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Consumer Preferences for Eco-Friendly Products to Support Environmental Sustainability

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Abstract Environmental degradation and unsustainable consumption have become urgent global issues, with consumer behaviour responsible for nearly 70% of all greenhouse gas emissions. Although awareness of eco-friendly lifestyles has grown, the actual use of green products remains low. This research uses the Quality Function Deployment (QFD) method to identify and rank consumer preferences for environmentally sustainable products. Unlike previous studies that examined individual features separately, this work combines consumer perception data from the Delhi National Capital Region (NCR) with expert industrial evaluations to close the gap between design and policy implementation. The findings show that consumers value non-toxic, biodegradable, and recyclable materials most, followed by accessibility, emission reduction, and clean energy use. The study offers a structured QFD-based prioritisation model that converts consumer preferences into practical design guidelines for sustainable product development. Policymakers and manufacturers in emerging economies can replicate this framework to align environmental objectives with consumer demands better.

Keywords: *Quality Function Deployment, Green Consumer Preferences, Biodegradable Materials, Sustainability, Environmental Product Design*

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1. Introduction

Over recent decades, unprecedented resource consumption has caused increasing environmental pressures. Rapid economic growth, globalisation, and product demand are driving pollution, climate change, and biodiversity loss [1,2,3]. Energy consumption and carbon footprints are rising sharply [4]. If these trends remain unchecked, the impacts on ecosystems and human well-being could be severe.

With the growth of economies and industry development, consumption has also increased. It has a significant harmful effect on the environment, as no products are completely ecological [5,6]. Although consumerism has brought prosperity to society, achieving true sustainability remains challenging. During development and production, waste is generated at various stages of manufacturing and final disposal [7,8]. Fonseca [9] stated that responsible consumption and production promote sustainable patterns. Green products designed to minimise adverse environmental impacts across their life cycles offer a pathway towards balancing economic growth with environmental responsibility. Although awareness of green lifestyles is increasing, turning this awareness into product adoption remains a challenge. Previous research shows gaps between environmental concern and actual purchasing behaviour [10,11]. Understanding what consumers value most in green products is vital for bridging this gap.

This study fills these research gaps by using Quality Function Deployment (QFD) to rank consumer preferences for eco-friendly products. It combines consumer survey data from Delhi NCR with expert insights from manufacturing industries to create a clear connection between consumer needs ("WHATs") and engineering design features ("HOWs"). This combined approach improves both the scientific understanding and industrial application of QFD in sustainability efforts.

The specific objectives of this study are to:

Identify and prioritise main consumer preferences for eco-friendly product features that promote environmental sustainability; and

Create a flexible QFD-based framework that manufacturers and policymakers can adopt to synchronise product innovation with environmental goals.

This approach builds on existing QFD methods by incorporating sustainability goals into the initial product design stages, offering new perspectives on implementing consumer-driven sustainability within the Indian industrial environment.

The paper is structured as follows: Section 2 reviews the relevant literature; Section 3 describes the methodology; Section 4 presents the results and analysis; and Section 5 offers conclusions and implications.

2. Literature Review

Population projections estimate that nearly 10 billion people will be living by 2050 [12], implying continued increases in resource use, waste, and pollution. Studies show that sustainable manufacturing — creating durable, eco-efficient products — can help reduce some environmental pressures [9,13]. Key drivers are tighter environmental regulations, stakeholder expectations, consumer preferences, and cost benefits from waste minimisation [14].

Green products are generally characterised by their minimal environmental impact throughout their life cycle, the use of non-harmful materials, energy efficiency, and eco-friendly disposal methods [15,16,17]. Earlier studies also highlight factors such as emotional value, perceived quality, eco-labels, price sensitivity, brand image, accessibility, and aesthetics as key influences on the adoption of green products [18,19,20].

Table 1. Customers' Preferences for Green Products

S. No.	Customer's preferences	Sources	Preference explanation
1.	Price (P)	[11, 22]	Customers will prefer green products if their prices are lower than those of normal products.
2.	Quality (Q)	[11, 23]	Perceived product quality attracts customers to buy green products.
3.	Quick Service Support (S)	[11, 24]	Responsiveness to customer complaints increased their orientation towards green products.
4.	Eco-labelling (E)	[25]	Provide green information on the packaging so customers can differentiate between green and non-green products.
5.	Product Life Cycle (L)	[11, 13]	Long life and low environmental impact during the whole product life cycle attract customers.
6.	Aesthetic look (A)	[22]	Appearance plays an important role in attracting customers to purchase the product.
7.	Brand (B)	[11, 26]	The product's popularity attracts customers.
8.	Accessibility of the product (As)	[26, 27]	Easy access to the products influences customers' buying behaviour.
9.	Environmental impact (EI)	[26]	Sensitive customers consciously consider the product's environmental rating.
10.	Easy to use (U)	[28, 22, 29]	Easily repairable, upgradable, and independent functions attract customers.

Most studies tend to focus either on narrow product categories or on individual preferences in isolation. There is less research that systematically combines multiple consumer preferences and ranks them comprehensively to directly guide product design. The QFD method has been used only sparingly but shows promise in linking consumer input with engineering features, especially in sustainability contexts. Biswas and Roy [21] demonstrated that specific product attributes, such as packaging, functionality, and perceived value, significantly influence green product choices. The various customer preferences identified from the literature are listed in Table 1.

3. Research Methodology

To promote conscious consumerism, it is essential to incorporate customers' preferences for eco-friendly products into product design and production. However, balancing multiple preferences can be challenging due to cost and other limitations. Several methods exist for ranking these preferences, such as various MCDM techniques and BWM. Nonetheless, quality function deployment (QFD) is more suitable here because it boosts customer satisfaction by incorporating their feedback and requires less time and expense. Therefore, this study employs QFD techniques to prioritise the preferences.

3.1. Research Design & Sample

Data were gathered through consumer surveys in Delhi NCR. To achieve a representative sample, respondents were chosen based on age, income, education, and gender. Furthermore, manufacturing experts were consulted to convert consumer needs into design features.

3.2. Quality Function Deployment (QFD) Framework

QFD was initially developed in Japan during the late 1960s under the framework of total quality control [30]. Since then, it has been adopted by numerous companies worldwide, including IBM, Motorola, and DuPont, across industries such as automotive (e.g., General Motors, Toyota, Ford), education, healthcare, and software development [31,32,33,34,35]. QFD can help reduce quality-related problems [36]. Its benefits include recognising customer needs and expectations, planning, and reducing [37]. The QFD method helps identify customer requirements and translate them into design solutions [38]. Every organisation with customers aims to determine the actions needed to satisfy or delight them, and QFD is the preferred tool for this purpose. Quality professionals often refer to QFD by various names, such as matrix product planning, decision matrix, and customer-driven engineering. Customer expectations are expressed through the Voice of the Customer. QFD is a customer-centred quality management and product development approach. It involves listening to customer feedback, converting it into detailed engineering specifications, and planning the production of products that meet their expectations.

QFD is visually represented and used to link consumer requirements ("WHATs") with design or engineering features ("HOWs"). The House of Quality (HOQ) enables converting qualitative consumer preferences into quantifiable, weighted features. The connections between WHATs and HOWs are categorised (strong, medium, weak) to calculate their relative importance.

House of Quality (HOQ), with its different regions shown in Figure 1.

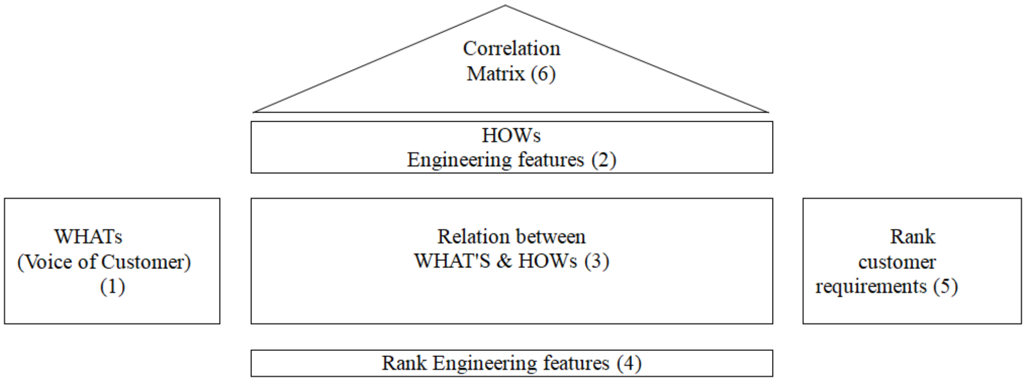


Figure 1. House of Quality

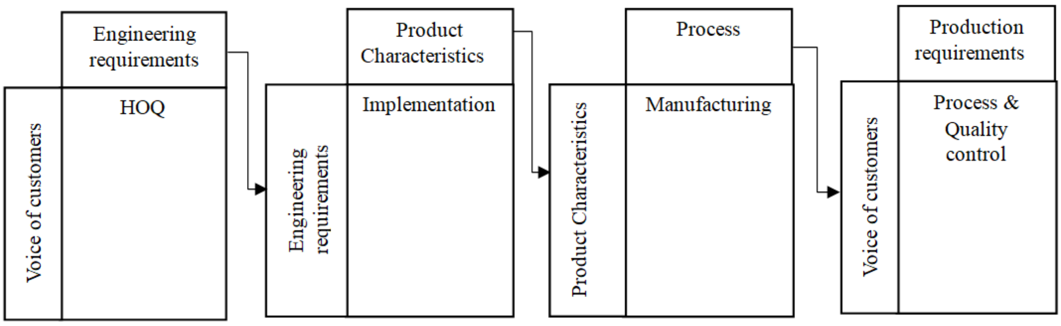


Figure 2. The QFD matrix phases [39,40,41]

Region 1: It is also called "What region". It represents the customer's requirements and the importance of each of them, β_i.

Region 2: It is also known as "How region". It represents the design specifications and the way of its development.

Region 3: It shows the relationship between 'how' and 'what'. The relationship is shown by the numbers Nij = 0, 1, 3..., 9.

Region 4: This region shows the combination of the design specification and its acceptance level, and the score

$$A_j = \sum(\beta_i * N_{ij}) \quad (1)$$

Region 5: The comparison of the product and competitors and the fulfilment of customer needs.

Region 6: The comparison between design specifications and their improvement affects each other.

Then, after identifying the customer needs, complete the preparation of the HOQ and after completion start to create the next matrix by placing all the important needs of the HOQ on the left side of the second matrix and their properties on the right side of the next matrix to facilitate communication and ensure that targets are not lost, The QFD matrix phases shown in Figure 2.

3.3. Data Analysis

- Identifying consumer preferences from literature and survey responses.
- Selection of relevant engineering and design features through expert consultation.
- Development of an interrelationship matrix using a weighting scale (9-3-1).
- Computation of relative importance and ranking of consumer preferences.

4. Results

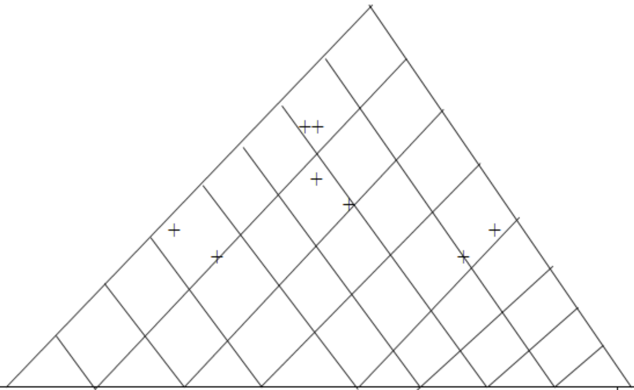
Customer expectations should be integrated into the product's design and manufacturing phases. A meeting has been convened with industry experts to determine how customer preferences can influence product development. Five experts from manufacturing industries A, B, C, D, and E have been invited. Industry A is based in Gurgaon (Haryana), Industry B in Bahadurgarh (Haryana), Industries C and D in Delhi, and Industry E in Mohali (Punjab). Industries A, B, and C produce medical equipment, while D and E manufacture auto parts for companies like Telco and Swaraj. Once customer preferences are translated, product design can proceed to meet these expectations. During development, customer preferences and environmental considerations should both be prioritised. Environmental impact can be minimised by adopting zero-carbon footprint manufacturing, utilising eco-efficient, reusable, recyclable, biodegradable, and non-toxic materials, expanding market demand to lower prices, implementing tighter tolerances, and adhering to regulatory sustainability guidelines. Strong top management commitment is also vital to achieving these goals. The extracted consumer preferences and related design features are summarised in Table 2.

4.1. Interrelationship Matrix

The third room of the HOQ illustrates the interconnection between the WHATs and the HOWs. These relationships are classified as 'strong', 'medium', 'weak', or 'none' for each pair of WHATs and HOWs, based on the extent to which the parameters contribute to meeting the VOC. A standard ratio is 9-3-1, where 9 indicates strong links, 3 indicates moderate links, and 1 indicates weak links. In the relationship matrix, these are shown by the symbols ○ (9), □ (3), and △ (1). The interrelationship matrix of WHATs and HOWs, and the House of Quality detailing various quality functions, are shown in Figure 3. The feature rankings derived from the QFD are listed in Table 3.

Table 2. The parameters required to meet the customers' preferences

S No	Preference (WHAT)	Sources	Design Feature(s) (HOW)
1.	Non-toxic, biodegradable and recyclable materials (H1)	[22,42,43]	Material sourcing & processing
2.	Clean/ non-conventional energy (H2)	[44,45]	Energy type in operations
3.	Reducing emissions (H3)	[22,46]	Process optimisation/ emissions control
4.	Providing a good market (access & availability) (H4)	[47]	Distribution channels, economies of scale
5.	Tighter tolerance (durability & precision) (H5)	[48,49]	Manufacturing precision, design robustness
6.	Regulatory compliance (H6)	[50]	Adherence to standards & certifications
7.	Latest technology (H7)	[11]	Incorporation of advanced production methods
8.	Top management commitment (H8)	[11]	Organisational strategy, resource allocation



WHATs (VOC)	Wt	HOWs								Competition	
		H1	H2	H3	H4	H5	H6	H7	H8	Green Product	Normal product
P	5	○	○	○	○	□	□	□		5	3
Q	4	○				○	△	□		4	3
S	3				□				△	3	3
E	3	□			△		□		△	1	1
L	1	○			□		△			3	1
A	4				○			□		3	4
B	4	□	□	□	□	□	△	□		3	3
As	3				□					1	4
EI	4	○	○	○		□	○	□	□	5	1
U	1							△		1	3
										Total	
Importance of Weight		147	93	93	117	75	69	64	18	676	
Relative importance		21.7 %	13.8 %	13.8 %	17.3 %	11 %	10.2%	9.5%	2.7%		
Ranking		1	3	3	2	4	5	6	7		

Figure 3. Describing various functions of the House of Quality

Table 3. The prioritized ranking

Rank	Feature	Relative Importance (%)
1	Non-toxic, biodegradable, recyclable materials	~22%
2	Providing good market/accessibility	~17%
3 (tie)	Use of non-conventional energy & reducing emissions	~14% each
4	Tighter tolerances (durability, precision)	~11%
5	Regulatory compliance	~10%
6	Latest technology	~9%
7	Top management commitment	~3%

4.2. Interpretation

Consumers prioritise environmental safety and material recyclability most. Market access is a key secondary factor, indicating that even eco-friendly product designs face barriers like limited availability or high costs. While emission reduction and clean energy are also important, consumers perceive them as slightly less urgent than material safety and market access.

