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What Makes a Thermoplastic Roof Sustainable?

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What Makes a Thermoplastic Roof Sustainable?

Presented By: Sika Sarnafil
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Description: Provides an overview of the features, benefits, and life cycle impacts of thermoplastic PVC roofing membrane that makes it a sustainable product.

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Learning Objectives

At the end of this program, participants will be able to:

- discuss the importance of proven performance and roof membrane durability
- explain the benefits of choosing a roof membrane that contains post-consumer recycled content versus post-industrial
- demonstrate a knowledge of the natural fire-resistant properties of some thermoplastic roof membranes, and
- define the term “life cycle analysis,” and compare roof membrane materials in terms of their life cycle impacts.

Table of Contents

Click on title to view

Copps Coliseum, Hamilton, Ontario

Documented Service Life

Introduction

In a time when words like “green,” “sustainable,” “environmentally friendly” and “all natural” are being used to describe many products, it is difficult to know exactly what attributes to look for when making a purchase, and roofing is no exception.

The product’s documented service life is the first attribute of a sustainable roof to consider, and is arguably the most important. A long-lasting roof provides a sustainability edge over other, less durable roofing systems. It’s a simple formula: The longer a roof lasts, the longer the replacement cycle and the smaller its carbon footprint. Longer life cycles equal less waste to the landfill and fewer carbon emissions in the production of new roofing system products.

The best way to determine roof service life is to ask the manufacturer for a list of projects with a documented performance history in your climate. The proof of roofing longevity is in demonstrated performance in the real world, not warranty length. Warranty exclusions, including prorating to decrease the roofing asset value over time, can limit the manufacturer’s financial exposure and increase your risk. The roof should perform problem-free over its intended life.

Long-Term Performance

Thermoplastic PVC membranes can show tremendous examples of long-term performance. Bogenhalle Reinhard, located in Switzerland, was constructed in 1967 and is still in place today. Part of a furniture manufacturing facility, it was originally built as a temporary structure. Notice the wooden beams in this photo; the roofing membrane was nailed to the wood frame structure because it was not expected to last this long, but it is still performing today.

Long-Term Performance

Two other examples of PVC membranes and long-term performance are First United Methodist Church in Laconia, New Hampshire, installed in 1976, and Robbins Hall at the University of California, Davis, installed in 1984. Both roofs are still in service.

Robbins Hall, University of California, Davis

First United Methodist Church in Laconia, New Hampshire

Testing Agencies

Roofing membrane standards in the U.S. are set by the American Society for Testing and Materials (ASTM), while in Canada they are set by the Canadian General Standards Board. Manufacturers test materials to a variety of physical properties, but there are no tests to determine how long the material will last.

The British Board of Agrément (BBA) is a unique governmental agency in the United Kingdom that provides a written estimate of material life. It performs physical property testing such as tensile strength, low-temperature flexibility, and accelerated aging as well as conducting field visits to older roofs, including taking samples for laboratory testing. Based on this analysis, the BBA provides an estimated material life.

In a 2008 report for one manufacturer, the retention of physical properties—in other words, the life of the PVC roofing—should be in excess of 35 years.

ASTM INTERNATIONAL

BBA BRITISH BOARD OF AGRÉMENT

Documented Service Life

In summary, the first attribute to look at when trying to decide if your current or future roofing membrane is considered a sustainable product is documented service life. The longer the roofing membrane lasts on the building, the less frequently it must be replaced, minimizing the need for replacement product and the amount of materials sent to landfills.

Recyclability

Introduction

The next three attributes of thermoplastic PVC roofing membranes address the importance of recycling in determining sustainability. The first two attributes address pre-consumer recycling or recycling membrane trimmings and other products that were not installed and would otherwise end up in a landfill.

Recycling reduces the environmental impacts of producing new materials at the beginning of the life cycle, and the burden on landfills at the end. Choosing a roofing material that is recyclable—from a roofing manufacturer that converts all of its raw materials into usable products, including recycling all production scrap and trimmings—will ensure that the membrane source is not contributing to the landfill.

Pre-Consumer Recycling

For almost 20 years, PVC roofing manufacturers have been recycling their production line trimmings into walkway pads and other roofing membrane products. Over time and with the advent of new production technology, it became possible to recycle those trimmings into new roofing membrane as well.

