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Identifying Sustainability Claims by Roof Type Utilizing Standards and Certifications from Manufacturers

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One of the essential elements of the built environment is the roofing system since it provides protection form environmental and natural elements. Therefore, roofing can play a critical role in sustainability via energy efficiency for any facility. Roofing manufacturers play a crucial role in the roofing industry, especially since the majority of the roofing materials are manufactured in the United States; however, exported to the world. The performance of a roof varies according to the type of roof, and each type has its own advantages and disadvantages as it relates to sustainability. Various roofing manufacturers make claims on various sustainability factors such as (a) UV Resistance, (b) Ozone Resistance, (c) Durability, (d) Energy Efficiency, (e) Emissivity, and (f) Environment Friendly. This study documents and evaluates the basis of sustainability claims of various types of roofing materials/systems. Sustainability claims were mapped and categorized with industry standards and certifications. Text analysis was performed by organizing and evaluating unstructured text from websites, brochures, technical data sheets, and specifications from seventeen roofing manufacturers. The current study allowed a visualized map among roofing manufacturer products, standards, certifications, and testing procedures with multiple sustainability claims.

Keywords: Roofing sustainability, built environment, sustainable development, roof types

Introduction

The U.S. Buildings are ubiquitous and form an integral part of society and life (Buyle et al., 2013). More than 20% of the world's CO2 emissions are currently attributed to the construction industry. Moreover, over 30% of the world's CO2 emissions come from the operation and maintenance of buildings (Faber, 2020). The construction industry practices do not positively impact the environment in terms of using the material, construction, and building operations (Ding, 2008). Building performance and minimizing its effect on the natural environment have become an important topic of interest as part of sustainable growth (Sev, 2009). On the other hand, demand for an ecologically sustainable built environment is increasing worldwide (Zhang et al., 2014).

The term sustainable development covers a broad range of definitions. However, generally it is defined as attitudes and judgment to help ensure long-term ecological, social, and economic growth in society (Ding, 2008). It is also defined as the environment's ability to sustain the present needs

without compromising the ability of future generations to meet their goals and ambitions. Given the built environment's impact on sustainability, it is critical to design sustainability solutions from the early project life phases (Mésároš et al., 2021).

One of the essential elements of the built environment is the roofing system since it provides protection from environmental and natural elements. Therefore, roofing can play a critical role in sustainability via energy efficiency for any facility. However, roofing is generally overlooked in the design phase since it does not form the key aesthetical element of the building façade for commercial sectors. The roofing industry comprises manufacturers, distributors, and contractors. Roofing manufacturers play a critical role in the roofing industry, especially since most of the roofing materials are manufactured in the United States; however, they are exported worldwide. The common types of roofing systems used in the roofing industry today include single-ply systems such as Thermoplastic Polyolefin (TPO), Polyvinyl Chloride (PVC), Ethylene Propylene Diene Terpolymer (EPDM). Multi- ply systems, also known as bituminous roofing systems (BR), such as BUR (Built-up Roof) and Modified Bitumen (MB), are also beingused in the roofing industry.

The performance of a roof varies according to the type of roof, and each type has its advantages and disadvantages as it relates to sustainability (Abuseif & Gou, 2018). Many claims have been made by various roofing manufacturers on their specific roofing systems as it relates to energy efficiency and sustainable performance. The previous studies conducted in the roofing industry are focused on the energy performance of built environment systems primarily during the operational phase of the facility (Taylor, 2019). Studies have also investigated energy efficiency, life cycle assessment, r-value, u-value, albedo, and reflectance and their effects on Urban Heat Island (O'Malley et al., 2014; Shickman & Rogers, 2019; Shimoda et al., 2004; Susca & Pomponi, 2020).

