THE IMPACT OF THE GREEN PRODUCT LIFE CYCLE AND CONTINUOUS IMPROVEMENT TECHNIQUES ON COST REDUCTION

Nawfal Hussien Abdulaah
PhD in Accounting
Department of accounting/ College of Administration and Economics / University of Wasit
Iraq, Wasit,

Abstract. Abstract. This study examines advanced approaches that simultaneously serve society and the environment, thereby supporting sustainable development. It focuses on the green product life cycle and continuous improvement techniques as effective tools for reducing green product costs and enhancing production processes. The study also aims to clarify the conceptual foundations of these approaches and their areas of application in supporting the competitiveness of business organizations. A theoretical analysis of the relevant literature was conducted to identify the potential areas of cost reduction through the implementation of the green product life cycle approach and continuous improvement techniques. The findings indicate that the adoption of these approaches contributes to improving production efficiency, reducing costs, preserving the environment, and achieving a sustainable competitive advantage.

Keywords: Green Product, Continuous Improvement, Cost Reduction, Sustainability, Operational Efficiency, Quality, Financial Performance, Environmental Costs.

Влияние жизненного цикла зеленого продукта и методов непрерывного совершенствования на снижение затрат

Науфаль Хуссейн Абдулла
Доктор философии (PhD) в области бухгалтерского учета
Кафедра бухгалтерского учета, Колледж управления и экономики,

Университет Васит
Васит, Ирак

Аннотация. Настоящее исследование посвящено анализу современных подходов, направленных на одновременное удовлетворение потребностей общества и охрану окружающей среды, что способствует достижению целей устойчивого развития. Основное внимание уделяется жизненному циклу зеленого продукта и методам непрерывного совершенствования как эффективным инструментам снижения затрат на экологически ориентированную продукцию и повышения эффективности производственных процессов. Исследование также направлено на раскрытие теоретических основ данных подходов и определение сфер их применения для повышения конкурентоспособности хозяйствующих субъектов. Для достижения поставленной цели был проведен теоретический анализ научной литературы, посвященной рассматриваемым вопросам, что позволило выявить основные направления снижения затрат посредством внедрения концепции жизненного цикла зеленого продукта и методов непрерывного совершенствования. Результаты исследования показывают, что применение данных подходов способствует повышению производственной эффективности, снижению затрат, сохранению окружающей среды и формированию устойчивого конкурентного преимущества.

Ключевые слова: зеленый продукт, непрерывное совершенствование, снижение затрат, устойчивое развитие, операционная эффективность, качество, финансовые результаты, экологические затраты.

Introduction

As a result of environmental developments in the field of business, advanced models of various economic technologies and activities that serve society and the environment have been developed, providing a basis for sustainable development and its implementation. This has prompted companies to search for modern manufacturing techniques. The Iraqi environment suffers from pollution as a result of economic units' failure to observe environmental conservation standards, as well as the solid and liquid waste generated by production processes and the emission of toxic gases. In addition to the damage caused by the use of some traditional products, these challenges have increased attention to environmental sustainability and the adoption of environmentally friendly practices in business operations, including the sustainable sourcing of materials, waste reduction, and end-of-life recycling.

In this context, it becomes important to understand the impact of these green initiatives on customer satisfaction. Customers are becoming increasingly aware of environmental issues and tend to support companies that demonstrate a commitment to sustainability. By adopting green product life cycles and continuous improvement practices, companies not only contribute to environmental protection but also meet the growing demand for sustainable products.

The First Axis

Research Methodology

Research Problem

The Iraqi environment suffers from pollution as a result of economic units' failure to comply with environmental protection standards, as well as the solid and liquid waste generated by production processes and the emission of toxic gases. In addition, the damage caused by the use of some traditional products affects both customers and the market share of economic units. Therefore, there is a need to transform activities throughout the product life cycle into green activities and eliminate non-green and non-value-adding activities. This contributes to the optimal use of resources and energy while minimizing environmental damage.

The research problem can be summarized in the following question:

How do the green product life cycle and continuous improvement techniques contribute to cost reduction?