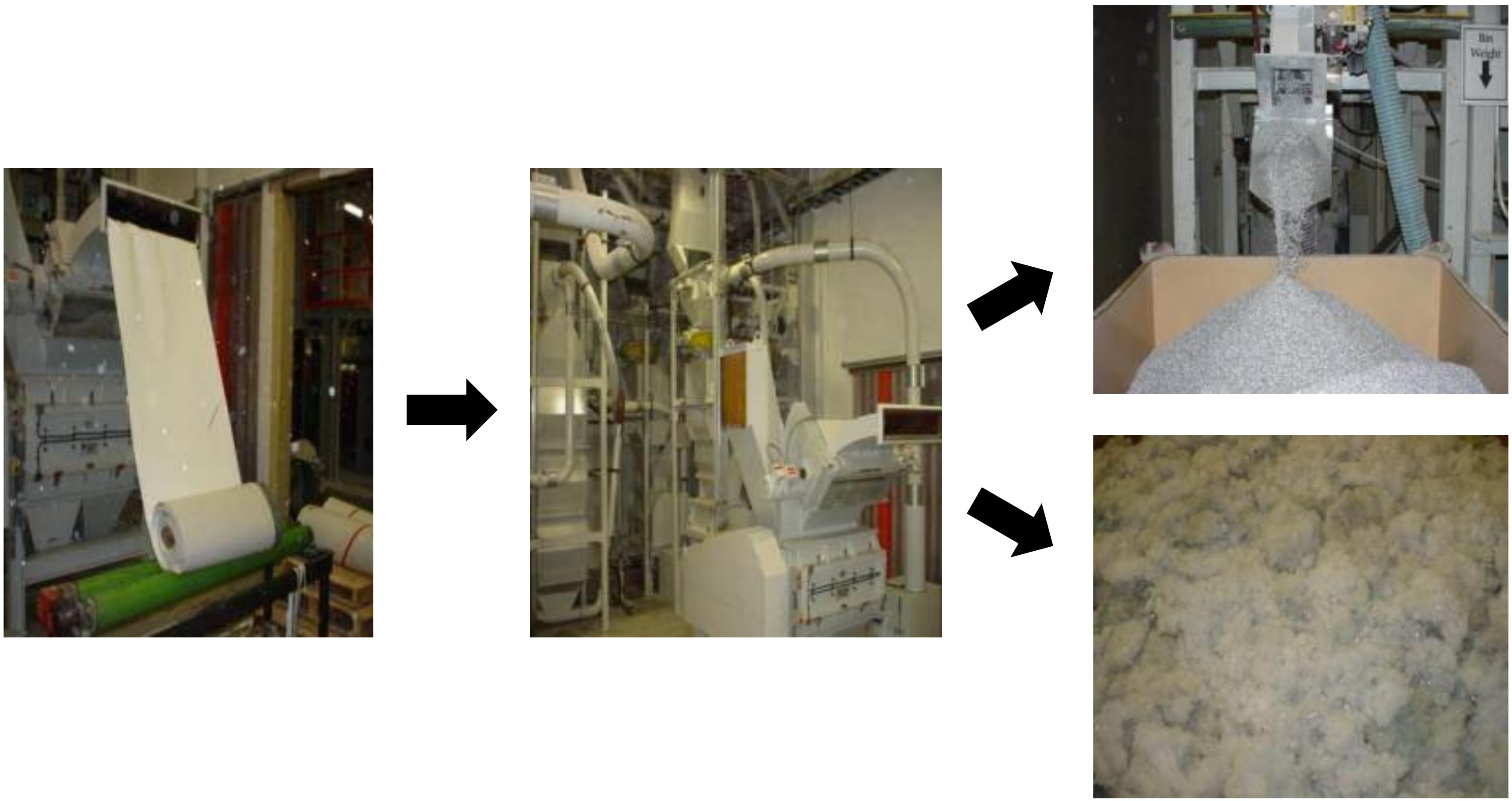
Walkway pads

State-of-the-Art Production Line

Pre-consumer material can be reintegrated into new membrane by grinding it in state-of-the-art equipment and putting it into the backside of the membrane. Currently, approximately 15% by weight of pre-consumer recycled material is used. Recycling pre-consumer material back into the membrane creates a closed loop that insures a 100% conversion of raw materials into finished product. Companies that recycle these materials at the manufacturing site eliminate the need for shipping the material back and forth to distant processing facilities and the resultant carbon production generated with this transportation.

State-of-the-Art Grinding Equipment

State-of-the-art recycling equipment separates the membrane scrim reinforcement, as well as the felt on felt-backed membranes, from the membrane polymer.



Scrim and Felt Backing Also Recycled

The scrim and felt is recycled into landscape blocks where it is used as a lightweight reinforcement or filler, or is used as fuel in waste-to-energy processes that turn that energy back into electricity.

Recycling Take-Back Programs

But what happens to the roofing material that is on the roof after its useful life is over? Can that material be recycled, as well?

Recycling take-back programs are the “holy grail” of any recycling discussion. The greatest recycling benefits are realized if a roof can be recycled at the end of its service life and put back into new material to prevent it from ending up in a landfill.

Recycling of PVC roof membranes at the end of their service life began in the U.S. in 2005.

Post-Consumer Recycling

One PVC manufacturer has been recycling roofs at the end of their service life in North America since 2005. The old roofing membrane is recycled into the backside of brand new membrane, which will then provide decades of service, creating a closed loop. This process assures that the material is not "down-cycled" into lower value or shorter life products.

A number of roofing manufacturers claim that their products "can be recycled," "theoretically could be recycled," or "are sort of recycled," but without a post-consumer collection process in place and the investment in production equipment, the actual recycling is only theoretical.

A recent presentation at a symposium about recycling other single-ply materials revealed that the limited roof membrane recycling that is taking place is converting the membrane into other applications such as filler for athletic turf fields.

First and Only Independently Certified Recycled Content

Any manufacturer claiming to recycle membrane should provide third-party certification. Underwriters Laboratories (UL) Environment, for example, certifies the recycled content claims and audits manufacturers once a year. The manufacturer must prove where the roof membrane came from, where it is processed, how it is processed, and how much of it is processed into new material, in order for UL Environment to certify a recycled content claim. Currently, only one single-ply membrane manufacturer is third-party certified for recycled content. These products contain an average of 10% recycled content.

UL Environment™
ENVIRONMENTAL CLAIMS VALIDATED

Environmental Claims Validated Mark

Third-Party Certification

Verification is important to avoid "green-washing," or the practice of making environmental claims not based on fact.

Companies such as Target Corporation rely on third-party certification from their vendors to assure that their claims to stakeholders regarding the use of ecologically sound practices—such as using PVC membranes for their long service life, reflectivity, and recyclability—are accurate.

Recycling

To summarize the previous recycling slides, you can reduce the environmental impact of a roofing system by selecting a manufacturer with an existing, proven, pre- and post-consumer roof membrane recycling program.