The sustainability claims commonly used by roofing manufacturers are (a) UV Resistance, (b) Ozone Resistance, (c) Durability, (d) Energy Efficiency, (e) Emissivity, and (f) Environment Friendly. UV resistance of a roof refers to the material's capacity to avoid UV radiation deterioration induced by UV absorption (Radius, 2021). Ozone Resistance in roofing refers to the ability of a membrane to withstand the effects of exposure to ozone (Rubber, 2022). Durability refers to weathering, fire, crack, and heat resistance, and waterproofing. Energy efficiency refers to the degree of efficiency that a roof plays in the amount of solar radiation absorbed by roofs in hot weather and the amount of heat lost through roofs in cold weather (Abuseif & Gou, 2018). Emissivity is described as the ability of roofing products to release absorbed heat (Star, 2022). A common term used as a factor by roofing manufacturers is "environment friendly." Based on the literature, it is closely defined as eco-friendly and environmentally safe (Siplast, 2022).

However, there are no studies documenting the basis of the product claims for various manufacturers and their products for sustainability. The basis of the claims needs to be verified against standards and industry certifications as roofs play a crucial role in various early design decisions, life cycle costing, and analysis for facilities as part of sustainable approaches (Khanum, et al., 2021; Rosasco & Perini, 2019; Cubi et. al, 2015).

Manufacturers are using a variety of organizations and third-party certifications for sustainability claims, such as:

- Cool Roof Rating Council (CRRC) program certifying roofing products on solar reflectance and thermal emittance (CRRC, 2022)
- Energy Star labeling and certifying roofing products qualified for saving the measurable amount of energy(Star, 2022)
- California Title 24 is a standard used to guarantee that both new and existing buildings are

energyefficient and maintain both indoor and outdoor environmental quality (Title24Express, 2021)

- ISO is the international standard for a quality management system.
- Leadership in Energy and Environmental Design (LEED) is a building rating system used to certify buildings with environmental and energy conservation goals.
- FM Standard evaluates single-ply, polymer-modified bitumen sheet, BUR (built-up roofing), and liquid-applied roof assemblies for their performance regarding fire from above and below the structural deck (WesternColloid, 2022).
- American Society for Testing and Material (ASTM) rates or confirm product quality (durability, emissivity, solar reflectance, and UV resistance). The various ASTM standards used by roofing manufacturers are shown in *Table 1*.

Table 1

ASTM Standard Types & Sustainability Factors

Standards	UV	OR	D	HEFP	HSR	E	EF
ASTM D4601	×	×	✓	×	×	×	×
ASTM D2178	×	×	✓	×	×	×	×
ASTM D 622	×	×	✓	×	×	×	×
ASTM D 6164	×	×	✓	×	×	×	×
ASTM D570	×	×	×	×	×	×	×
ASTM G154	✓	×	✓	×	×	×	×
ASTM C1549	×	×	×	×	✓	×	×
ASTM C1371	×	××		×	×	✓	×
ASTM D4434	×	×	✓	×	×	××	
ASTM D4637	×	×	✓	×	×	××	
ASTM D6878	×	×	✓	×	×	××	

UV - UV Resistance; OR – Ozone Resistance; D – Durability; HEFP – High Energy Efficiency Performance; HSR – High Solar Reflectance; E – Emissivity; EF – Environmentally Friendly

This study documents and evaluates the basis of sustainability claims of various types of roofing materials/systems. It investigates the logical path such as standards and certifications used for any of the claims. The objectives of this study are to 1) identify the types of sustainability claims used by various roofing manufacturers, 2) map and categorize the claims with industry standards and certifications, and 3) collect and categorize the claims against deficiencies.

Methods

The goal of the study was to document and evaluate sustainability claims regarding roofing products from seventeen (17) major manufacturers identified in the United States. The methodology for this study is shown in *Figure 1* below.

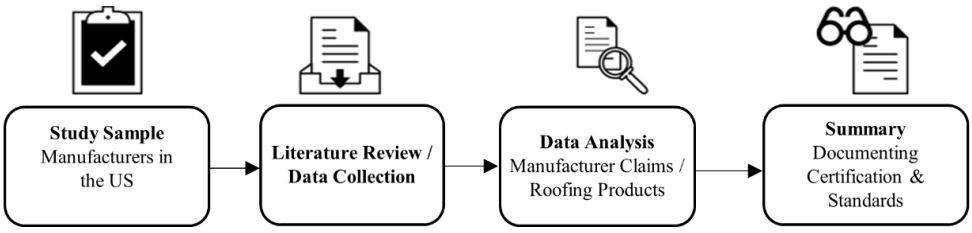

Figure 1. Study overview

A steering committee comprised of four major manufacturers in the roofing industry was created to guide the study framework, sustainability factors, and validation. The seventeen (17) manufacturers represented most of the roofing manufacturers in the roofing industry and holds 70 to 80 percent of the US roofing market. Text analysis was performed by organizing and evaluating unstructured text. Text analysis consisted of identifying key sustainability terms across each manufacturer's website, brochures, technical data sheets, and specifications. The claims from various sources regarding sustainability were identified fordifferent roofing products. A detailed literature review for various industry standards and certifications was conducted prior to mapping and categorizing various claims for each identified standard. For example, various claims relevant to sustainability for PVC roofing product from each manufacturer was further categorized into the following sustainability factors (a) UV Resistance, (b) Ozone Resistance, (c) Durability, (d) Energy Efficiency, (e) Emissivity, and (f) Environment Friendly.

Analysis and Discussion

Study sample

Table 2 shows the number of manufacturers that produce the different types of roofing systems. Nine (9) out of seventeen (53%) manufacturers made TPO, seven (7) out of seventeen (41%) manufacturers produced PVC, seven (7) manufacturers out of seventeen (41%) produced EPDM, and only four (4) manufacturers out of seventeen(24%) produced BR.

Table 2
Study Sample – Roof Types by Manufacturers

Manufacturers*	TPO	PVC	EPDM	BR
A*	✓	×	✓	×
B*	✓	✓	✓	×
C*	✓	✓	✓	×
D*	✓	×	✓	×
E*	×	×	×	✓
F*	×	×	×	✓
G*	×	✓	×	✓
H*	×	×	×	×
I*	×	×	×	×
J*	×	✓	×	×
K*	×	×	×	×
L*	×	✓	×	×
M*	✓	×	×	×
N*	✓	✓	×	✓
O*	✓	×	✓	×
P*	✓	✓	✓	×
Q*	✓	×	✓	×

Manufacturers Claims and Roofing Products

Figure 2 shows the various claims relevant to sustainability for all roofing products from each manufacturer categorized into the sustainability factors identified for this study. 70% of the manufacturers claimed that their roofing products exhibit UV Resistance, 35% of the manufacturers

claimed that their roofing products exhibit Ozone Resistance, 100% of the manufacturers claimed that their roofing products are Durable, 52% of the manufacturers claimed that their roofing products have high Energy Efficiency Performance, 82% of the manufacturers claimed that their roofing products have high Solar Reflectance and 26% manufacturers claimed that their roofing products have good Emissivity, and 47% manufacturers claimed that their roofing products are Environment-friendly. Based on the data collection, TPO, PVC and EPDM roofing products claimed all the properties related to sustainable factors, namely, UV Resistance, Ozone Resistance, Durability, High Energy Efficiency Performance, High Solar Reflectance, Emissivity, and Environmental-friendly. Bituminous only claimed properties related to UV Resistance, Durability, High Energy Efficiency Performance, and High Solar Reflectance.