5. Conclusion & Implications

This study introduces an innovative framework that connects consumer preferences to engineering design parameters using the QFD method to support sustainable product development. Results show that material safety—especially the use of non-toxic, biodegradable, and recyclable materials—remains the top consumer priority. Concerns about market accessibility, emissions control, and the use of renewable energy follow.

This research is original in combining consumer and expert feedback within a structured QFD matrix, thereby providing thorough prioritisation of sustainability-focused product features. Unlike earlier QFD studies that treated environmental factors more abstractly, this study demonstrates how green consumer insights can be translated into measurable, design-related metrics.

Practical Implications:

For manufacturers: prioritise using safe, recyclable materials; enhance supply chains to improve accessibility; and adopt technologies that reduce emissions**.**

For Policymakers: Develop incentives and regulations to promote eco-friendly materials, enhance infrastructure for distributing green products, and simplify standards and certifications.

For future research: consider conducting comparative studies across various regions or product categories, tracking preferences over time as awareness and technology develop, and integrating pricing and willingness-to-pay trade-offs more thoroughly.

Overall, this research enhances sustainable manufacturing by offering an empirically validated, repeatable framework that translates consumer preferences into practical design and policy recommendations for developing economies.

References

[1] Steffen, W.; Crutzen, J.; McNeill, J.R, The Anthropocene: Are humans now overwhelming the great forces of Nature? Ambio 2007, 36, 614–621.

[2] Clark, G, Evolution of the global sustainable consumption and production policy and the United Nations Environment Programme's (UNEP) supporting activities. J. Clean. Prod. 2007, 15, 492–498.

[3] Scheel C, Eduardo A, Bello B, Decoupling economic development from the consumption of finite resources using circular economy. A model for developing countries. Sustainability, 2020, 12(4):1291.

[4] Li Q, Long R, Chen H, Empirical study of the willingness of consumers to purchase low-carbon products by considering carbon labels: a case study. J Clean Prod, 2017, 161, 1237–1250.

[5] Akhtar, R.; Sultana, S.; Masud, M.M.; Jafrin, N.; Al-Mamun, A. Consumers' environmental ethics, willingness, and green consumerism between lower and higher income groups. Resour. Conserv. Recycl. 2021, 168, 105274. [CrossRef].

[6] Perez-Castillo, D.; Vera-Martinez, J. Green behaviour and switching intention towards remanufactured products in sustainable consumers as potential earlier adopters. Asia Pac. J. Mark. Logist. 2021, 33, 1776–1797.

[7] Dyllick, T.; Rost, Z. Towards true product sustainability. J. Clean. Prod. 2017, 162, 346–360.

[8] Bravo, A., Vieira, D., & Rebello, T. A, The Origins, Evolution, Current State, and Future of Green Products and Consumer Research: A Bibliometric Analysis. *Sustainability*, 2022, *14*(17), 11022.

[9] Fonseca, L. M., Domingues, J. P., & Dima, A. M, Mapping the sustainable development goals relationships. *Sustainability*, 2020, *12*(8), 3359.

[10] Kollmuss A, Agyeman J, Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res, 2002, 8:239–260.

[11] Kumar, P., Singh, M. K., & Agrawal, S, An analysis of customer's purchase intention towards the green products and its effect on manufacturing: A statistical approach. *Journal of Engg. Research ICARI Special Issue pp*, 2021, *1*, 10.

[12] https://www.un.org/en/desa/world-population-projected-reach-98-billion-2050-and-112-billion-2100 (accessed on 20th April 2023).

[13] Machado, C. G., Winroth, M. P., & Ribeiro da Silva, E. H. D, Sustainable manufacturing in Industry 4.0: an emerging research agenda. *International Journal of Production Research*, 2020, *58*(5), 1462-1484.

[14] Sartal, A., Bellas, R., Mejías, A. M., & García-Collado, A. (2020). The sustainable manufacturing concept, evolution and opportunities within Industry 4.0: A literature review. *Advances in Mechanical Engineering*, *12*(5), 1687814020925232.

[15] Ljungberg, L.Y. Materials Selection and Design for Development of Sustainable Products. Mater. Des. 2007, 28, 466–479.

[16] Ghazali, I.; Rashid, S.H.A.; Dawal, S.Z.M.; Aoyama, H.; Tontowi, A.E.; Ghazilla, R.A.R. Green Product Preferences with Respect to Cultural Influences: Empirical Study in Indonesia. Int. J. Autom. Technol. 2018, 12, 842–852.

[17] Sun Y, Wang S, Gao L, Li J, Unearthing the effects of personality traits on consumer's attitude and intention to buy green products. Nat Hazards, 2018, 93(1):299–314.

[18] Yadav R, Pathak GS, Determinants of consumers' green purchase behavior in a developing nation: applying and extending the theory of planned behavior. Ecol Econ, 2017, 134:114–122.

[19] Sharma, A., & Foropon, C, Green product attributes and green purchase behavior: A theory of planned behavior perspective with implications for circular economy. *Management Decision*, 2019, *57*(4), 1018-1042.

[20] Goncalves HM, Lourenco TF, Silva GM, Green buying behaviour and the theory of consumption values: a fuzzy-set approach. J Bus Res, 2016, 69(4):1484–1491.

[21] Biswas, A., & Roy, M, Consumer motivation for purchasing green products: An empirical analysis from emerging economies. Journal of Cleaner Production, 2023, 389, 135835.

[22] Ghazali, I., Abdul-Rashid, S. H., Md Dawal, S. Z., Huda, N., Shariff, A. H. M., Herawan, S. G., ... & Sakundarini, N, Guidelines for designing green products considering customers' cultural preferences. *Sustainability*, 2021, *13*(2), 673.

[23] Joshi, Y.; Rahman, Z. Factors Affecting Green Purchase Behaviour and Future Research Directions. Int. Strateg. Manag. Rev. 2015, 3, 128–143.

[24] Tseng, M.-L.; Lin, S.; Chen, C.-C.; Calahorrano Sarmiento, L.S.; Tan, C.L. A Causal Sustainable Product-Service System Using Hierarchical Structure with Linguistic Preferences in the Ecuadorian Construction Industry. J. Clean. Prod. 2019, 230, 477–487.

[25] Jad'ud'ová, J.; Badida, M.; Badidová, A.; Marková, I.; Tah ˇ úˇnová, M.; Hroncová, E. Consumer Behavior towards Regional Eco-Labels in Slovakia. Sustainability 2020, 12, 5146.

[26] Dinh, C. T., Uehara, T., & Tsuge, T, Green attributes in young consumers' purchase intentions: a cross-country, cross-product comparative study using a discrete choice experiment. *Sustainability*, 2021, *13*(17), 9825.

[27] Young W, Hwang K, McDonald S, Sustainable consumption: green consumer behavior when purchasing products. Sustain Dev, 2010, 18(1):20–31.

[28] Ackermann, L. Design for Product Care: Enhancing Consumers' Repair and Maintenance Activities. Des. J. 2018, 21, 543–551.

[29] Mustafa, S., Tengyue, H., Qiao, Y., Sha, S. K., & Sun, R, How a successful implementation and sustainable growth of e-commerce can be achieved in developing countries; a pathway towards green economy. Front. *Environ. Sci*, 2022, *10*(940659), 10-3389.

[30] Akao, Y, QFD: Past, present and future. In A. Gustafsson, B. Bergman & F. Ekdahl (Eds.), Proceedings of 3rd Annual International QFD Symposium (Vol. 1). Sweden: Linköping, 1997.

[31] Burn, G. R, Quality function deployment. In Managing Quality. London: Phillip Allan, 1994.

[32] Dika, R. J, The first seven years. In Quality up and costs down: A manager's guide to Taguchi methods and QFD. Dearborn: ASI Press, 1995.

[33] Foster, W. F, Customer driven healthcare: QFD for process improvement and cost reduction. Quality Progress, 2001, 34, 123–124.

[34] Chan, L. K., & Wu, M. L, Quality function deployment: A literature review. European Journal of Operational Research, 2002, 43, 463–497.

[35] Pai, W. C, A quality-enhancing software function deployment model. Information Systems and Management, 2002, 19, 20–24.

[36] PMI (Project Management Institute), A guide to the project management body of knowledge (PMBOK guide) (4th ed.). Pennsylvania: Project Management Institute, 2008.

[37] Tran, T. L., & Sherif, J. S, Quality function deployment (QFD): An effective technique for requirements acquisition and reuse. In Proceedings of IEEE International Software Engineering Standard Symposium, Los Alomitos, CA, 1995.

[38] Xie, M., Tan, K. C., & Goh, T. N, Advanced QFD applications. Milwaukee: ASQ Quality Press, 2003.

[39] Benner, M., Linnemann, A. R., Jongen, W. M. F., & Folstar, P, Quality Function Deployment (QFD)—can it be used to develop food products? *Food Quality and Preference*, 2003, *14*(4), 327-339.

[40] Rubert, C. K., de Carvalho, C. P., de Almeida, M. D. G. D., de Barros, J. G. M., & de Souza Sampaio, N. A, Development of automotive packaging by applying the QFD method. *Revista de Gestão e Secretariado (Management and Administrative Professional Review)*, 2023, *14*(6), 10527-10548.

[41] Ginting, R., & Ishak, A, An Integrated of AHP–QFD Methodology For Poduct Design: A Review. *Jurnal Ilmiah Teknik Industri*, 2020, *8*(1).

[42] Sohn, J.S.; Kim, H.K.; Kim, S.W.; Ryu, Y.; Cha, S.W, Biodegradable Foam Cushions as Eco-Friendly Packaging Materials. Sustainability, 2019, 11, 1731.

[43] Khan, M.A.; Mittal, S.; West, S.; Wuest, T. 2018. Review on Upgradability—A Product Lifetime Extension Li, G., Lim, M. K., & Wang, Z, Stakeholders, green manufacturing, and practice performance: Empirical evidence from Chinese fashion businesses. *Annals of Operations Research*, 2020, *290*, 961-982.

[44] Gafurovich, D. U., & Sotivoldievich, Z. M, The use of non-conventional power sources is a requirement of the period. *Academicia Globe: Inderscience Research*, 2021, *2*(7), 1-6.

[45] Sultonboevich, A. A., Olimjonov, D. B., Shamsiddinov, S. F., & Zikriyoxujaeva, M. (2022, May). The Use Of Non-Conventional Energy Sources In Urban Development, 2022, 95-98, In *Conference Zone*.

[46] Liu, Z., Qian, Q., Hu, B., Shang, W. L., Li, L., Zhao, Y., ... & Han, C, Government regulation to promote coordinated emission reduction among enterprises in the green supply chain based on evolutionary game analysis. *Resources, Conservation and Recycling*, 2022, *182*, 106290.

[47] Li, G., Lim, M. K., & Wang, Z, Stakeholders, green manufacturing, and practice performance: Empirical evidence from Chinese fashion businesses. Annals of Operations Research, 2020, 290, 961-982.

[48] Mohagheghian, E., Hosseini-Nasab, H., Zare-Mehrjerdi, Y., & Fakhrzad, M. B, A hybrid approach to investigate the relationship between design factors and sustainability. *RAIRO-Operations Research*, 2021, *55*(5), 2711-2737.

[49] Jadayel, M., & Khameneifar, F, Improving geometric accuracy of 3D printed parts using 3D metrology feedback and mesh morphing. *Journal of Manufacturing and Materials Processing*, 2020, *4*(4), 112.

[50] Becker, J., Manske, C., & Randl, S, Green chemistry and sustainability metrics in the pharmaceutical manufacturing sector. *Current Opinion in Green and Sustainable Chemistry*, 2022, *33*, 100562.