Research Importance

The primary objective of economic units is to provide services and manufacture products in order to achieve profits. However, in the twenty-first century, the objectives of economic units have expanded beyond profit generation to include the integration of financial and environmental goals. Therefore, the importance of this research lies in clarifying the conceptual foundations of the green product life cycle and continuous improvement techniques, as well as their areas of application in supporting the competitiveness of economic units.

Research Objective

The objective of this research is to examine the role of the green product life cycle and continuous improvement techniques and their impact on cost reduction.

Research Hypothesis

There is a significant impact of the green product life cycle and continuous improvement techniques on cost reduction through the analysis of product processes and activities and the redesign of products in accordance with environmental requirements, supported by the continuous improvement of production processes and activities.

The Second Axis

Theoretical Aspect

Green Product Lifecycle Concept

In recent years, competitive pressures and market openness have significantly influenced the policies of economic units regarding product development. As a result, product life cycles have become shorter, leading to greater product diversity. At the same time, economic units face increasing pressure to reduce production costs and deliver products to customers more quickly.

Reducing production time can be achieved through product redesign and the use of modern information and communication technology (ICT) tools for product design, development, and manufacturing. These opportunities have become available due to recent technological advances. The product lifecycle model emerged as a product-oriented and ICT-supported approach in which product data are shared among organizational processes throughout the various stages of the product life cycle to achieve higher levels of product performance (Duque, Garetti & Terzi, 2009, p. 148).

As a result of environmental developments and the emergence of environmentally friendly products, green product design has become more systematic and clearly defined. Green product design represents the core of environmental awareness and involves the integration of environmental considerations throughout the entire product life cycle. With social and technological progress, green design has become not only an important social responsibility but also an effective means of achieving economic benefits. It is expected to become a dominant trend in future product development due to growing environmental concerns and the need to promote sustainable development. Economic units seeking continuous growth must take advantage of this opportunity by adopting green product and process design while enhancing their competitiveness (He & Li, 2017, p. 123).

The Green Product Life Cycle (GPLC) is the process through which environmentally friendly products are designed, marketed, used, and disposed of in a manner that minimizes their environmental impact (Swetha, 2024, p. 4599).

The Green Product Lifecycle perspective is broader in scope because it takes into account the environmental impacts of activities both within and beyond the boundaries of the organization. It pays particular attention to raw materials, supply chains, product use, disposal impacts, and opportunities for reuse and recycling (European Union, 2010, p. 10).

Green Product Life Cycle Stages

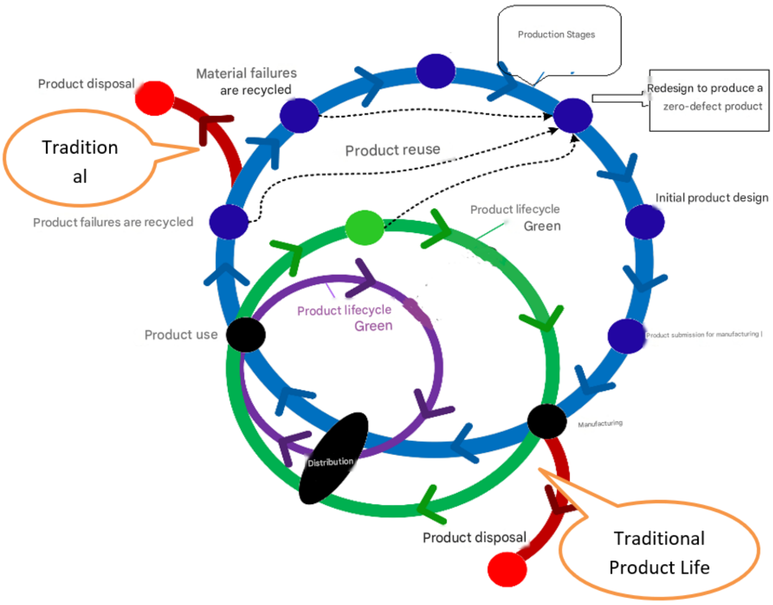
The life cycle of a green product is similar to that of conventional products, as it passes through several important stages, beginning with research, design, and development and ending with product disposal. However, because the green product life cycle focuses on environmental impacts, the final stage can be extended to include product reuse and recycling. The green product life cycle has evolved by incorporating modern sustainability concepts such as waste-free manufacturing, product reuse, and recycling.