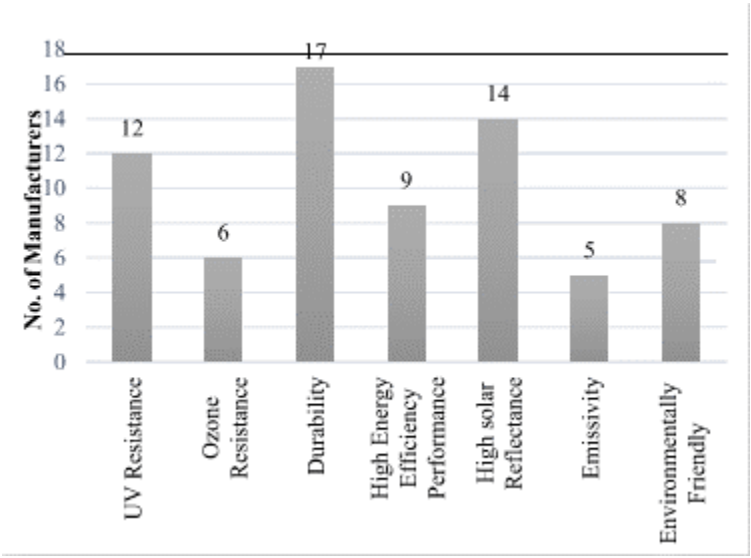

Figure 2. Sustainability Claims by Roofing Manufacturers

Figure 3 shows the various claims relevant to sustainability for TPO, PVC, BR, and EPDM roofing systems from each manufacturer categorized into the sustainability factors identified for this study. 78% of the TPO Roofing manufacturers claimed their products exhibit durability and high energy efficiency performance. 67% of the TPO roofing manufacturers claimed their products exhibit UV resistance and high solar reflectance. 55% of the TPO roofing manufacturers claimed their products show ozone resistance and are environmental-friendly. 33% of TPO roofing manufacturers claimed their products exhibit emissivity as one of the key properties. Similar claims for PVC, BR, and EPDM products are also shown. Interestingly, only one out of seven made any claims about ozone resistance andemissivity for PVC products, whereas no manufacturer for BR claimed about ozone resistance, environmental friendly and emissivity. For EPDM, the majority of the manufacturers showed benefits around durability and ozone factors.