By choosing a manufacturer who recycles this material back into roofing membrane products, you are assured that the material is being used in the same, long-lasting, high-value product, and is not down-cycled into a short-lived, disposable application that will quickly end up in a landfill.

To verify recycling claims, ask for third-party certification.

Recycling reduces the environmental impacts of producing new materials at the beginning of the life cycle, and the burden on landfills at the end.

ENERGY STAR® Cool Roof Program

Cool Roofs

The next attribute to consider is whether the roof membrane you have or are considering meets the standards of the ENERGY STAR® cool roof program.

A cool roof is defined as one that can deliver high solar reflectance (reflecting visible, ultraviolet and infrared wavelengths) and high thermal emittance (the ability to radiate absorbed solar energy). Preventing solar radiation from increasing a building's internal temperature is an important strategy in reducing building cooling energy consumption.

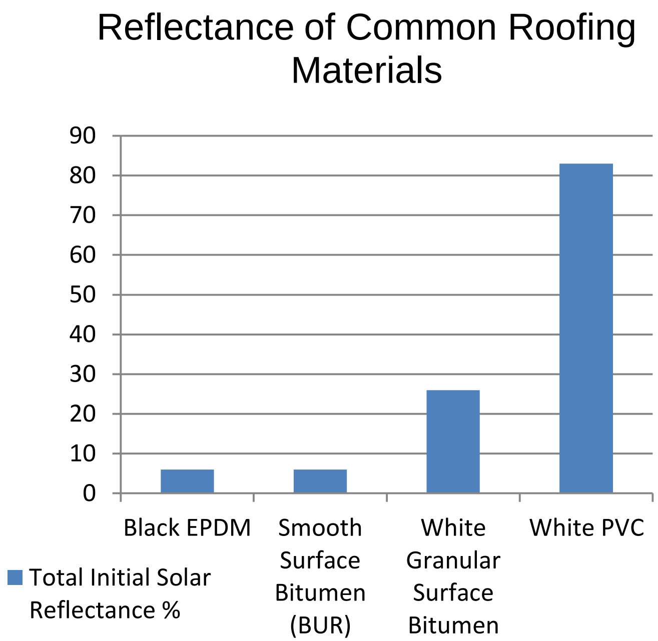
Cool roofs are an important strategy to improve urban air quality through the reduction of the urban heat island effect. Dark, low-reflecting surfaces absorb solar radiation and cause an increase in ambient air temperature in urban areas. The heat causes increased energy consumption for cooling, elevated emissions of air pollutants and compromised human health and comfort. Reducing the amount of low-reflecting surfaces through the use of cool roofs helps to decrease the ambient air temperature and its associated ill effects.

Reflectivity

Most, if not all, thermoplastic membrane types offer a white or cool roof option that meets or exceeds ENERGY STAR®'s requirement of 0.65 reflectance. This chart compares the reflectivity of common roofing materials.

Black EPDMs reflect about 6% of the energy, meaning they absorb 94% of the energy. Smooth surface bituminous roofs also have 6% reflectivity, while white granular bitumen has roughly 26% reflectivity.

This graph may be dated, as some modified bitumen can now achieve higher initial reflectivities. However, all of those reflectivity numbers are well below the 83% that white thermoplastic membranes exhibit.



Source: Cool Roofing Material Database/Lawrence Berkeley National Laboratory
http://eetd.lbl.gov/CoolRoof/membrane.htm

White Reflective Roof

In a Lawrence Berkeley National Laboratory (LBNL) study commissioned by the U.S. Department of Energy and the EPA, researchers compared the energy consumption of a 100,000-sq.-ft. Texas facility over a two-year period—with a black rubber EPDM roof in use, and then a white cool roof.

The cool roof reduced peak summertime air conditioning demand by 14%, and resulted in an estimated savings of $7,200 (7.2 cents per square feet per year in 2000, when the study was conducted).

White Reflective Roof

The facility shown in this photo is the School of Environmental Science at the University of California, Santa Barbara. When the roof was installed, a white PVC cool roof was used to achieve the Urban Heat Island Reduction Credit for LEED®.

Bren School of Environmental Science & Management,
University of California, Santa Barbara
LEED Platinum

ENERGY STAR® Cool Roofing

Choosing materials that meet or exceed the requirements set by ENERGY STAR® for cool roofing is an important attribute for sustainability, because it reduces energy consumption and the ambient temperature, thereby reducing the effects of urban heat islands such as poor air quality and smog formation.

Thermal Insulation

Roofing Insulation

Thermal insulation on the roof helps to minimize the heat flow between the interior and exterior of the building, reducing the amount of electricity consumed to cool the building on warm days, and the amount of energy needed to heat the building on cool days.

According to ASHRAE 90.1, the minimum R-value of insulation above the deck on commercial buildings should be R-20 in all climate zones in the U.S.

The National Roofing Contractors Association recommends two layers of insulation with staggered seams to further minimize the movement of air through the insulation.

System Solutions for All Conditions

Roofing insulation is available in a wide variety of configurations and materials to meet a project's specific requirements.

Efficient Use of Resources

Petroleum Content

This section discusses one of the key advantages of PVC. As a material, less than half of the actual polymer comes from oil, which is important because now, more than ever, decreasing the United States' dependence on foreign oil is a universally accepted priority.

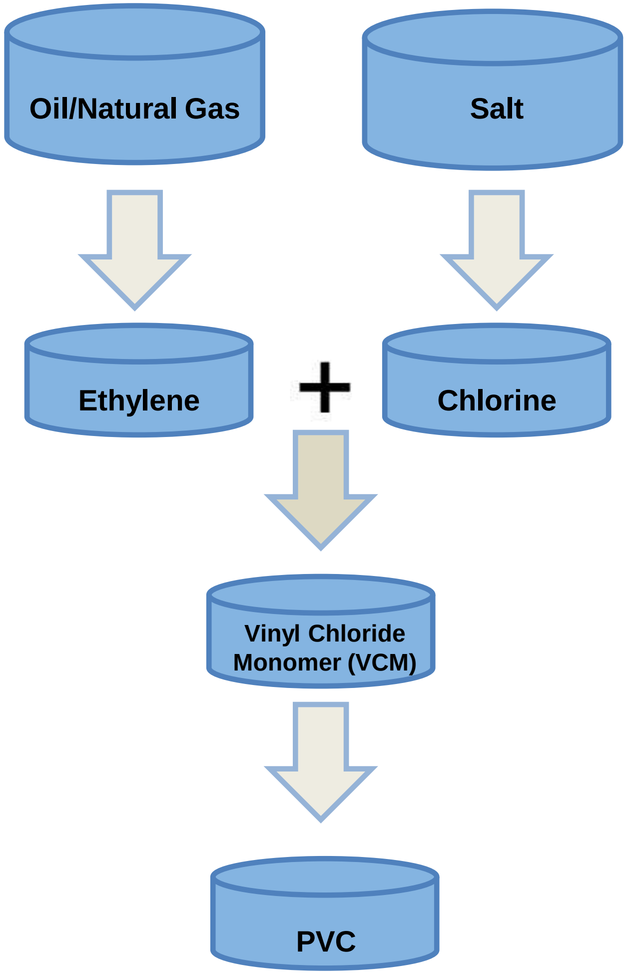
When choosing a roofing material, consider the amount of nonrenewable resources required to produce the roof material.

Production of PVC

The production of PVC begins with oil or natural gas. The oil or natural gas is cracked into ethylene.

The second ingredient, salt, is split into chlorine and sodium hydroxide, which is used in a variety of chemical processes like the making of soap and paper.

The residual chlorine is reacted with ethylene to make vinyl chloride monomer, which is then polymerized to make long chains, resulting in PVC.

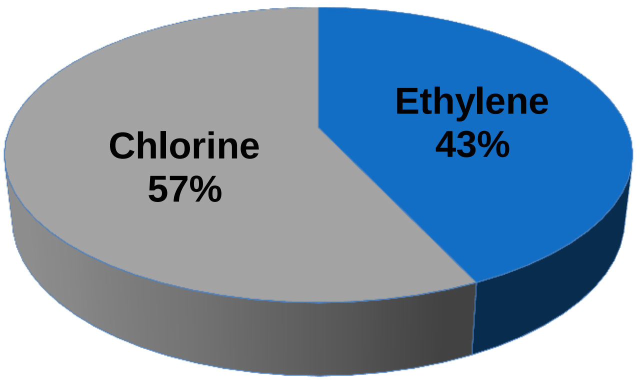


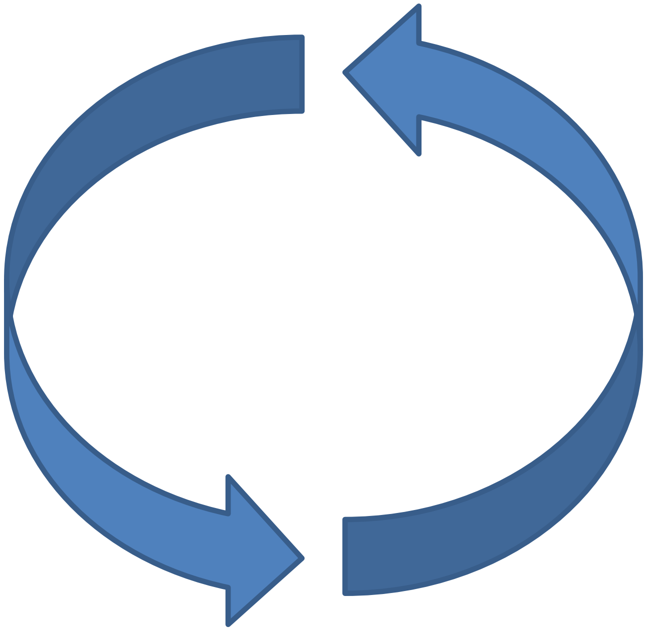
More Than 50% of the PVC Molecule Derived from Salt

More than half of the PVC molecule is derived from salt, which is essentially an inexhaustible material. Less than half of the PVC molecule comes from oil or natural gas, making it the most efficient plastic of any material used in roofing, in terms of consumption of nonrenewable resources.

Despite the huge size of the industry, PVC consumes only 6.3% of the world's oil or natural gas, and 10% of the salt.

Choosing a product that uses fewer nonrenewable resources in production is an important factor of sustainability.





Life Cycle Analysis

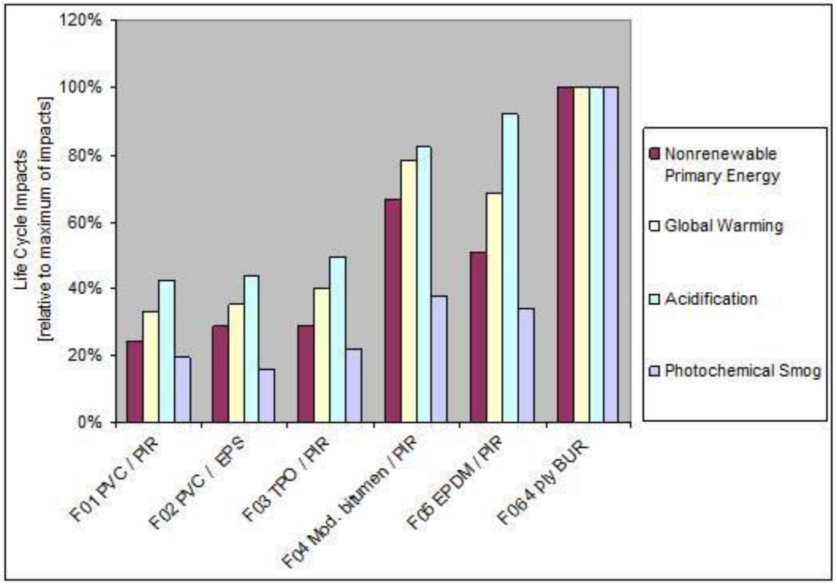
Life Cycle Analysis

This section of the course covers the topic of life cycle analysis, a methodology that is rapidly growing in importance.

A life cycle analysis provides an assessment of the environmental impacts of a product from raw material extraction, to manufacture, to distribution, use and disposal. The goal of this assessment is to evaluate the full range of environmental impacts throughout a product or system's entire life cycle.

Comparison of Life Cycle Impacts

The life cycle analysis shown on the graph compares PVC-based roof systems to TPO, EPDM, modified bitumen, and four-ply BUR roofing, all incorporating polyisocyanurate insulation. The PVC membrane system is shown with both EPS insulation and with polyiso insulation to provide a comparison of the impact of the two different insulation types.



Ecological and Economical Assessment of US Flat Roofing Systems
Carbotech AG, Basel, Switzerland, 2004

The red bars represent nonrenewable energy sources—which are primarily oil or natural gas—including energy used to manufacture the material plus the use of it as a raw material, and energy saved in using cool roof materials. The other colored bars represent global warming, acidification (acid rain) and photochemical smog, which is environmental smog from urban heat islands and other effects.

Comparison of Life Cycle Impacts

Each impact category is measured using different metrics. In order to be able to show all of them on the same figure, the highest value for each impact category is assigned a value of 100. For example, the BUR assembly imposes the greatest life environmental impacts in all four categories considered. The values for the other systems are shown as a percentage of the maximum value for each impact category.

Compared to the BUR assembly, the PVC assembly uses about 25% of the nonrenewable primary energy; it generates about 35% of the global warming impact; 40% of the acid rain impact; and 20% of the photochemical smog impact. When comparing all of these with the same insulation, PVC results in lower environmental impacts than TPOs. PVC has a much lower impact than modified bitumens, EPDMs, and BURs.

Comparison of Life Cycle Impacts

The key drivers of PVC's favorable life cycle impacts are low consumption of raw materials, cool energy savings, and longer life expectancy.

Relatively fewer raw materials are used in manufacturing when compared to modified bitumen and BUR, which are both thick, heavy materials. In addition to using less material, PVC's raw materials consume fewer nonrenewable resources, as mentioned earlier. PVC benefits from energy savings in the usage phase of the material through cooling energy savings. TPO also benefits from energy savings, which is why they have fairly close life cycle impacts—but the key difference lies in life expectancy.

End of Life Cycle Advantage

One important consideration that is not reflected on this graph is the fact that PVC can be recycled at the end of its service life.

When this study was done, the industry hadn't started recycling PVC into new membrane in the U.S., although Europe's industry started in 1993. PVC's post-consumer recycling further reduces the product's life environmental impacts relative to the other materials.

PVC roofing membranes, when evaluated on life cycle, are rated the highest in eco-efficiency when compared to competing products.

Low Relative Carbon Footprint

Carbon Offsetting

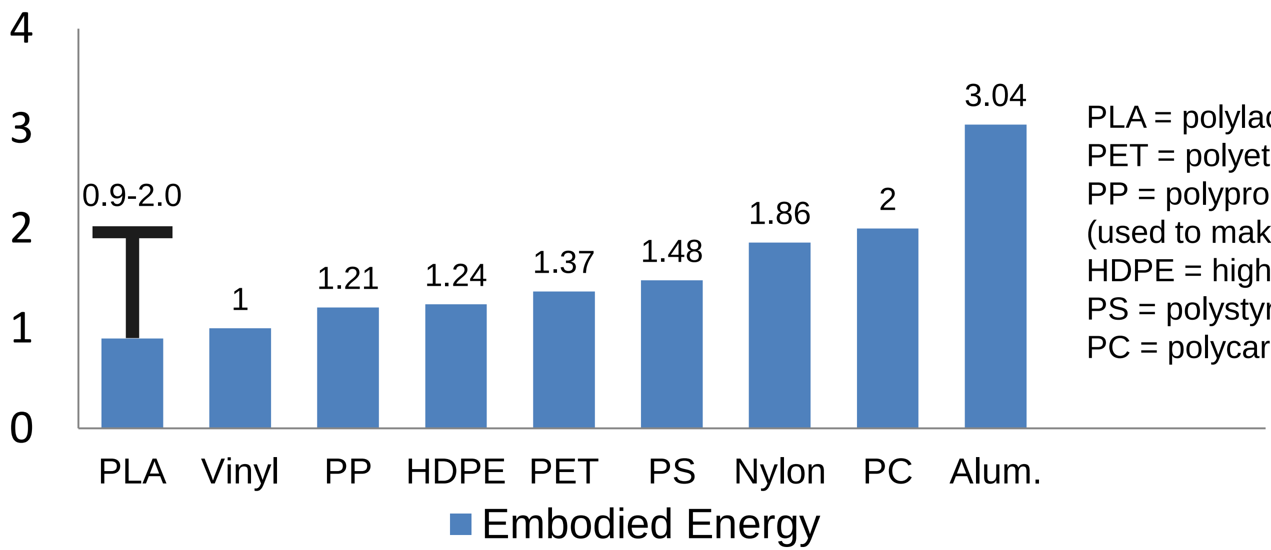
Next is a discussion of a product's carbon footprint and how it can be reduced—also known as carbon offsetting.

Producing roofing materials of any type generates carbon dioxide. A cool roof offsets the carbon from the membrane production process through cooling energy savings achieved by using highly reflective membranes.

Carbotech Inc., an environmental consulting firm, determined that on average across the U.S., the CO_2 savings associated with the energy savings from cool roofs would result in a CO_2 "payback" of the CO_2 generated during manufacturing, of less than two years. Projected over an estimated life expectancy of 25 years for some PVC roof membranes, the result is a "return" on carbon more than 15 times the carbon "invested" during membrane manufacturing.

Comparison of Embodied Energy

The graph depicts the embodied energy of different plastics. Here the term vinyl is a commonly used shorthand for PVC. This is a European study, so the units of measurement are in kilojoules per kilogram plastic or similar. Vinyl is used as the baseline. Polypropylene consumes about 21% more energy than vinyl to produce. Polyethylene is 24% greater, polyethylene teraphthalate is 37%, polystyrene is 48%, and nylon is 86%. Polycarbonate is double that of vinyl.



PLA = polylactic acid
PET = polyethylene terephthalate
PP = polypropylene
(used to make disposable water bottles)
HDPE = high-density polyethylene
PS = polystyrene
PC = polycarbonate (hard plastic)

PLA Vink, et al. "Polymer Degradation and Stability." 80 (2003), 403-419,
and GaBi 4. "Other Plastics." *Plastics Europe Ecoprofiles.* www.plasticseurope.org

Comparison of Embodied Energy

Also included in the graph is aluminum, which is viewed as an environmentally favorable material because it is very lightweight, lasts a long time, and recycles very well. The downside of aluminum is that it takes a tremendous amount of energy to produce. Because of this, when an aluminum foundry is built, a power plant is co-located at the foundry. Although aluminum does have a number of positive environmental attributes, it takes three times as much energy to produce the same amount of aluminum as it does to make vinyl.

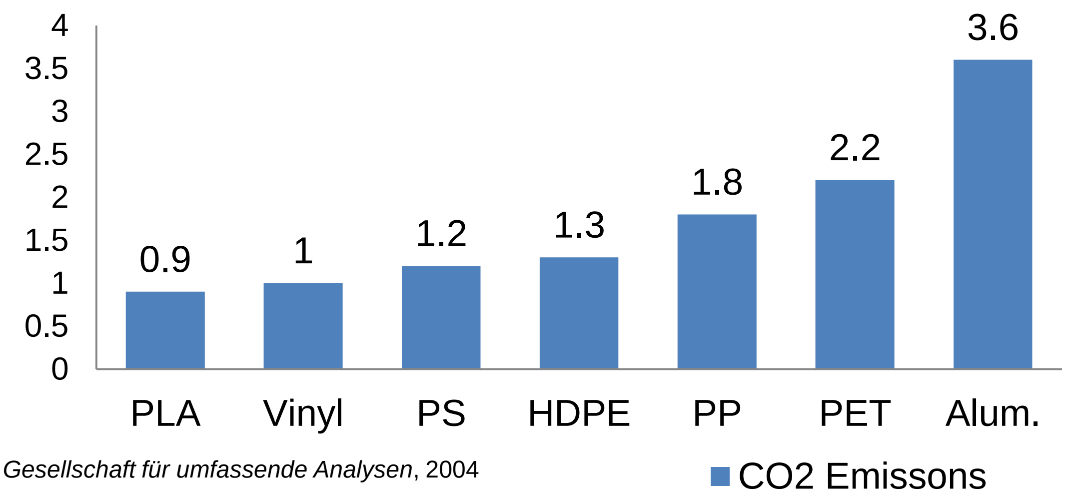
Comparison of Embodied Energy

PLA, polylactic acid, is a family of plastics that are plant-based as opposed to being made from oil or natural gas. PLAs are made from sugarcane and other plant-based materials. They're viewed as the future, because they allow the use and manufacture of plastic without depletion of oil reserves. That being said, PLAs take up to two times the amount of energy to produce as vinyl does.

An environmental advantage of PLAs is that they decompose very readily because they are a plant-based material. However, this same attribute is a disadvantage in building construction, where products are expected to last a very long time. The last thing any roofing or construction material should do is decompose in sunlight. There is considerable research and development to be done before PLAs are formulated to become a long-lasting, durable material suitable for construction.

Comparison of CO_2 Emissions

The manufacturing of any material results in CO_2 emissions, the most common greenhouse gas; energy production also results in greenhouse gas emissions. In the graph below, vinyl is again used as a baseline. Polystyrene results in about 20% more generation of greenhouse gases, specifically CO_2. The production of polyethylene results in 30% more, and 80% more from polypropylene. Polypropylene is what TPO is made of—notice that it resulta in almost double the CO_2 emissions compared to vinyl. Polyethylene is well over double. Aluminum has 3.6 times the greenhouse gas emissions of vinyl. At the left of the graph, note that polylactic acid is slightly better than vinyl in terms of CO_2 emissions.



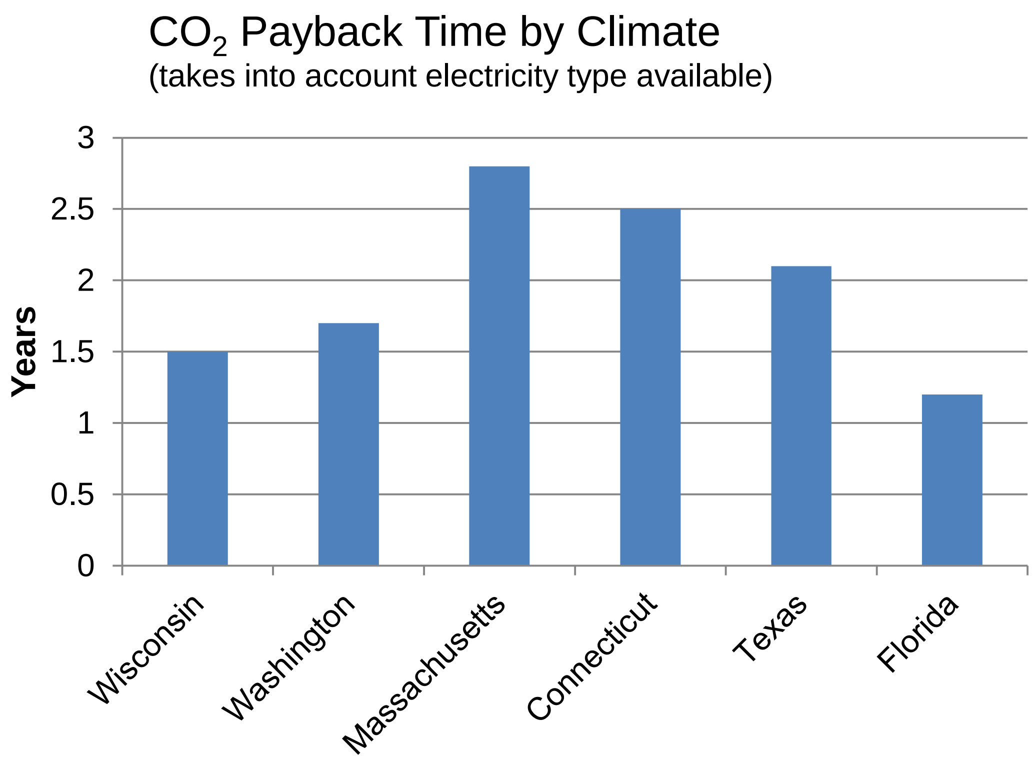
PLA = polylactic acid
PET = polyethylene terephthalate
PP = polypropylene (used to make disposable water bottles)
HDPE = high-density polyethylene
PS = polystyrene

GUA, Gesellschaft für umfassende Analysen, 2004

CO_2 Payback

The reduction in CO_2 emissions resulting from energy savings is also dependent on the local power mixture. For example, coal is generally used in the Midwest, which generates a lot of CO_2, and results in much greater impacts than a location with nuclear power generation, which produces minimal emissions.

This graph compares how long it will take, in a number of states, for the energy savings due to the use of a vinyl cool roof to compensate for the greenhouse gases generated by the production of the membrane. It's similar to a financial payback period, but based on CO_2 rather than dollars.



CO_2 Payback

In Wisconsin, the average payback is about a year-and-a-half. Washington State is approximately 1.7 years. Massachusetts is fairly high because it is colder in New England, so there is less cooling benefit. That being said, the Northeast generally has relatively clean energy sources such as hydroelectric power, which does not generate nearly as much CO_2. The overall average for the U.S. is about a 1.7-year payback.

In financial terms, a 1.7-year payback is tremendous. As a rule of thumb, a payback of less than five years is often viewed as a good financial investment.

With a conservative estimate of a 20-year roof life, there is a payback of about 12 times the CO_2 investment over the life of the roof. Assuming that the roof will last 25 years, the payback will be 15 times the CO_2 investment over the life of the roof, an excellent return on the initial use of CO_2.

A low relative carbon footprint is another important consideration for roofing sustainability.

Committed to the Environment and all Stakeholders

Responsible Care® and ISO 14001

Another consideration is the roofing manufacturer's commitment to the environment in areas such as manufacturing.

Responsible Care® and ISO 14001 are two globally recognized standards designed to help companies maintain safe and secure environments for employees, assure responsible environmental stewardship, and promote harmony in the community. Roofing manufacturers can get certified as compliant with these two important environmental and health and safety standards.

Responsible Care® is a global chemical industry performance initiative implemented in the U.S. by the American Chemistry Council. Responsible Care® companies have reduced environmental releases by 73% over the past 18 years and achieved an employee safety record that is more than four times safer than the average of the U.S. manufacturing sector as a whole.

Responsible Care® and ISO 14001

The International Organization for Standardization (ISO) is the world's largest developer and publisher of International Standards. Successful registration to the ISO 14001:2004 standard means that an organization has met specific environmental management system standards. RC 14001 combines Responsible Care with ISO 14001.

Certification by an accredited, independent third party to these standards provides a good indication of a company's commitment to sustainability.

Flame Resistance and Sustainability

How Are Fire Resistance and Sustainability Connected?

The next consideration is a roofing membrane's ability to resist the spread of fire. What does flame resistance have to do with the environment?

Fire, and resisting the spread of fire, is first and foremost a life safety issue, as it allows greater time to evacuate the building in the event of a fire.

People don't necessarily think of the sustainability implications of a fire, but building fires leave a heavy environmental footprint, generating soot and other airborne particulate matter. Additional environmental burdens are caused by the sourcing and transportation of new raw materials and finished goods to rebuild what fire has destroyed.

★ Please remember the **exam password AIRBORNE**. You will be required to enter it in order to proceed with the on-line examination.

Real World Example

PVC is one of the best-performing materials in a fire situation, as it doesn't support combustion when the flame source is removed.

The photo on this slide shows the result of a massive fire inside a Ballantyne's building in the Midwest. The fire came out through the vent stacks and other penetrations to the roof surface, but didn't propagate across the roof, which was a very important factor in not losing the entire building. After the fire was over, the charred PVC roof material was cut out, and new membrane was flashed to the old membrane without having to replace the roof.