Unlike the traditional product life cycle, which generally assumes a single life cycle for a product, the green product life cycle recognizes that products may be reused, remanufactured, or recycled multiple times. It encompasses all stages from product design to disposal or recycling. When a product reaches the end of its useful life, it may enter a recycling or reuse phase rather than being discarded. In many cases, products can continue to function according to their original design or can be adapted for other uses.

Therefore, the fundamental concept of the green product life cycle is based on reuse, recycling, and responsible disposal in order to enhance sustainability. The traditional product life cycle views products as having only one life cycle, whereas the green product life cycle may involve multiple cycles throughout the product's lifespan. Once the initial useful life of a product has ended, it can be used as a component in the manufacture of other products, remanufactured, or reused. If the product can no longer be used in its original form, its components and materials may still be recovered and reused.

The recovery and reuse of resources invested in manufacturing contribute to greater sustainability. The reuse cycle may occur at various stages of production and continue until the final product reaches the customer. Recycling generally applies to materials, since resources such as manufacturing time and labor cannot be recycled. Nevertheless, the green product life cycle enables organizations to make better use of natural resources, human effort, manufacturing time, and product design capabilities.

The information and feedback generated throughout the green product life cycle support the development of new sustainable products that are compatible with environmental objectives. Ultimately, the green product life cycle seeks to improve the three dimensions of sustainability: economic, environmental, and social performance. Extending the productive life of products not only reduces material waste but also improves the efficiency with which resources such as capital, labor, and time are utilized (May & Psarommatis, 2022, p. 4).



Source: Psarommatis, F., & May, G. Achieving Global Sustainability Through Sustainable Product Life Cycle. IFIP Advances in Information and Communication Technology, September 2022. DOI: 10.1007/978-3-031-16407-1_46.

The Importance of the Green Product Life Cycle

The importance of the green product life cycle is similar to that of the traditional product life cycle, with the added dimension of sustainability (Abbas & Zaher, 2022, p. 46).

1. The green product life cycle is essential for strategic planning, as it enables organizations to select an appropriate life cycle for their products, develop

strategic alternatives, and formulate suitable marketing strategies to influence customers while taking market developments into account.

2. The product life cycle is considered a behavioral model that influences sales and profits. It is used as a marketing tool for developing new products to replace outdated ones and for formulating marketing and production strategies for all stages of the product life cycle in order to respond to internal and external conditions.
3. The product life cycle provides managers with important information regarding market share growth, competitive position, and profitability.
4. Additional importance has been attributed specifically to the green product life cycle (European Union, 2010, p. 10), including:

- Gathering background information on the environmental impacts of market-oriented policies and promoting innovative product design.

- Understanding trends in product supply chains and identifying opportunities for improving supply chain performance.

- Developing resource management strategies, such as optimal waste management.

- Increasing consumer awareness through green branding and public procurement systems.

Green Product Lifecycle Costs

Product lifecycle costs are determined according to the stages of product development and production. Although these costs vary from one product to another, they generally include the following categories (Atrill & McLaney, 2009, p. 148):

- Pre-production costs. This stage covers the period before the production of a product or service. It mainly includes research and development activities for both products and services. During this stage, products and production methods are designed and developed. It also includes the acquisition and installation of production facilities, as well as advertising and promotional activities.

- Production costs. These are the costs incurred during the manufacturing, sale, or servicing of products and services for customers.

- Post-production costs. These costs arise after products or services have been sold and are often referred to as after-sales costs. They include expenses associated with correcting defects, providing after-sales services, shutting down production facilities, and product reuse or recycling activities. Since after-sales services may begin after the first sale and continue long after the final sale, this stage often overlaps with the production and service delivery stages.

The Concept of Continuous Improvement

The concept of continuous improvement emerged after World War II, when Japan suffered significant industrial and economic damage. Japanese industries faced numerous difficulties that contributed to their decline. To support reconstruction efforts, General MacArthur invited several distinguished experts from the United States to visit Japan and provide recommendations. One of these experts was Dr. W. Edwards Deming, a statistician and specialist in quality improvement. Deming emphasized the importance of focusing on processes rather than results and encouraged teamwork as a means of improving organizational performance (Khan & Hongqi, 2018, p. 7).

Continuous improvement is defined as “a Japanese concept that refers to the gradual and continuous reduction of product costs throughout the product life cycle” (Hussain, 2023, p. 49). Rewers defined continuous improvement as a management tool that focuses on generating ideas aimed at improving all areas of an organization through employee participation and the elimination of non-value-adding and unnecessary activities, thereby reducing costs and improving product quality (Abboud et al., 2024, p. 2415).

Continuous Improvement Cycle

An important element of the continuous improvement approach is its nature as an ongoing process that continuously examines and questions the details of production processes and organizational activities. This repetitive and cyclical approach is reflected in several continuous improvement models. The two most widely used models are the PDCA cycle (often called the Deming Cycle) and the DMAIC cycle, which became popular through the Six Sigma methodology (Slack et al., 2010, p. 571).

The PDCA cycle consists of the following stages:

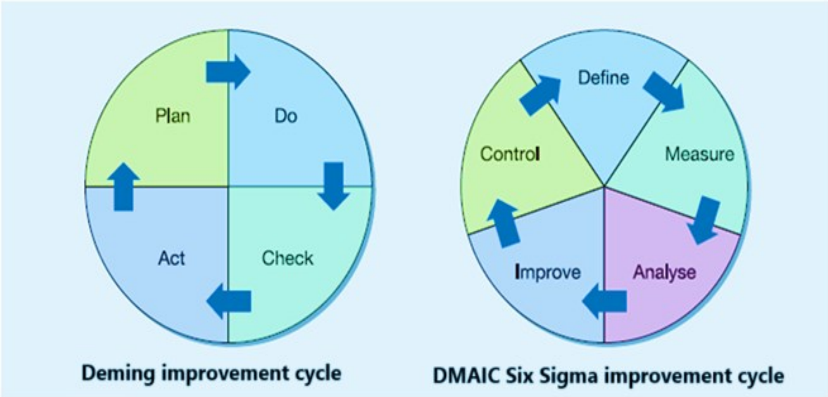
- Planning Phase. This stage involves examining the current production process, identifying problems, collecting and analyzing data, and developing an action plan aimed at improving performance. Once the plan is approved, implementation begins.

- Do Phase. During this stage, the proposed plan is tested and implemented within the process targeted for improvement. Implementation is monitored and any problems encountered are identified and addressed. This phase may itself involve a smaller PDCA cycle.

- Check Phase. At this stage, the results of implementing the new plan are evaluated and compared with the expected outcomes to determine whether the improvement objectives have been achieved.

- Act Phase. During this stage, the results achieved are reviewed thoroughly. If the plan is successful, it is standardized and applied more broadly. If it is unsuccessful, lessons learned are documented and used to improve future initiatives.

- The DMAIC cycle differs from the PDCA cycle by adopting a more analytical and data-driven approach. DMAIC begins with defining the problem and identifying the requirements for improvement. The second stage involves establishing specific improvement objectives. This is followed by the measurement stage, during which data are collected and analyzed to understand the extent of the problem and assess performance accurately. The analysis stage focuses on identifying the root causes of the problem and developing hypotheses regarding possible solutions. Once the causes have been identified, improvement actions are implemented to eliminate them. After successful implementation, the solutions are standardized, and their results are measured and monitored to ensure continuous improvement. Figure () illustrates the operation of both models (Slack et al., 2010).



Source: Slack, N., Chambers, S., & Johnston, R. Operations Management (6th ed.). 2010.

The Importance of Continuous Improvement

Reinser identified the importance of continuous improvement as follows (Hassan & Al-Abbas, 2024, p. 102):

- Developing solutions to existing problems and preparing reports that include both the identified problems and the proposed solutions.

- Increasing employees’ awareness of the importance of quality principles and encouraging the effective utilization of human resources in improvement activities.

- Training employees in improvement processes and ensuring that they assume the responsibilities assigned to them.

- Ensuring the production of defect-free products while minimizing wasted time and resources.