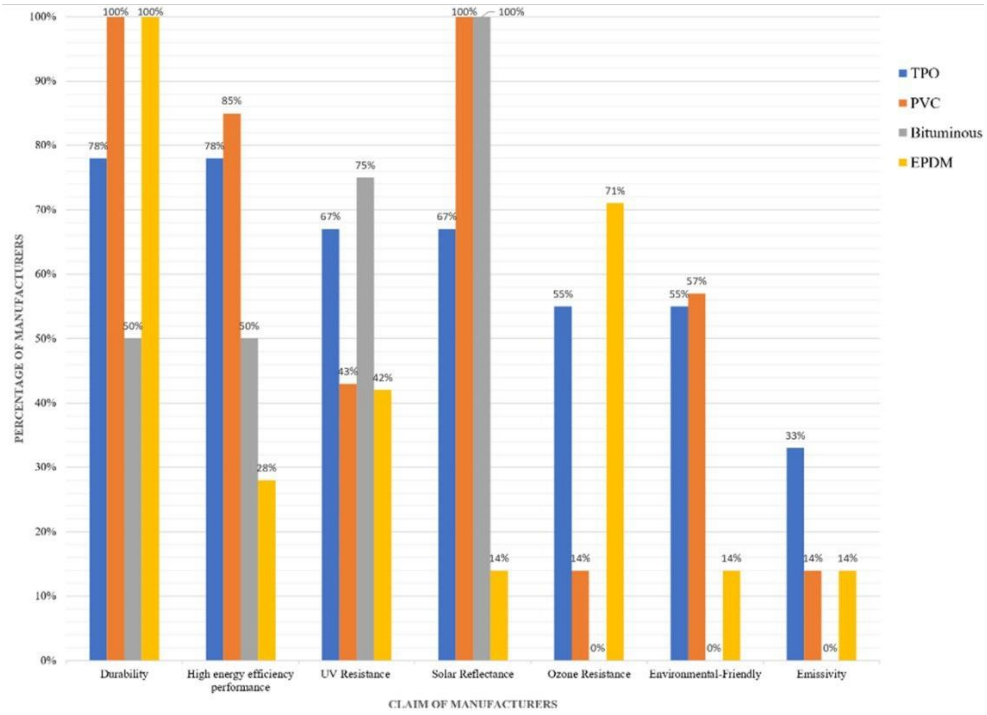

Figure 3. Roofing Manufacturer's Sustainability Claims by Roof Type

Further, sustainability claims of various roofing products were mapped to industry standards and certifications, asshown in Table 3. Manufacturers adopted certifications such as CRRC, Energy Star, California Title 24, LEED, and ASTM to support their claims for various roofing products. There is no documentation that shows any industry standards, certifications, or testing used as a basis for Ozone Resistance for various roofing products. ASTM G154 and LEED credits are the only standards and prescriptive requirements that require environmentally friendly and UV resistance approaches for various roofing products. The claim by manufacturers for high energy efficiency performance is supported by standards namely, Energy Star and California Title 24. The claim of highsolar reflectance is supported by means namely, CRRC, Energy Star, California Title 24, FM Standard 4470, and ASTM C1549. It is evident that only three (3) standards have been used by manufacturers to support the claimof "high energy efficiency performance," six (6) standards to validate the claim of "high solar reflectance," and three (3) standards for "emissivity." TPO used five different standards, PVC used seven standards, and BR used six standards. However, EPDM manufacturers only used ASTM C1549, ASTM C1371, and ASTM D4637, which primarily emphasized solar reflectance, emissivity, and tensile strength.

Table 3

Sustainability Factors and Standards/Certifications by Roofing Type

Standards	TPO	PVC	EPDM	BR	Sustainability Factors
CRRC	✓	✓	×	×	Solar Reflectance, Emissivity
Energy Star	✓	✓	×	×	Energy Efficiency, Solar Reflectance And Emissivity
California Title 24	✓	✓	×	×	Energy Efficiency, Solar Reflectance And Emissivity

LEED	✓	✓	×	×	Energy Efficiency, Emissivity, Environmental Friendly
ISO 9001:2015	×	×	×	✓	Effective Application of The Roofing System
ASTM D4601	×	×	×	✓	Crack Resistant
ASTM D2178	×	×	×	✓	Waterproofing
FM Std. 4470	×	×	×	✓	Water-leakage, Corrosion of Metal Parts
ASTM D 622	×	×	×	✓	Waterproofing
ASTM D 6164	×	×	×	✓	Waterproofing
ASTM D570	×	✓	×	×	Water Absorption of Plastic
ASTM G154	×	✓	×	×	UV Resistance Test
ASTM C1549	×	×	✓	×	Solar Reflectance
ASTM C1371	×	×	✓	×	Emissivity
ASTM D4434	×	✓	×	×	Fire Resistance, Wind Uplift Resistance
ASTM D4637	×	×	✓	×	Tensile Strength
ASTM D6878	✓	×	×	×	Weather Exposure (Only For TPO)

Conclusion

The study documented and evaluated the basis of sustainability claims of various types of roofing materials/systems. It investigated the logical path such as standards and certifications used for any of the claims by roofing manufacturers for various roofing products such as TPO, PVC, EPDM and BR. Specifically, this study identified the types of sustainability claims used by various roofing manufacturers and mapped/categorized the claims with industry standards and certifications.

The current study allowed a visualized map among roofing manufacturer products, standards, certifications and testing procedures with multiple sustainability claims. The sustainability claims were documented primarily based on external accreditation and standards and not supported by peer-reviewed published studies. The degree ofimpact on various sustainability factors, such as reflectance, emissivity, etc., was also not documented onthe manufacturer's website, brochures, technical data sheets, and specifications. For example, high solar reflectance was claimed by one (1) EPDM manufacturer, six (6) TPO manufacturers, seven (7) PVC manufacturers, and four. (4) BR manufacturers out of a total of seventeen (17) manufacturers. However, it lacked any documentation on numerical validation or support from peer-revied publications. A few manufacturer claims werenot supported by any certification, standards, or published studies.

For future study, the different components of the roofing need to be verified as a system against sustainability claims. Manufacturers play a crucial role in roofing sustainability thus the role of roofing manufacturers in sustainability should be studied in addition of their perspective towards sustainability. And this study paves a way to study sustainability claims for other sectors in the construction industry. Also, the degree of impact needs to be documented for user applicability against peer-reviewed research. A systematic literature review to document various sustainability claims to provide a degree of impact by various roof types is needed. As for limitations, the study only focused on the sustainability claims from the roofing industry. Roofing warranties lie between five years to lifetime, and the roofing replacement interval is not considered for this research. This study paves the way to study sustainability claims for other sectors in the construction industry.

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