Laboratory Testing: Video

This video shows a vertical spread of flame test. The products being tested are PVC, TPO, EPDM, and modified bitumen. Each of these materials is Class A fire rated when installed in defined roofing assemblies. The flame is put directly to the products for 15 seconds, and then extinguished. This test is used to measure if, and how far, a flame will propagate in a given amount of time.

As you can see here, only the PVC membrane stops burning, while the other three products continue to burn. This is because vinyl is inherently flame resistant.

VIDEO HERE?

UL Testing

PVC membranes clearly perform much better than most other roofing materials at resisting the propagation of flames. PVC roof membranes have UL Class A fire ratings at four times the slope of TPO membranes over polyisocyanurate insulation, the most commonly used insulation on low-slope, non-residential buildings.

Spread of flame fire tests conducted at UL confirm that EPDM and TPO membranes spread up to twice as far as PVC membranes on like surfaces and slopes. Further, EPDM and TPO membranes will continue to burn after the flame source is removed, while PVC membranes self-extinguish.

Summary

Summary

In summary, thermoplastic PVC membranes out-perform other roofing materials in some very important sustainability attributes.

Proven performance and life expectancy are always the biggest drivers of any life cycle assessment. A roof that must be replaced every 10 years, for example, results in more raw materials and energy consumed replacing the materials more frequently than a roof that lasts between 20 and 30 years.

The PVC roofing industry can recycle both pre-consumer and post-consumer material into new membrane, which is a first in the industry. PVC is currently the only low-slope roofing material with a third-party certified recycled content in the industry. Post-industrial recycling of production scraps and trimmings assures full utilization of raw materials. More importantly, the membrane can be recycled at the end of its service life.

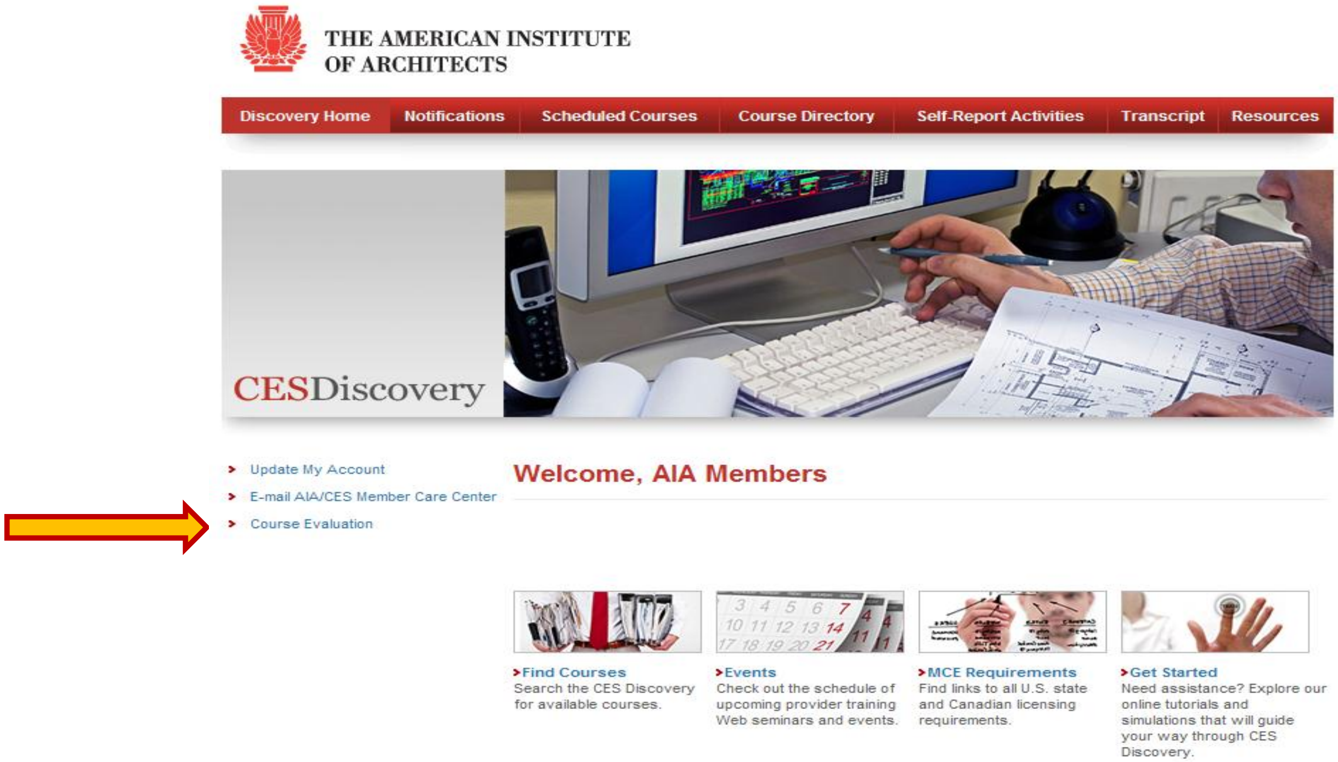
Summary

In addition, the PVC resin itself is composed of less than 50% non-renewable raw materials, PVC roof systems have the lowest life cycle impacts of any single-ply system sold in the U.S. and most are ENERGY STAR® certified for energy savings. This results in a very small carbon footprint that, when balanced against the carbon savings of cool roofs, provides a very favorable environmental profile.

Finally, PVC has the best resistance to spread of flame in the commercial roofing industry.

Course Evaluations

In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the Course Evaluation link on the left side of the page.



Conclusion

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