- Establishing strong relationships with suppliers, customers, and other economic units.

- Improving performance in all organizational activities, both inside and outside the organization.

- Encouraging innovation and creative thinking among employees.

- Focusing on the continuous improvement of production processes rather than relying solely on the final results of improvement efforts.

Principles of Continuous Improvement of the Green Product

1. In order to identify activities that require improvement, it is necessary to understand the principles upon which the improvement process is based, as well as to have a clear understanding of production processes. This facilitates the identification and application of the fundamental concepts of continuous improvement within the organization. Several key principles of continuous improvement can be applied to green products.
2. Relying on collaboration and active participation in generating and implementing improvement ideas.
3. Focusing on human resources, Kaizen management principles, and the achievement of competitive advantage.
4. Emphasizing continuous process improvement and teamwork.
5. Continuous improvement is concerned with establishing standards and continuously enhancing them in order to achieve higher levels of performance. From the above, it can be concluded that the principles of continuous improvement focus on improving processes, work methods, and procedures to enhance results, continuously develop work standards, and support behaviors that facilitate improvement. These principles also define work practices that encourage continuous improvement activities. Therefore, management and employees must work together to identify daily improvement opportunities and overcome work obstacles. Continuous improvement represents a key factor in organizational competitiveness through employee participation in developing improvement proposals. It is a methodology that relies on a set of techniques and tools aimed at improving production processes and establishing standards for continuous development (Al-Shafeay, 2024, p. 10).

Objectives of Continuous Improvement

In general, continuous improvement aims to enhance quality and reduce costs while meeting customer requirements. Hamza and Fathia identified several objectives of continuous improvement (Rash & Al-Jubouri, 2023, p. 337):

- Reduction of resource consumption. Any use of resources beyond planned levels is considered waste and requires corrective improvement actions.

- Elimination of errors. Most errors result from human factors, which makes employee training and qualification essential for reducing mistakes.

- Anticipation of customer needs. Continuous improvement focuses on identifying and satisfying customer expectations.

- Reduction of workplace accidents. Continuous improvement requires proper planning of production processes in order to reduce errors and accidents, thereby minimizing compensation costs and operational disruptions.

- Increasing employee satisfaction. Employee satisfaction is an important component of continuous improvement and can be enhanced through employee participation in improvement teams.

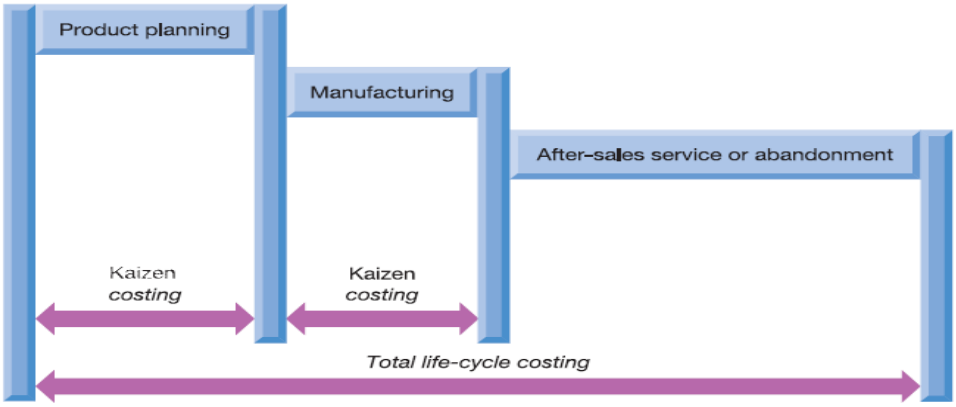
Green Product Lifecycle Costs and Continuous Improvement Costs

Continuous improvement costs are closely related to overall green product lifecycle costs through their focus on achieving cost savings during the production stage. Since production is a relatively late stage in the product life cycle, opportunities for cost reduction may be more limited than in earlier stages. Nevertheless, valuable savings can still be achieved.

By integrating continuous improvement with product lifecycle costing, economic units seek to reduce the unit manufacturing cost of products or services below the cost achieved in previous periods. Specific cost reduction targets can be established and monitored. Production employees are often encouraged to identify opportunities for reducing costs, drawing on their practical experience and knowledge of production processes.

Although the scope for cost reduction during the production stage may be limited, significant savings can still be realized. Once the product design and development process has been completed, the production stage begins, and continuous improvement techniques can be used to enhance the efficiency of production operations. Continuous improvement focuses on gradual and ongoing enhancements to product design and production processes while establishing cost reduction targets for specific periods and comparing them with actual performance.

Employee participation is essential for achieving desired cost reductions. Suggestions provided by employees frequently result in substantial savings. Continuous improvement is closely associated with lean manufacturing and the green product life cycle, both of which are committed to eliminating waste through ongoing improvement efforts. Figure () illustrates product lifecycle costs and the areas in which continuous improvement can contribute to cost reduction (Atrill & McLaney, 2009, p. 329).



Total life-cycle costing covers all three phases of the product life cycle, and *Kaizen* costing

Source: Atrill, P., & McLaney, E. Management Accounting for Decision Makers (6th ed.). 2009.

The Third Axis

Practical Aspect

Compatibility between Green Product Lifecycle and Continuous Improvement in Cost Reduction

To test the research hypothesis, the study relies on tire manufacturing factories in Iraq, namely the Babylon Tire Factory and the Diwaniya Tire Factory. These factories suffer from manufacturing problems and high production costs, particularly with respect to tire raw materials, which are not available locally and therefore must be imported. In addition, some production lines have stopped operating, and these companies still rely on traditional manufacturing and reporting systems that are no longer compatible with the developments occurring in the modern business environment.

Furthermore, some of these companies do not adequately incorporate sustainability considerations into their operations, resulting in a decline in market share compared with imported products and limiting their ability to make decisions that support organizational development. The research hypothesis assumes that the adoption of sustainability-oriented practices contributes to making more effective managerial decisions, improving company performance, and addressing shortcomings related to sustainability.

One area in which companies can benefit significantly is the treatment and recycling of solid waste generated by final products. Among the most problematic forms of waste are used automobile tires due to their resistance to biodegradation and their high flammability. In addition, disposing of tires in landfills, particularly in humid environments, may result in the release of toxic substances into the soil. Because of the difficulties associated with tire disposal, this issue has become a major environmental challenge in many countries. Consequently, environmental organizations and specialized institutions have promoted safe and environmentally friendly methods for addressing this problem. These methods can be summarized as follows:

1) Recycling of Tire Components

- The recycling process aims to recover the main industrial materials contained in used tires and reintroduce them into the production process while reducing waste. The most important recovered materials are rubber granules and steel wire. This process consists of several stages.

- Collection Stage. During this stage, used and damaged tires are collected. This process is relatively simple and does not require significant effort. Tires may be purchased from suppliers contracted with the company. The average purchase cost of one used tire (R20 size) is approximately 5,000 Iraqi dinars.

- Sorting and Cleaning Stage. At this stage, tires are sorted according to their condition and size. They are then cleaned by removing impurities and any components that cannot be recycled.

- Disassembly Stage. During this stage, the tires are cut into smaller sections. The steel wire is separated from the rubber, and the tire components are then processed through crushing equipment.

The costs of this operation are presented below in Iraqi dinars.

Table 1. Costs of the Tire Recycling Process (Iraqi Dinars)

Machine Name	Machine Cost (IQD)	Number of Workers	Annual Depreciation (IQD)
Wire Drawing Machine	3,000,000	1	300,000
Cutting Machine	7,000,000	–	700,000
Rubber Recycling Machine	40,000,000	1	4,000,000
Conveyor Belts	50,000,000	–	5,000,000
Control Device	5,000,000	–	500,000
Total	**105,000,000**	**2**	**10,500,000**

Source: Prepared by the researcher based on the technical specifications and operational data provided by Ilder Recycling Company, Denmark, a company specialized in the manufacture of tire recycling production lines.

The table was prepared by the researcher based on data provided by Ilder Recycling, a Danish company specializing in the manufacture of used-tire recycling production lines. The main products obtained from this process are:

- Rubber granules
- Steel wire

These production lines process an average of 50 tires per hour of size R20. The approximate weight of each tire is 10 kg. According to international standards, steel wire represents approximately 15% of the tire weight, while the remaining 85% consists of rubber granules.

Calculation of the Number of Recycled Tires per Year

Number of working days per year:

365 days − 49 weekly holidays − 15 public holidays = 300 working days per year

Number of operating hours per year: 300 days × 7 working hours per day = 2,100 hours per year

Number of tires processed annually: 2,100 hours × 50 tires per hour = 105,000 tires per year

Calculation of Recovered Materials

Amount of recycled materials: (Tire weight × material percentage) × number of tires

Rubber granules: (10 kg × 85%) × 105,000 = 892,500 kg

Steel wire: (10 kg × 15%) × 105,000 = 157,500 kg

The purchase price of one kilogram of rubber granules is 725 Iraqi dinars, while the purchase price of one kilogram of steel wire is 525 Iraqi dinars.

Rubber granules are used in many industries and can also serve as a raw material in tire manufacturing. Likewise, steel wire can be reused in various industrial applications. Consequently, the recycling process contributes to significant cost savings.

Value of Recovered Materials

Rubber granules: 892,500 × 725 = 647,062,500 IQD

Steel wire: 157,500 × 525 = 82,687,500 IQD

Total value of recovered materials: 647,062,500 + 82,687,500 = 729,750,000 IQD

Costs of the Recycling Process

Cost of purchasing used tires: 105,000 × 5,000 = 525,000,000 IQD

Annual depreciation: 10,500,000 IQD

Direct labor costs: 2 workers × 750,000 × 12 months = 18,000,000 IQD

Indirect manufacturing costs: 5,000,000 IQD

Total annual operating costs: 525,000,000 + 10,500,000 + 18,000,000 + 5,000,000 = 558,500,000 IQD

Net annual savings: 729,750,000 − 558,500,000 = 171,250,000 IQD

2) Using the Pyrolysis Method to Obtain New Products

According to this method, used tires are processed in an oxygen-free environment and subjected to thermal decomposition (pyrolysis) at specific temperatures in order to prevent environmental pollution. Companies such as Pyrum Innovations AG in Germany specialize in the production of tire pyrolysis systems. Through this process, several valuable products are obtained, including pyrolysis oil, carbon black, syngas, and steel wire. The cost of a tire pyrolysis production line is presented in the following table.

Table 2. Cost of the Tire Pyrolysis Production Line (Iraqi Dinars)

Machine Name	Machine Cost (IQD)	Processing Time per Tire (Minutes)	Number of Workers	Annual Depreciation (IQD)
Thermal Decomposition Reactor	160,000,000	0.4	1	16,000,000
Thermal Heating Unit	50,000,000	1.0	1	5,000,000
Impurity Removal System	20,000,000	0.1	–	2,000,000
Condensation Unit	80,000,000	0.1	–	8,000,000
Control System	10,000,000	–	–	1,000,000
Total	**320,000,000**	**1.6**	**2**	**32,000,000**

Source: Prepared by the researcher based on the technical specifications of Pyrum Innovations AG, Germany.

As shown in Table 2, the time required to process one tire is 1.6 minutes. Through this process, several products are obtained, including pyrolysis oil, carbon black, steel wire, and syngas. The following table presents the production percentage, quantity produced, selling price, and total revenue generated from each product.

Based on the data used in the first method, the actual operating time of the production line is 2,100 working hours per year. Since the processing time for one tire is 1.6 minutes, the production line can process: 60 minutes ÷ 1.6 = 37.5 tires per hour

Annual processing capacity: 2,100 hours × 37.5 tires = 78,750 tires per year

Since the average weight of one tire is 10 kg, the annual processing capacity of one production line is: 78,750 × 10 = 787,500 kg per year

Table 3. Products Obtained from the Tire Pyrolysis Process

Product	Production Percentage	Quantity Produced (kg)	Selling Price (IQD/kg)	Total Revenue (IQD)
Pyrolysis Oil	40%	315,000	1,100	346,500,000
Carbon Black	35%	275,625	600	165,375,000
Steel Wire	15%	118,125	525	62,015,625
Syngas	10%	78,750	250	19,687,500
Total	**100%**	**787,500**	—	**593,578,125**

