologies that provide reduced R-value and air-sealing performance, and over time, would result in greater greenhouse gas emissions. As an example of the importance of life-cycle considerations for foam insulation, the

life cycle assessment[1] for SPF demonstrates that GHG emissions from the current HFC blowing agents may be recovered, or paid back, within 3 to 8 years using a 60 plus year service life of the product.

- Foam insulation products are manufactured by various businesses entities, including small-medium enterprises (SMEs).[2] SMEs may face challenges in reformulating products that are unique given their relative size and capacity, including investment in new facilities, low own capital, and specialized products lines produced in small lots that may be unable to support new investments.

[1] *See* Life Cycle Assessment of Spray Polyurethane Foam Insulation for Residential & Commercial Building Applications. *Available at*: http://www.sprayfoam.org/technical/energy-the-environment.

[2] Businesses with 500 employees or less as defined by the North American Industry Classification System Codes. Additional information *available at*: http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf.