

Greenwashing in Wood Substitute Products: The Case of PVC Window Frames

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Wood is a renewable material, and advancements in machinery have made it possible to produce wood-based products in large quantities. This has led to environmental problems, which in turn have increased consumers' environmental concern. This concern has caused consumers to prefer environmental-friendly products. Alongside green products and green marketing, greenwashing practices, which are not actually green but exploit consumer sensitivity, have also become widespread. These deceptive claims confuse consumers and provide an unfair competitive advantage against genuinely environmentally friendly products. Polyvinyl chloride (PVC) windows, which can be used as a substitute for wood windows, were chosen as a research focus, and the greenwashing practices of enterprises manufacturing PVC window were investigated. The research was conducted using deductive content analysis. The corporate websites of the enterprises were examined in terms of greenwashing. Artificial intelligence was used, but identified greenwashing types were checked by the researcher. The study found that PVC window manufacturers most frequently resorted to greenwashing involving no proof, vagueness, and hidden trade-off approaches. Greenwashing types were also examined by topics, revealing that "general environmental benefits" is the most common type.

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INTRODUCTION

Wood is a renewable and easy-to-process material that does not contain harmful substances (Çolak *et al.* 2024). It is primarily composed of cellulose, lignin, and other organic substances (Asif *et al.* 2002). Wood-based products sequester CO₂ and require a low amount of fossil energy for their production. At the end of their useful life, they can be recovered as raw materials, used in the production of other wood-based products, or disposed of by converting them into energy (Çolak *et al.* 2024). Wood-based products are generally considered to have lower environmental impacts compared to substitute products made from non-renewable raw materials (Sokka *et al.* 2015).

The Industrial Revolution brought about significant changes in the use of wood. The development of steam power and later electric machinery made it possible for businesses to be much more efficient and for mass production to be carried out on a much larger scale. For example, wood was widely used as a basic material in the production of railway sleepers. The rise of mass production and urbanization dramatically increased the demand for wood. This increase in demand also brought about widespread deforestation

(Forehand 2024). World forest area decreased by 3.1% between 1990 and 2020. This deforestation has caused negative changes in the environment. Deforestation reduces carbon storage in woody biomass and increases atmospheric CO₂, thereby contributing to climate change (Gu 2023). Therefore, in today's world, where climate change and environmental disasters are occurring, the use of wood as a sustainable resource has gained importance. When obtained from sustainable forestry practices, wood has a lower environmental impact compared to materials with high energy density (Forehand 2024).

The concept of environmental awareness, which emerged in the 1960s (Chen and Hung 2016), has created a trend in consumer demand and behaviour towards using and purchasing green products (Chen *et al.* 2011; Strizhakova and Coulter 2013). Many businesses worldwide have begun adopting green strategies because of reasons such as social responsibility, increasing their competitiveness, customer and government pressure, and stakeholder expectations (Hasan *et al.* 2019).

With increasing environmental awareness, consumers are becoming increasingly concerned about the environmental impact of the products they buy. This concern is leading consumers to monitor the environmental impact of businesses more closely. This, in turn, encourages enterprises to position their products and services as “green” or “greener” compared to their competitors (Spaniol *et al.* 2024). Nemes *et al.* (2022) state that greenwashing as a concept has been studied by numerous academic disciplines, so it is not surprising that there is no single definition of the concept. They also state that as greenwashing becomes increasingly important, definitions will continue to evolve and change.

Spaniol *et al.* (2024) analyse 79 academic definitions of greenwashing and propose an integrated definition. They state that six basic conditions must be met simultaneously for greenwashing to be diagnosed. These conditions are: “a claim on environmental performance; by a private sector organization; marketing a product or a service; which cannot be substantiated; with deceptive intent; done to establish a competitive advantage”. TerraChoice defines greenwashing as “the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service” (TerraChoice Environmental Marketing Inc. 2009).

Enterprises adapt differently to this new situation. While some enterprises genuinely produce green products and communicate this to their stakeholders through various channels, others mislead their stakeholders through communication channels despite their negative environmental impacts (Delmas and Burbano 2011). Delmas and Burbano (2011) classify the factors that drive businesses to behave in this way as non-market external factors, non-market internal factors, organizational factors, and individual psychological factors. Another classification is based on the environmental impact of businesses. According to this classification, businesses are divided into four classes: i) Vocal green, companies with high genuine environmental performance that is communicated publicly; ii) Silent green, companies with high environmental performance that is not shared with the public; iii) Greenwashing, companies with poor environmental performance that communicate positively/exaggeratedly about the environment; and iv) Silent brown, companies with low environmental performance which is not communicated publicly (Delmas and Burbano 2011). Another classification is “firm-level greenwashing” and “product-level greenwashing” (TerraChoice Environmental Marketing Inc. 2007).

Greenwashing is not a single type of practice. It is a phenomenon with different forms. The TerraChoice (2009) report categorizes greenwashing types into seven groups. These can be summarized as: i) Hidden trade-off: Highlighting only a single positive

environmental feature of a product while ignoring or concealing other significant environmental impacts; ii) No proof: The absence of independent certifications, technical reports, or quantitative data to support the claimed environmental assertion; iii) Vagueness: The use of vague, unstandardized terms such as eco-friendly, eco, green, and natural; iv) Irrelevance: Presenting a legally required or environmentally insignificant feature as a significant environmental advantage; v) Lesser of two evils: Marketing a relatively “lesser” option as “green” within a generally environmentally problematic product category (fossil fuel vehicles, disposable products, *etc.*); vi) Fibbing: This involves making untrue, outright false statements; mentioning a non-existent certification or using a fake eco-label are typical examples of this offense; and vii) Worshiping false labels: Giving the impression of independent approval or accreditation. This involves the use of logos and symbols that are presented as official but are in reality created by the company. It creates the perception of “official approval” in the consumer's mind (TerraChoice Environmental Marketing Inc. 2009).

Baum's (2012) content analysis of magazine advertisements found that Clorox's Green Works product line exemplified hidden trade-off greenwashing because, despite emphasizing plant-based ingredients, it overlooked the use of petroleum-based plastic packaging. The same study classified Dow Chemical's claim that it had reduced energy intensity by 22% as no proof greenwashing, since no supporting evidence was provided, and it treated expressions such as “environmentally friendly” and “eco-conscious” as vagueness greenwashing because they lacked specific and measurable explanations. Baum (2012) also classified Volvo's Drive SUV advertisement as lesser of two evils greenwashing, on the grounds that, although it emphasized lower fuel consumption within its own product category, it obscured the broader environmental impacts associated with the SUV category as a whole. de Freitas Netto *et al.* (2020) identify as a typical example of worshiping false labels greenwashing a paper towel product whose packaging featured a certification-like visual element and the phrase “fights global warming,” thereby implying environmental superiority. The same authors describe the claim “CFC-free” as a typical example of irrelevance greenwashing, since chlorofluorocarbons had already been prohibited by regulation and the claim therefore did not indicate any meaningful environmental advantage for consumers. Siano *et al.* (2017), in turn, cite the Volkswagen Dieseldiesel case as an example of fibbing greenwashing, involving false environmental claims. In addition, Volkswagen was subjected to severe criminal penalties in the United States for engaging in corporate deception by making misleading environmental claims that its “clean diesel” vehicles complied with legal emissions standards while manipulating emissions tests through fraudulent software (United States v. Volkswagen AG, 2017).

Boncinelli *et al.* (2023) report that greenwashing leads to several problems, including influencing and confusing consumer purchasing behaviour. They attribute this to consumers' inability to distinguish between truly environmental-friendly products and those that have undergone greenwashing. They also report that companies implementing green marketing strategies that are not actually employing green practices gain an unfair competitive advantage, while genuinely nature-friendly companies may experience a decline in consumer trust due to greenwashing companies, potentially leading to the loss of sales for their more sustainable products. Truly ecologically safe companies often operate at higher costs (Çetiner 2025).

Lyon and Montgomery (2015) report that lax and vague government regulations have paved the way for greenwashing, which in turn reduces the likelihood of being penalized for it. A weak regulatory environment allows firms to manipulate consumer and

investor demand for green products, services, and companies. Delmes and Burbano (2011) state that the difficulty in measuring and assessing the degree of greenwashing at the firm level is an obstacle to enacting legislation. However, there are some attempts to tackle greenwashing. A draft law by the European Union (EU) requiring companies to support their climate-friendly claims with evidence. This “green claims verification initiative” encountered stalled negotiations after the EU stated that it would place an excessive burden on small companies (Abnett 2025). The EU aims to empower consumers for the green transition. To this end, Directive (EU) 2024/825 (European Parliament and Council of the European Union 2024) was issued to increase protection against misleading commercial practices (especially greenwashing, non-transparent sustainability labels, *etc.*) and to enable consumers to make more informed purchasing decisions. Another example of such efforts is the Digital Markets, Competition and Consumers Act (DMCC Act 2024). The “unfair commercial practices” provisions of the DMCC Act 2024 contain consumer protection rules that prohibit misleading or generally unfair behaviour by businesses in their commercial practices towards consumers (Competition and Markets Authority 2025).

In Türkiye, Article 61/3 of the Law on Consumer Protection prohibits misleading commercial advertising. Article 62/1 specifically defines and prohibits practices that are deceptive in nature as unfair commercial practices (Official Gazette 2013). Another legal regulation, Article 17 of the Regulation on Commercial Advertising and Unfair Commercial Practices, concerns advertisements related to the environment and prohibits misleading advertisements concerning the environment (Official Gazette 2015). A guide published by the Ministry of Trade, Guide on Advertisements Containing Statements Regarding the Environment-2023, explains with examples how environmental statements in commercial advertisements and commercial practices should be presented (Ministry of Trade 2023).

A green product is a product designed and manufactured to minimize the environmental impact of its production, distribution, and consumption processes. For a product to be considered green, it must: i) be easily reusable; ii) be produced from natural and/or renewable resources; iii) contain recycled content; iv) be easily recyclable; v) be biodegradable; vi) be energy efficient; and vii) have a durable structure with low maintenance requirements (Yang 2017). According to another definition, green products are products that have less impact on the environment and are less harmful to human health compared to their alternatives (Shrum *et al.* 1995). According to these definitions, wood or wood-based materials have a lower environmental impact (positive environmental impact if obtained from sustainable forestry practices) compared to alternative materials such as plastic and metal, are a renewable resource, and are harmless to human health. In other words, they meet the definition of a green product.

Wood has traditionally been used in window frame production due to its ease of production and availability. It has the lowest thermal conductivity among materials suitable for window frames (Asif *et al.* 2002). Asif *et al.* (2002) compared the life cycles of materials used in window construction. Their study compared window frames made of wood, PVC, and aluminum with dimensions of 1.2 m × 1.2 m. A PVC window of these dimensions required 2990 MJ of energy, while a wood window frame of the same dimensions required 995 MJ of energy. Accordingly, the amount of energy used to produce a PVC window frame is three times that required for the production of a wood window frame. The same study also reported that PVC window production is a process that uses 70 MJ of energy per kilogram, and that this process produces many toxic pollutants,

decomposes very slowly into its components, and contains environmentally hazardous substances that can slowly seep into groundwater (Asif *et al.* 2002).

Wood windows require maintenance every 5 years, making them more expensive to maintain in comparison to their competitors. However, PVC window frames also need maintenance and should be cleaned with an alkaline detergent every 6 months to maintain their appearance. A wood frame can last for over 40 years, while a PVC frame has a service life of 25 years (Asif *et al.* 2002).

Life cycle assessment (LCA) provides a suitable framework for comparing alternative window-frame materials because it evaluates environmental impacts across the product life cycle and highlights key methodological issues related to production, use phase, service life, and end-of-life scenarios. According to the review by Souviron *et al.* (2019), wood-based window frames often show lower embodied environmental burdens than PVC and some other frame materials, particularly during the production stage. Some Western European studies cited in the review report that plastic frames have a markedly higher environmental footprint than timber, consuming about three times more coal and oil and emitting about seven times more greenhouse gases during raw-material production. The review further notes that two cradle-to-gate LCA studies identified wood as the frame material with the lowest embodied energy, global warming potential, and acidification potential among the compared options, even without accounting for the carbon storage potential of wood. This pattern is consistent with the cradle-to-gate study of Sinha and Kutnar (2012), who reported carbon footprints of 130 kg CO_{2e} for the wood window frame, 258 kg CO_{2e} for the PVC window frame, and 486 kg CO_{2e} for the aluminum window. Accordingly, the carbon footprints of aluminum and PVC window frames are approximately 2 and 4 times higher than those of wood, respectively.

When used as a building material, wood consumes 44% to 85% less energy than steel and 70% to 87% less energy than concrete (Mørkved and Opdal 1990). Fossdal (1995) compared the energy and emissions used in the construction of two detached houses, one using wood and the other using lightweight aggregate concrete block walls. As a result, the house built using wood used 41% to 46% less energy per m². Jönsson *et al.* (1995) compared solid pine, linoleum, and vinyl flooring materials. The comparison was made per m², and the extraction, manufacturing, and waste processing parts of the raw material were considered as parts of the life cycle. As a result, solid pine flooring consumed 49% to 54% less electricity and 78% to 80% fewer fossil fuels than the other two materials. Solid pine flooring did not generate any waste. In contrast, both linoleum and vinyl generate a certain amount of harmful waste. Engelbertsson (1997) examined the use of laminated timber beams *versus* steel beams in roof construction. The comparison was made per square meter. The product life cycle included raw material extraction, manufacturing, work in construction, and transportation for waste disposal. As a result, it was concluded that steel beams have 2 to 8 times more negative environmental impact than laminated timber beams. In another study, Kočí (2019) compared the environmental impacts of transport pallets made of wood and plastic. He reported that the environmental impact is less when wood pallets are burned at the end of their life cycle, especially for energy recovery (Kočí 2019).

The pressure on companies to strengthen their environmental image has come not only from growing public awareness but also from competing industries. Sectors such as plastics, steel, and cement have positioned their products as eco-friendly alternatives by highlighting the negative impacts of wood use through environmentally themed rhetoric (Wagner and Hansen 2002). For example, in 1997, the steel industry launched a 5-year, \$100 million campaign to promote steel, aiming to capture 25% of the housing market by

2002. In contrast, 85 forestry businesses ran a 3-year, \$45 million program aimed at promoting wood (Wagner and Hansen 2002).

Environmental claims associated with commercial plastic products have been identified in the academic literature. Nazareth *et al.* (2019) experimentally assessed plastic products marketed in Canada, the United States, and Brazil with claims such as “biodegradable” and “100% degradable” and found no evidence of degradation after 180 days in seawater for four of the six samples studied. This finding was interpreted as evidence of greenwashing practices in commercial plastic products. Viera *et al.* (2020) addressed a case study involving plastic straws marketed under false biodegradability claims, indicating that some products presented as biodegradable were not actually biodegradable as claimed. In a similar vein, Moreno *et al.* (2023) quantitatively estimated the incidence of greenwashing among single-use utensils sold in the Brazilian market by inspecting biodegradability-related labels, claims, seals, composition, technical standards, and prices; the authors concluded that none of the analyzed products claiming biodegradability were, in fact, biodegradable. Taken together, these studies show that misleading or insufficiently substantiated environmental claims in commercial plastic products have already been examined in the academic literature, thereby providing a relevant basis for extending this discussion to other product categories.

There has been a lack of studies directly examining the types of greenwashing employed by firms that use, as a substitute for an environmentally friendly material, an alternative with greater negative environmental impacts. Such studies become particularly important when substitute materials are marketed through claims of environmental superiority. The primary objectives of this study are: (i) to identify the types of greenwashing employed by firms that use PVC, as a substitute for wood, despite its more pronounced negative environmental impacts; (ii) to reveal the environmental issues emphasized according to the type of greenwashing used; and (iii) to test the hypothesis that H_a : Different types of greenwashing are significantly associated with one another. A secondary objective is to draw attention to the negative substitution effect of choosing PVC windows over wooden windows.

RESEARCH APPROACH

Focus

Enterprises producing PVC windows were selected as the research focus. PVC is one of the building materials used as a substitute for wood in window frame production. In Türkiye, wood window production decreased from approximately 1.6 million units in 2005 to approximately 0.6 million units in 2024. In contrast, PVC window frame production increased from approximately 5.8 million to 114 million in the same years (TUIK 2025). Figure 1 shows the decrease in wood window frame production and the increase in PVC window frame production over the years, respectively. About 113 enterprises in Türkiye produce plastic window systems (PAGEV 2025).

In Türkiye, PVC windows have largely replaced wood and aluminum, with a preference rate of 85%. According to 2022 data, the preference rate for PVC windows was 90%. Dilik (2020) reports that wood has traditionally been widely used in window production because of its superior physical and mechanical properties and its status as a renewable resource. However, in recent years, the depletion of forest resources, price increases, and negative aspects in quality and performance characteristics have led to a

decrease in the use of wood materials in the face of PVC and aluminium materials. However, he notes that the demand for PVC and aluminium windows has slowed down, while the demand for wood and composite materials is on an upward trend (Dilik 2020).

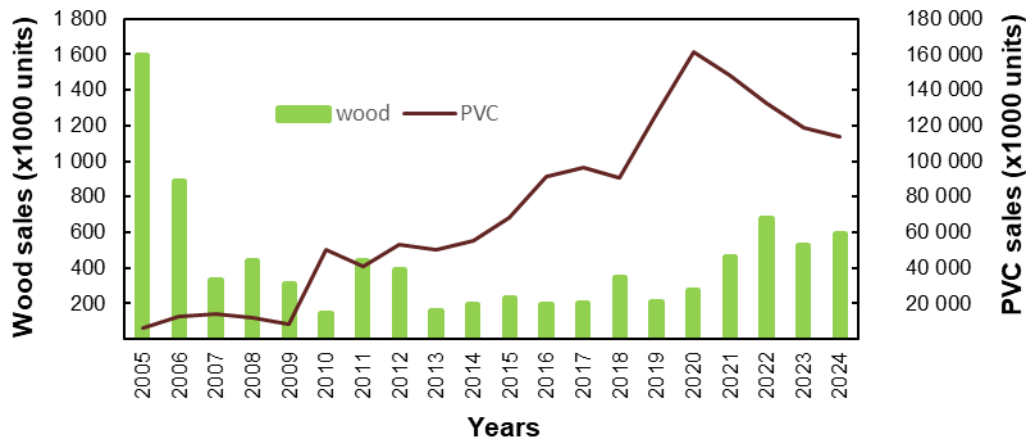


Fig. 1. Changes in wood and PVC window production in Türkiye (TUIK 2025)

Methods

Content analysis, as a research method, is a systematic and objective approach to describing and quantifying phenomena. It is a method that can be used with both qualitative and quantitative data. It can be applied in an inductive or deductive manner. Which approach to apply depends on the purpose of the research. The inductive approach is used if there is insufficient prior information about the phenomenon under investigation; the deductive approach is used if the analysis structure is based on pre-existing information. In deductive content analysis, a structured or free-form analysis matrix can be used depending on the purpose of the research (Elo and Kyngäs 2008). In this study, the term “content” refers to textual content, particularly the written texts used on web pages to present products as environmentally friendly.

Content analysis has been used as a method in studies related to greenwashing. Leonhardt and Guertler (2025) used content analysis in the mining sector, Dai *et al.* (2014) in the analysis of advertisements made in China, and Wagner and Hensen (2002) in the evaluation of green advertising of forest products in the United States.

This current study utilized a structured deductive content analysis approach. The codes used in the research were determined according to the TerraChoice report (TerraChoice Environmental Marketing Inc. 2009), which identifies 7 basic deception techniques used by companies to mislead consumers with environmental claims. The types of environmental claims mentioned in this report were also designated as research codes: “i) Sin of the hidden trade-off, ii) Sin of no proof, iii) Sin of vagueness, iv) Sin of worshipping false labels, v) Sin of irrelevance, vi) Sin of lesser of two evils, and vii) Sin of fibbing”. In this study, no distinction was made between company and product levels for greenwashing types. The sample size representing the main population was calculated using the following Eq. 1 (Arikan 2011):

$$n = [N \times t^2 \times p \times q] / [(N - 1) \times D^2 + t \times p \times q] \quad (1)$$

In Eq. 1, n represents the sample size; t represents the confidence coefficient (1.96 for $\alpha = 0.05$); N represents the population size (113); and p is the estimated value of the occurrence

of the examined characteristic in the population and was taken as 0.9 in this study. Also, q is the probability of not seeing the characteristic and is defined as $q=1-p$. The accepted sampling error (D) was accepted as 5% in this study. Accordingly, the sample size (n) was calculated as 62.

Aggarwal and Kadyan (2014) conducted a similar study comparing four different sectors (electronics, automotive, food, beverage, and personal care). They obtained their data by examining the websites of the businesses they sampled. In their study, 10 businesses representing each sector –a total of 40 businesses – represented the main sample.

In this study, the web pages of 62 PVC window manufacturers in Table S1, randomly selected from among 113 firms producing PVC window systems in Türkiye, were examined to identify the types of greenwashing presented on their websites. Even if the same greenwashing claim was repeated on different pages, it was counted only once. An artificial intelligence (AI) model (OpenAI, ChatGPT 5.2 Thinking) was used to perform this process (OpenAI 2025). The OpenAI conducted the scans according to a prompt created by the researcher. The types of greenwashing identified by the OpenAI were individually checked by the researcher. The agreement rate was found to be 97.6%. Subsequently, the data obtained from each company was entered into an SPSS dataset and analysed (IBM Corp. 2010). Examples of the use of artificial intelligence in studies related to greenwashing include the work of Amaliyah *et al.* (2025) and Bijker *et al.* (2024). Domínguez-Díaz *et al.* (2025) state that traditional content analysis relies on coding performed by multiple independent coders trained with a codebook, followed by reliability testing; therefore, the process is costly in terms of time and resources. They also note that artificial intelligence platforms can simplify this process, making it possible to achieve reliability levels equivalent to, or even higher than, human coding.

RESULTS AND DISCUSSION

The frequency distributions of greenwashing types, detected by artificial intelligence and checked by the researcher in the texts on the corporate websites of PVC window manufacturers, were found as shown in Fig. 2. According to Fig. 2, while the worshipping false labels type of greenwashing was never encountered; the sin of no proof was found to be the most frequently used (327) greenwashing offense.

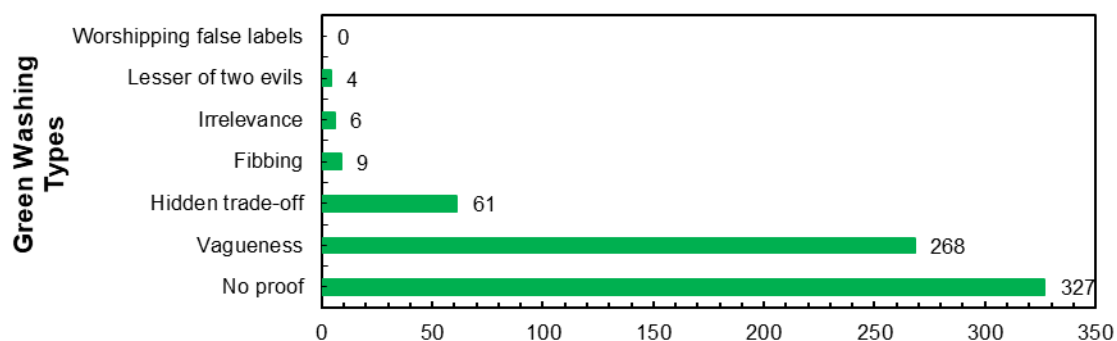


Fig. 2. Total frequencies of green washing types used by PVC window manufacturers

Other statistics regarding greenwashing claims made by enterprises are as shown in Table 1. According to the table, a total of 675 instances of greenwashing were detected in the 62 enterprises included in the study. This means the average number of greenwashes per enterprise was 10.89. Table 1 also shows that each enterprise performed approximately one hidden trade-off type of greenwashing on average. The total frequency of lesser of two evils, irrelevance, and fibbing type greenwashing was 19, representing 2.8% of the total, as can be calculated from the values in Table 1. Four of the 62 enterprises examined did not exhibit any type of greenwashing. The percentage of enterprises that did not engage in greenwashing was found to be 6.5% in the current study. Rahman *et al.* (2017) also report the percentage of products without greenwashing to be 6% in their study (Rahman *et al.* 2017). Both findings appear similar. In another study, Baum (2012) found that 66% of the 247 advertisements he sampled contained at least one instance of greenwashing. This result represented 75% for the United States and 51.6% for the United Kingdom. He also found this difference between countries to be statistically significant according to the Chi-square test. In this study, the prevalence of at least one misleading greenwashing claim was found to be even higher (93.5%) among enterprises producing PVC windows. The reason for this high rate of greenwashing may be an attempt to mitigate the negative perception of PVC's environmental impact. Furthermore, Baum's (2012) study included advertisements from seven different sectors, not just one, and suggests that some sectors are more prone to including misleading claims in their advertisements than others. He cites the automotive and energy sectors, which are inherently directly related to certain environmental issues, as an example. In another study, Dai *et al.* (2014), like Baum (2012), examined the distribution and characteristics of green advertisements published in newspapers and magazines. The advertisements examined were selected from different sectors. The distribution of green claims by sector showed that the "oil, chemicals, and plastics sector" had the highest number with 327. This result supports the assertion that sectors with environmental problems are more prone to greenwashing.

Another study that revealed the prevalence of greenwashing claims was conducted in North America. This study reported that 98% of 2219 products committed at least one greenwashing offense (TerraChoice Environmental Marketing Inc. 2009). It can be said that claims of being green are widespread and the results are quite similar.

Table 1. Statistics on Greenwashing Types

Types	N	Range	Sum	%	Mean	Standard Deviation	Variance
Worshipping false labels	62	0	0	0.00	0.00	0.00	0.00
Lesser of two evils	62	1	4	0.59	0.06	0.25	0.06
Irrelevance	62	1	6	0.89	0.10	0.30	0.09
Fibbing	62	2	9	1.33	0.15	0.44	0.19
Hidden trade-off	62	5	61	9.04	0.98	1.21	1.46
Vagueness	62	14	268	39.70	4.32	3.31	10.94
No proof	62	16	327	48.44	5.27	3.83	14.63
Total	62	30	675	100	10.89	6.71	45.02

The no-proof type of greenwashing was not encountered in 9.7% of businesses. In the remaining 90.3%, at least one instance of a lack of proof was committed. The frequency distribution range in businesses was found to be 1 to 16. For example, while this type of greenwashing was detected once in 7 businesses, it was detected 16 times in 1 business. This study has found that PVC window manufacturers made the most greenwashing claims

of this type, constituting 48.4% of the total frequency. Rahman *et al.* (2017) detected this claim in 70% of the businesses within the scope of their study. The reason for this difference may be that Rahman *et al.* (2017) investigated greenwashing claims within the scope of the product. Dai *et al.* (2014) found that the no proof type of greenwash was the most common, at 52.1%. This finding is consistent with this current study (48.4%) in terms of both percentage and prevalence. Baum (2012) reported that the claim of no proof was 19% in his study.

In 8.1% of the businesses (5 businesses), no greenwashing of the vagueness type was observed. In the remaining businesses, greenwashing of the vagueness type was detected in the distribution range of 1 to 14. For example, 2 instances of greenwashing of this type were detected in 12 businesses. This type of greenwashing was found to be the second most common, accounting for 39.7% of the total. Baum (2012) found that the vagueness sin was committed most frequently, at 57.1%. Although there is a difference in the percentages, both studies commonly found that this type of sin is widely committed.

The hidden trade-off type of greenwashing was not encountered in 46.8% of businesses. The frequency distribution range for this type ranged between 1 and 5. This offense was committed once in 16 businesses. With a rate of 9.4% of the total, it was the third most frequent type of greenwashing. The fibbing type of greenwashing claim was not committed by 88.7% of businesses, while the remaining 11.3% did. The frequency distribution of this claim in businesses was between 1 and 2. It was detected once in 5 businesses, and twice in 2 businesses. The total frequency was 9.

The sin of irrelevance was committed by 9.7% of enterprises. The frequency distribution range for this sin was found to be one. It was found that this sin was committed once in each of 6 businesses. Baum (2012) reports that claims of irrelevance and false labelling were very rare. In this current study, irrelevance was observed at a rate of 0.89%, and false labelling was not observed at all. From this, it can be concluded that the occurrence rates of the sins of irrelevance and false labelling were very close. Dai *et al.* (2014) also found that the sins of irrelevance and fibbing were among the least committed sins. In this current study, these two types of sins were also found to be among the least detected sins.

The prevalence of greenwashing can vary from country to country. Baum (2012) found that the lesser of two evils sin accounted for one-third of the total in America, while it accounted for one-tenth in the UK. He attributes this difference to variations in consumer markets. Dai *et al.* (2014) found the lesser of two evils type of greenwashing to be 23%. The prevalence found in this current study (0.59%) was quite different.

The study investigated whether there was a correlation between the frequency values of greenwashing types, and it was found that the correlations between the greenwashing types listed in Table 2 were statistically significant. No significant correlation was found between other types. All the correlations found were positive.

A correlation was found between hidden trade-off and no-proof and fibbing types ($p=0.001$ and $p=0.030$). Looking at the correlation coefficients, a moderately strong relationship was found between hidden trade-off and no-proof ($r_s=0.415$); a weak relationship was found between hidden trade-off and fibbing ($r_s=0.276$). Another significant relationship was found between no-proof and vagueness ($p=0.001$). The relationship between these two green wash types was moderately strong ($r_s=0.403$).

Table 2. Types of Greenwashing with Statistically Significant Correlations

			Hidden Trade-off	No Proof	Vague	Fibbing
Spearman's rho	Hidden trade-off	Correlation Coefficient	1.000	0.415	0.248	0.276
		Sig. (2-tailed)	.	0.001	0.052	0.030
		N	62	62	62	62
	No proof	Correlation Coefficient		1.000	0.403	0.191
		Sig. (2-tailed)		.	0.001	0.138
		N		62	62	62
	Vagueness	Correlation Coefficient			1.000	0.248
		Sig. (2-tailed)			.	0.052
		N			62	62
	Fibbing	Correlation Coefficient				1.000
		Sig. (2-tailed)				.
		N				62

The types of greenwashing used by PVC window manufacturers have been reclassified according to their subject matter. They are presented in Tables S2-S7 in the Appendix. The rationale for doing so was to understand whether there is a similarity between the topics preferred by businesses when making green claims, depending on the type of claim. Table S2 is a classification of the total of 327 “no proof claims” obtained in the current study, according to their subject matter. It shows that 37.9% of enterprises making no proof claims resorted to greenwashing regarding certification. This was followed by energy efficiency and insulation at 33.3%, and waste recycling at 15%. Enterprises made environmental claims on these topics without providing any evidence, measurements, or documents. The reason for the high finding regarding certification may result from enterprises producing their products in accordance with a certification, but since they did not share any document proving this certification, it was considered greenwashing. Regarding energy efficiency and insulation, Asif *et al.* (2002) reported that among the materials that can be used as window frames, wood has the lowest thermal conductivity and the amount of energy used to produce PVC window frames is 3 times that used to produce wood windows.

Table S3 shows the ranking of vague greenwashing claims made by enterprises according to their subject matter. Of the 268 businesses that made vague environmental claims in the table, 57.5% made green claims regarding overall environmental benefits. This was found to be the most preferred claim by businesses that engage in vague greenwashing. This was followed by vague claims about “energy efficiency/insulation” at 20.9%, which were not measured. Sustainability, recycling and waste reduction, chemical safety, and carbon/CO₂ issues are other topics of vague greenwashing. Looking at the green product definitions of Shrum *et al.* (1995) and Yang (2017), wood is the most suitable material for window manufacturing. Therefore, it can be said that it is more advantageous than its substitutes in terms of general environmental benefits. Goldhahn *et al.* (2021) report that wood, as a green, renewable, and biodegradable material, is a valuable resource for the development of more sustainable materials. They report that innovative wood-based materials show great potential in several areas, one of which is their use as replacements for traditional engineered materials such as plastics and metals. Similarly, Carlisle and Friedlander (2016) found that with minimal maintenance, wood and PVC windows could last 20 years, while with high maintenance, painted wood window frames could last 80 years. However, PVC windows could only last 30 years with low maintenance because the UV-blocking coating cannot be reapplied or extended.

Green claim topics belonging to the hidden trade-off type, where a single environmental feature is used to claim greenness while other important environmental impacts are ignored, were found as shown in Table S4. It was found that 50.8% of businesses committed this sin in terms of “recycling and waste reduction,” while the remaining 49.2% committed it in terms of “chemical safety, energy efficiency and insulation, material substitution, carbon emissions, and maintenance-free”. Interestingly, 9.8% of businesses (6 businesses) claimed to be environmentally friendly because they used PVC instead of wood. PVC is very slow to decompose and contains environmentally hazardous substances that can leach into soil and groundwater as a waste product. Recycling PVC is a complex process due to the additives it contains (Asif *et al.* 2002). Wood, on the other hand, is a renewable material and, under appropriate waste management conditions, can be recycled, biodegradable, or used for energy recovery.

In this study, 9 out of a total of 675 green claims identified were found to be fibbing greenwashing. The greenwashing topics covered by these enterprises through fibbing claims are shown in Table S5. According to the table, 44.4% of the enterprises making fibbing claims used carbon emissions as the basis for their claims. Other fibbing greenwashing concerns the claims that PVC is natural or renewable, that its production is environmentally friendly, and that its performance is superior. Hassegawa *et al.* (2022) reported that wood products often have lower greenhouse gas emission values throughout their life cycles compared to their counterparts made from other materials; Sinha and Kutnar (2012) reported that the carbon footprint of PVC window frames is twice that of wood. The results of these two studies show that the claims made by PVC manufacturers on this subject are not true.

It was found that 0.9% of enterprises committed the irrelevance sin. In this type of greenwashing, the businesses’ claims may be true, but these claims reflect a situation that is already legally required or irrelevant. This can be seen in Table S6. Although the CE mark is related to product safety, it is linked to the product’s environmental impact, as seen here. The table shows that businesses made irrelevance greenwashing claims regarding packaging, certification, regulatory compliance, social responsibility, and chemical safety.

Table S7 provides a summary of the distribution of greenwashing types identified in the study, categorized by topic. Accordingly, 26.4% of the total greenwashing claims relate to general environmental benefits. Energy efficiency and insulation come in second with 25.9%. Topics with low frequency values are grouped under “others”, representing 1.5% of the total. The table once again shows that the most frequently used greenwashing types in the top four topics are “no proof”, “vague” and “hidden trade-off”. Greenwashing claims in these four areas constitute 85% of the total.

Recommendations

Greenwashing is a multifaceted phenomenon. It is studied by various disciplines and can manifest in diverse forms at the product or company level. The fact that greenwashing can occur at the company and product level through overt environmental claims, visual elements, symbolic representations, and practices makes it difficult for consumers to recognize this phenomenon. Even informed consumers who are knowledgeable about this phenomenon and the market may struggle to distinguish misleading environmental claims (de Freitas Netto *et al.* 2020). Therefore, it can be said that it is difficult for consumers with limited knowledge on the subject to recognize greenwashing practices and make purchasing decisions in favor of truly environmentally friendly products. Consequently, while educating and raising awareness among consumers

about greenwashing is important, it should not be considered a sufficient solution on its own.

Environmental claims should be based on measurable, comparable, and verifiable evidence. Such claims should be supported by lifecycle-based indicators, including raw material sourcing, recycled content, energy performance, carbon footprint, durability, recyclability, and end-of-life management. Public authorities or accredited independent third-party verification mechanisms can play a significant role in assessing the validity of environmental claims and reducing information asymmetry between producers and consumers. Furthermore, public authorities should establish clear rules for environmental claims, prohibit vague and unproven statements, conduct regular audits, and impose deterrent sanctions for non-compliance. Such measures will not only protect consumers but also promote fair competition by preventing firms with genuine environmental performance from being disadvantaged by misleading green marketing practices.

Finally, AI-based tools can be used as complementary tools in detecting potential greenwashing practices. AI systems trained on different types of greenwashing can help consumers discern suspicious environmental claims and assist public authorities in pre-evaluating product labels, advertisements, and online marketing materials for compliance with relevant legislation. However, these tools should not replace expert assessment, scientific evidence, and formal audit processes; they should only be used as decision support mechanisms that complement these processes.

Limitations of the Study

This study is limited to the accessible web content of the enterprises included in the research. The findings are valid only for the accessible content at the time of examination, as web content can change over time. Due to technical limitations in the data collection process, it was not possible to read all pages of some sites at the full text level. The content of such sites was evaluated only through search engine snippets. Therefore, the frequencies for some businesses may be lower than they appear to be.

CONCLUSIONS

1. Despite the existence of one published law, one regulation, and one guideline against consumer deception, it has been concluded that PVC window manufacturers commonly engage in greenwashing claims. This leads to two further conclusions: i) legal regulations against consumer deception are ineffective in Türkiye, and ii) enterprises are aware of consumers' environmental concerns and view greenwashing as a tactic to gain a competitive advantage.
2. The most common types of greenwashing used by PVC window manufacturers, in order from most to least common, are: i) declaring their products or businesses to be environmentally friendly without providing evidence, ii) making vague or ambiguous environmental claims, and iii) highlighting a single environmental feature of their products or businesses while concealing other environmental harms. Except for the almost unused "sin of worshipping false labels", the remaining greenwashing sins were committed very rarely by PVC window manufacturers within the study period.
3. The types of greenwashing found to be most prevalent in the areas of i) general environmental benefits, ii) energy efficiency and insulation, iii) certifications and

standards, and iv) recycling and waste reduction. Although studies in the literature have investigated different types of greenwashing, very few studies have addressed the specific issues covered by these types of greenwashing.

4. It may be suggested that there is a correlation between greenwashing practices and weakening demand for wood window frames, which are far more environmentally friendly than PVC. However, this correlation alone cannot be considered as causality. Nevertheless, greenwashing can negatively impact the market position of genuinely eco-friendly products by reducing consumer confidence, increasing confusion, and weakening green purchasing intentions.

REFERENCES CITED

- Abnett, K. (2025, June 23). "EU halts talks on law tackling companies' fake 'green' claims," in: *EU Climate and Energy Policy in Brussels*, Retrieved on 12/18/2025 Reuters: <https://www.reuters.com/sustainability/climate-energy/eu-halts-talks-law-tackling-companies-fake-green-claims-2025-06-23/>
- Aggarwal, P., and Kadyan, A. (2014). "Greenwashing: The darker side of CSR," *Indian Journal of Applied Research*, 4(3), 61-66. <https://doi.org/10.15373/2249555X/MAR2014/20>
- Amaliyah, F., Putri, A. H., Andyna, N. P., and Amri, Z. K. (2025). "PRISMA systematic review: The application of natural language processing (NLP) to identify greenwashing in sustainability reports within the oil and gas industry," *Journal of Innovation Materials, Energy, and Sustainable Engineering* 3(1), 58-74. <https://doi.org/10.61511/jimese.v3i1.2025.2004>
- Arikan, R. (2011). *Research Methods and Techniques*, Nobel Academic Publishing, Ankara.
- Asif, M., Davidson, A., and Muneer, T. (2002). "Life cycle analysis of window materials—A comparative assessment," in: *Proceedings of the CIBSE National Technical Conference*, London, UK.
- Baum, L. M. (2012). "It's not easy being green...or is it? A content analysis of environmental claims in magazine advertisements from the United States and United Kingdom," *Environmental Communication* 6(4), 423-440. <https://doi.org/10.1080/17524032.2012.724022>
- Bijker, R., Merkouris, S. S., Dowling, N. A., and Rodda, S. N. (2024). "ChatGPT for automated qualitative research: Content analysis," *Journal of Medical Internet Research* 26, 1-18. <https://doi.org/10.2196/59050>
- Boncinelli, F., Gerini, F., Piracci, G., Bellia, R., and Casini, L. (2023). "Effect of executional greenwashing on market share of food products: An empirical study on green-coloured packaging," *Journal of Cleaner Production* 391(2023), article 136258. <https://doi.org/10.1016/j.jclepro.2023.136258>
- Carlisle, S., and Friedlander, E. (2016). "The influence of durability and recycling on life cycle impacts of window frame assemblies," *The International Journal of Life Cycle Assessment* 11(21), 1645-1656. <https://doi.org/10.1007/s11367-016-1093-x>
- Chen, F.-Y., Hsu, P.-Y., and Lin, T.-W. (2011). "Air travellers' environmental consciousness: A preliminary investigation in Taiwan," *International Journal of Business and Management* 6(12), 78-86. <https://doi.org/10.5539/ijbm.v6n12p78>

- Chen, S.-C., and Hung, C.-W. (2016). "Elucidating the factors influencing the acceptance of green products: An extension of theory of planned behavior," *Technological Forecasting and Social Change* 2016(112), 155-163.
<https://doi.org/10.1016/j.techfore.2016.08.022>
- Competition and Markets Authority (2025). *Unfair Commercial Practices*, Retrieved from https://www.gov.uk/government/publications/unfair-commercial-practices-cma207/unfair-commercial-practices?utm_source=chatgpt.com
- Çetiner, B. (2025). "Prevention of greenwashing in EU and Turkish law," *Istanbul Law Review* 83(2), 487-505. <https://doi.org/10.26650/mecmua.2025.83.2.0005>
- Çolak Bayram, G., Atılğan Türkmen, B., and Özsin, G. (2024). "Environmental sustainability applications of wood plastic composite materials: Life cycle assessment," *Bilecik Seyh Edebali University Journal of Science* 11(2), 437-450.
- Dai, X., Goh, T.-T., and Cheng, S. (2014). "A content analysis of green advertising in China," *Journal of Marketing Research and Case Studies* 2014, article 850595. <https://doi.org/10.5171/2014.850595>
- de Freitas Netto, S. V., Sobral, M. F. F., Ribeiro, A. R. B., and da Luz Soares, G. R. (2020). "Concepts and forms of greenwashing: A systematic review," *Environmental Sciences Europe* 32, article 19. <https://doi.org/10.1186/s12302-020-0300-3>
- Delmas, M. A., and Burbano, V. C. (2011). "The drivers of greenwashing," *California Management Review* 54(1), 64-87. <https://doi.org/10.1525/cmr.2011.54.1.64>
- Dilik, T. (2020). "A research on the effects of technological innovations on window systems and production," *Furniture and Wooden Material Research Journal* 1(3), 52-60. <https://doi.org/10.33725/mamad.748679>
- Domínguez-Díaz, A., Goyanes, M., and de-Marcos, L. (2025). "Automating content analysis of scientific abstracts using ChatGPT: A methodological protocol and use case," *MethodsX*, 15, article 103431. <https://doi.org/10.1016/j.mex.2025.103431>
- Elo, S., and Kyngäs, H. (2008). "The qualitative content analysis process," *Journal of Advanced Nursing* 62(1), 107-115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>
- Engelbertsson, T. (1997). *LCA of Roof Constructions in a Sports Centre*. Stockholm: Royal Institute of Technology (KTH), Department of Structural Engineering.
- European Parliament and Council of the European Union. (2024). *Directive (EU) 2024/825 of the European Parliament and of the Council*. (Retrieved from Official Journal of the European Union: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202400825)
- Forehand, L. (2024). *Building Construction and Materials: An Open Educational Resource Textbook*, Pressbooks, Long Beach, CA, USA. Retrieved from <https://lbcc.pressbooks.pub/buildingconstruction/>, (accessed 2 Feb 2025).
- Fossdal, S. (1995). *Energy-and Environmental Accounts of Buildings*, Norwegian Building Research Institute, Oslo, Norway.
- Goldhahn, C., Cabane, E., and Chanana, M. (2021). "Sustainability in wood materials science: An opinion about current material development techniques and the end of lifetime perspectives," *Philosophical Transactions of the Royal Society A* 379, article 20200339. <https://doi.org/10.1098/rsta.2020.0339>
- Gu, S. (2023). "The impact of increasing forest loss areas on the global temperature, and tourism industry," *Asian Journal of Research in Agriculture and Forestry* 9(3), 42-55. <https://doi.org/10.9734/AJRAF/2023/v9i3205>

- Hasan, M. M., Nekmahmud, M., Yajuan, L., and Patwary, M. A. (2019). "Green business value chain: a systematic review," *Sustainable Production and Consumption* 2019(20), 326-339. <https://doi.org/10.1016/j.spc.2019.08.003>
- Hassegawa, M., Brusselen, J. V., Cramm, M., and Verkerk, P. J. (2022). "Wood-based products in the circular bioeconomy: Status and opportunities towards environmental sustainability," *Land* 11(12), 1-16. <https://doi.org/10.3390/land11122131>
- IBM Corp. (2010). *IBM SPSS Statistics for Windows*, Version 19.0.
- Jönsson, Å., Svensson, T., and Tillman, A. M. (1995). *Life-Cycle Assessment of Flooring Materials: A Comparison of Linoleum, Vinyl Flooring and Solid-Pine Flooring*, Swedish Council for Building Research, Stockholm.
- Kočí, V. (2019). "Comparisons of environmental impacts between wood and plastic transport pallets," *Science of the Total Environment* 2019(686), 514-528. <https://doi.org/10.1016/j.scitotenv.2019.05.472>
- Leonhardt, C., and Guertler, K. (2025). "Unearthing corporate greenwashing: A content analysis of sustainability reporting in the mining sector," *Tripodos* 57, article 6. <https://doi.org/10.51698/tripodos.2025.57.06>
- Lyon, T. P., and Montgomery, A. W. (2015). "The means and end of greenwash," *Organization and Environment* 28(2), 223-249. <https://doi.org/10.1177/1086026615575332>
- Ministry of Trade. (2023). Guidelines on Advertisements Containing Environmental Claims, General Directorate of Consumer Protection and Market Surveillance. Retrieved February 4, 2026 from <https://tuketici.ticaret.gov.tr/data/63ada5bc13b876a1c8715f73/%C3%87EVREYE%20%C4%B0L%C4%B0%C5%9EK%C4%B0N%20BEYANLAR%20%C4%B0%C3%87EREN%20REKLAMLAR%20HAKKINDA%20KILAVUZ.pdf>
- Moreno, B. B., Rodrigues, B. V., Afonso, L. R., Jimenez, P. C., and Castro, Í. B. (2023). "High incidence of false biodegradability claims related to single-use plastic utensils sold in Brazil," *Sustainable Production and Consumption* 41, 1-8. <https://doi.org/10.1016/j.spc.2023.07.024>
- Mørkved, K., and Opdal, T. (1990). *Energy Resource-Accountance for Wood as Building Material*, Norwegian Institute of Wood Technology, Oslo, Norway.
- Nazareth, M., Marques, M. R., Leite, M. C., and Castro, Í. B. (2019). "Commercial plastics claiming biodegradable status: Is this also accurate for marine environments?" *Journal of Hazardous Materials* 366, 714-722. <https://doi.org/10.1016/j.jhazmat.2018.12.052>
- Nemes, N., Scanlan, S. J., Smith, P., Smith, T., Aronczyk, M., Hill, S., Lewis, S. L., Montgomery, A. W., Tubiello, F. N., and Stabinsky, D. (2022). "An integrated framework to assess greenwashing," *Sustainability* 14(8), article 4431. <https://doi.org/10.3390/su14084431>
- OpenAI (2025). *ChatGPT*, version 5.2 (thinking mode). Available at: <http://chat.openai.com/>
- PAGEV (2025). *Türkiye Plastics Construction Materials Sector Monitoring Report*, 2025/6. Retrieved on 12/13/2025 from <https://pagev.org/upload/files/Plastik%20%C4%B0n%C5%9Faat%20Malzemeleri%20Sekt%C3%B6r%20Raporu%202025%20Ocak%20-Haziran.pdf>
- PUKAD (2023). *2022 Turkey Window and Glass Market Report*, Istanbul. Retrieved 12/13/2025 from https://pagev.org/upload/files/PUKAD_RAPOR_2022.pdf

- Rahman, B., Ali, I., and Nedelea, A.-M. (2017). “Greenwashing in Canadian firms: An assessment of environmental claims,” *Ecoforum* 6(2), 1-7.
- Official Gazette (2013). *Law on Consumer Protection*, Law No. 6502. Available at: <https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=6502&MevzuatTur=1&MevzuatTertip=5>
- Official Gazette (2015). *Regulation on Commercial Advertising and Unfair Commercial Practices*, Issue No. 29232. Available at: <https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=20435&MevzuatTur=7&MevzuatTertip=5>
- Shrum, L. J., McCarty, J. A., and Lowrey, T. M. (1995). “Buyer characteristics of the green consumer and their Implications for advertising strategy,” *Journal of Advertising* 24(2), 71-82. <https://doi.org/10.1080/00913367.1995.10673477>
- Siano, A., Vollero, A., Conte, F., and Amabile, S. (2017). “ ‘More than words’: Expanding the taxonomy of greenwashing after the Volkswagen scandal,” *Journal of Business Research* 71, 27-37. <https://doi.org/10.1016/j.jbusres.2016.11.002>
- Sinha, A., and Kutnar, A. (2012). “Carbon footprint versus performance of aluminium, plastic, and wood window frames from cradle to gate,” *Buildings* 2(4), 542-553. <https://doi.org/10.3390/buildings2040542>
- Sokka, L., Koponen, K., and Keränen, J. T. (2015). *Cascading Use of Wood in Finland – with Comparison to Selected EU Countries*, VTT Technical Research Centre of Finland Ltd., Espoo, Finland.
- Souviron, J., van Moeseke, G., and Khan, A. Z. (2019). “Analysing the environmental impact of windows: A review,” *Building and Environment* 161, 1-14. <https://doi.org/10.1016/j.buildenv.2019.106268>
- Spaniol, M. J., Danilova-Jensen, E., Nielsen, M., Rosdah, C. G., and Schmidt, C. J. (2024). “Defining greenwashing: A concept analysis,” *Sustainability* 16(20), article 9055. <https://doi.org/10.3390/su16209055>
- Strizhakova, Y., and Coulter, R. A. (2013). “The “green” side of materialism in emerging BRIC and developed markets: The moderating role of global cultural identity,” *International Journal of Research in Marketing* 30(1), 69-82. <https://doi.org/10.1016/j.ijresmar.2012.08.003>
- TerraChoice Environmental Marketing Inc. (2007). *The Six Sins of Greenwashing*, Available at: https://sustainability.usask.ca/documents/Six_Sins_of_Greenwashing_nov2007.pdf
- TerraChoice Environmental Marketing Inc. (2009). *The Seven Sins of Greenwashing*, TerraChoice Environmental Marketing Inc., Ottawa, Canada. Available at: https://people.chem.ucsb.edu/feldwinn/darby/greenworks/Readings/7_Sins_of_Greenwashing.pdf
- TUIK. (2025). *Industrial Products Volume of Production*, 2005-2024.
- United States v. Volkswagen AG, No. 2:16-cr-20394-SFC-APP-8 (E.D. Mich. 2017).
- Viera, J. S., Marquesb, M. R., Nazareth, M. C., Jimenez, P. C., and Castro, Í. B. (2020). “On replacing single-use plastic with so-called biodegradable ones: The case with straws,” *Environmental Science and Policy* 2020(106), 177-181. <https://doi.org/10.1016/j.envsci.2020.02.007>
- Wagner, E. R., and Hansen, E. N. (2002). “Methodology for evaluating green advertising of forest products in the United States: A content analysis,” *Forest Products Journal* 52(4), 17-23.
- Windows Active. (2025). *Market Data Western European Window Market: Clear Upward Trend*, Windows Active: Retrieved from

https://www.windowsactive.com/western-european-window-market-clear-upward-trend/?utm_source=chatgpt.com

WWF. (2025). *Window of Opportunity*, WWF. Retrieved 12/11/2025 from

https://www.wwf.org.uk/sites/default/files/2017-06/windows_0305.pdf?utm_source=chatgpt.com

Yang, Y. C. (2017). "Consumer behavior towards green products," *Journal of Economics, Business and Management* 5(4), 160-167.

<https://doi.org/10.18178/joebm.2017.5.4.505>

Yavuz, F. (2007). *Türkiye Aims for First Place in PVC*, Retrieved from on 12/3/2025

https://www.yapi.com.tr/haberler/turkiye-pvcde-birinci-siraya-oyunyor_95610.html?utm_source=chatgpt.com

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APPENDIX

Supplementary Materials

Table S1. PVC Window Manufacturing Enterprises Whose Websites Were Examined in the Study

1	Adopen	www.adopen.com.tr	32	Krauss	www.krauss.com.tr
2	Ak Plast	www.aplas.com.tr	33	KVC Pen	www.kvcpen.com
3	Ak PVC	www.akpvc.com	34	Maestro	www.maestropencere.com
4	Akansupen	www.akansu.com	35	Nasaplast	www.nasaplast.com.tr
5	Akdoorplast	www.akdoorplast.com	36	Neowin	www.neowin.com.tr
6	Aleynapen	www.aleynapen.com	37	Nuriş	www.maxwin.com.tr
7	Alfapen	www.alfapen.com.tr	38	Orpen	www.orpen.com.tr
8	Altındağ	www.schonline.com	39	Öz Ekin	www.ozekin.com.tr
9	Arsanlar	www.aslanlarmetal.com	40	Özgüneş	www.ozgunesmetal.com.tr
10	Asaş	www.asastr.com	41	Pakpen	www.pakpen.com.tr
11	Aspero PVC	www.asperopvc.com.tr	42	Pensa	www.pensa.com.tr
12	Ayhan Profil	www.ayhanprofil.com.tr	43	Pidosan	www.interpen.com.tr
13	Bilkapen	www.bilkapen.com.tr	44	Pimapen	www.pimapen.com.tr
14	Çeçen PVC	www.cecenpvc.com	45	Pmk Plastik	www.pmkplastik.com
15	Doğru Pen	www.dogrupen.com.tr	46	Polerplast	www.polerplast.com
16	Doğupen	www.dogupen.com.tr	47	Polipen	www.polipen.com
17	Eceplast	www.eceplast.com.tr	48	Proline PVC	www.prolinepvc.com
18	Ege Profil	www.egepen.com.tr	49	Royalpen	www.royalpen.net
19	Enderpen	www.enderpen.com.tr	50	Saray PVC	www.saray.com
20	Erpen	www.erpen.com.tr	51	Şen Pen	www.senpencambalkon.com.tr
21	Ersaşpen	www.ersaspen.com.tr	52	Soray PVC	www.soraypvc.com
22	Eryap Grup	www.eryapgrup.com.tr	53	Taurus PVC	www.tauruspvc.com
23	Euroline	www.eurolinepvc.com	54	Tecnoplas	www.tecnoplas.com.tr
24	Europen	www.europen.com.tr	55	Toripen PVC	www.toripen.com
25	Farkpen	www.farkpen.com.tr	56	Uras Plastik	www.urasplastik.com
26	Firat Plastik	www.firatpen.com.tr	57	Windoline	www.windoline.com
27	Flashpen	www.flashpen.com.tr	58	Winsa	www.winsa.com.tr
28	Haratoğlu	www.haratoglupen.com.tr	59	Wintürk	www.winturk.com.tr
29	Karakoç Pen	www.karakocpvc.com.tr	60	Yağmurpen	www.yagmurpen.com
30	Karpen	www.karpen.com.tr	61	Yapipen	www.yapi-pen.com.tr
31	Kompen	www.kompen.com.tr	62	Zeus PVC	www.zeuspvc.com

Table S2. Frequency Distribution of No Proof Greenwashing by Topics

Topics	Freq.	%	Example claims
Certification/Standard/Report	124	37.9	Claims regarding documents or standards such as ISO, EN, TSE and EPD; report/analysis references.
Energy efficiency and insulation	109	33.3	Technical claims such as energy saving percentages; heat/sound insulation; passive house compliance; U-value.
Recycling and waste reduction	49	15.0	Claims regarding recyclability; number of recycles; waste reduction; reuse.
Overall environmental benefits	24	7.3	Generalizations such as environmentally friendly, sustainable, contribution to nature.
Carbon/CO ₂ /emissions	15	4.6	Carbon footprint reduction; emission reduction; CO ₂ comparisons.
Chemical safety	6	1.8	Claims such as lead-free; toxicity reduction; prevention of harmful emissions.
Total	327	100	

Table S3. Frequency Distribution of Vagueness Greenwashing Based on Topics

Topics	Freq.	%	Sample Claims
General environmental benefit	154	57.5	Unmeasured/general statements such as environmentally friendly, sustainable, respectful of nature.
Energy efficiency/insulation	56	20.9	Vague statements that do not specify evidence or criteria, such as energy saving, insulation/comfort.
Sustainability	31	11.6	General corporate statements such as environmental policy, vision/commitment, sense of responsibility, etc.
Recycling and waste reduction	18	6.7	Vague statements such as recycling, circularity, waste reduction.
Chemical safety	5	1.9	Unclear statements such as healthy, harmless, non-toxic.
Carbon/CO ₂ /emissions	4	1.5	Unmeasured and vague statements regarding carbon/CO ₂ /emissions/climate impact
Total	268	100	

Table S4. Frequency Distribution of Hidden Trade-Off Greenwashing by Topics

Topics	Freq.	%	Sample claims
Recycling and waste reduction	31	50.8	Environmental friendliness based on a single attribute such as 100% recyclable or waste is reintroduced into production.
Chemical safety	10	16.4	Imposing the holistic environmental superiority of the product by emphasizing lead-free or heavy metal-free status.
Energy efficiency and insulation	9	14.8	Presenting a benefit such as heat/sound insulation or energy savings as if it encompasses all life cycle impacts.
Material substitution	6	9.8	Transforming the use of uPVC instead of wood into a broad environmental benefit such as reduces deforestation.
Carbon/CO ₂ /emissions	4	6.6	Highlighting carbon footprint or CO ₂ values while excluding other environmental impacts.
Durability/maintenance-free	1	1.6	Linking an attribute such as durability/long service life to a claim of overall environmental superiority.
Total	61	100	

Table S5. Frequency Distribution of Fibbing Greenwashing by Topics

Topics	Freq.	%	Sample claims
Carbon/CO ₂ /emissions	4	44.4	Absolute zero claims such as "it emits no gases", "it produces no waste in nature."
Naturalness/renewability	2	22.2	Statements presenting the product/raw material as being from a natural, organic or renewable source.
Environmentally friendly production	2	22.2	Statements that exaggerate the production effect, such as "environmentally friendly production", "produced with less energy."
Absolute performance superiority	1	11.1	Claims of absolute superiority, such as the best product.
Total	9	100	

Table S6. Frequency Distribution of Irrelevance Type Greenwashing by Topic

Topics	Freq.	%	Sample claims
Packaging obligation symbol	2	33.3	"Green Dot is a brand user...meaning it fulfils its legal obligations".
Certification/standard/ report	1	16.7	"The CE mark...means it will not harm the environment..."
Commitment to complying with regulations	1	16.7	"We commit to meeting applicable legal requirements..."
Social responsibility	1	16.7	"We are pleased to participate in a project that will breathe life into the future of our city..."
Chemical safety	1	16.7	"BPA and phthalate free"
Total	6	100	

Table S7. Distribution of Greenwashing Types by Topic

Topics	No Proof	Vague	Hidden Trade-off	Fibbing	Irrelevance	Lesser of Two Evils	Total	
							Freq.	%
Overall environmental benefits	24	154	0	0	0	0	178	26.4
Energy efficiency and insulation	109	56	9	0	0	1	175	25.9
Certification/standard/ report	124	0	0	0	1	0	125	18.5
Recycling and waste reduction	49	18	31	0	0	0	98	14.5
Sustainability	0	31	0	0	0	0	31	4.6
Carbon/CO ₂ /emissions	15	4	4	4	0	2	29	4.3
Chemical safety	6	5	10	0	1	0	22	3.3
Material substitution	0	0	6	0	0	1	7	1.0
Others	0	0	1	5	4	4	10	1.5
Total	327	268	61	9	6	4	675	100