The total operating cost of this process is 450,750,000 IQD and consists of the following components:

Cost of acquiring used tires for processing: 78,750 × 5,000 = 393,750,000 IQD

Annual depreciation: 32,000,000 IQD

Labor costs: 18,000,000 IQD

Indirect manufacturing costs: 7,000,000 IQD

Total operating costs: 393,750,000 + 32,000,000 + 18,000,000 + 7,000,000 = 450,750,000 IQD

Net savings generated by the process: 593,578,125 − 450,750,000 = 142,828,125 IQD

The Fourth Axis

Conclusions and Recommendations

Conclusions

1. Traditional cost reduction approaches focus primarily on production costs and often overlook costs incurred throughout the entire product life cycle.
2. The green product life cycle approach and continuous improvement are among the modern approaches that contribute to broader cost reduction because they address all stages of the product life cycle, from design to disposal and recycling.
3. There is a strong relationship between the green product life cycle and continuous improvement, as both approaches emphasize product and process design as key factors in achieving cost reduction and sustainability.
4. The green product life cycle provides valuable information for pricing decisions, cost management, performance evaluation, and continuous improvement initiatives.
5. The adoption of green product lifecycle technologies and continuous improvement practices contributes to the production of environmentally friendly products and enhances sustainable organizational performance.
6. The application of green product lifecycle principles and continuous improvement techniques helps preserve the environment through the efficient use of environmentally friendly resources and the reduction of waste.

Recommendations

1. Economic units should adopt modern management and production approaches that are compatible with the requirements of the contemporary business environment in order to improve efficiency and reduce costs.
2. Greater attention should be given to the integration of green product lifecycle and continuous improvement approaches, as both consider all stages of the product life cycle, from design to end-of-life management.

3. Economic units should adopt product recycling practices rather than relying solely on product disposal methods, thereby reducing environmental damage and increasing resource utilization.
4. Product lifecycle techniques and continuous improvement methods should be employed to analyze organizational activities and eliminate non-value-adding activities, leading to lower product costs.
5. A recycling stage should be formally incorporated into the product life cycle to enable the reuse of materials and components until the end of the product's useful life.
6. Research and Development (R&D) departments should be strengthened through scientific and practical training, and periodic reports should be prepared on production processes, environmental performance, and customer satisfaction.

References

1. Duque, N., Garetti, M., & Terzi, S. (2009). Product lifecycle management approach for sustainability. In Proceedings of the 19th CIRP Design Conference: Competitive Design (pp. 147–154). Cranfield University.
2. He, W., & Li, W. (2017). Research on green product design and sustainable development. In Proceedings of the 2017 9th International Economics, Management and Education Technology Conference (IEMETC 2017). Advances in Economics, Business and Management Research, 48, 117–120. Atlantis Press. https://doi.org/10.2991/iemetc-17.2017.24
3. Swetha, P. (2024). Impact of the Green Product Life Cycle on Customer Satisfaction and Loyalty. International Research Journal of Modernization in Engineering Technology and Science (IRJMETS), 6(12), 4597–4603.
4. European Union. (2010). Life cycle thinking and assessment for waste management. Luxembourg: Publications Office of the European Union.
5. Psarommatis, F., & May, G. (2022). Achieving global sustainability through sustainable product life cycle. In L. Wang et al. (Eds.), IFIP Advances in

Information and Communication Technology (Vol. 664, pp. 465–474). Springer. https://doi.org/10.1007/978-3-031-16407-1_46

6. Abbas, Z. O., & Zaher, Q. K. (2022). Customer knowledge management and its contribution to the product life cycle. Journal of Business Economics, 3(6), 46–58.
7. Khan, H. U., Ali, S., & Li, H. (2018). Impact of continuous improvement on organization performance: Insight from Pakistan—An empirical study. International Journal of Innovation, Management and Technology, 9(1), 1–8.
8. Hussain, Y. M. (2023). Adopting continuous improvement to achieve strategic success: An analytical study of the opinions of a sample of senior management leaders in hotel organizations (Deluxe) in Baghdad. Journal of Al-Israa University College for Social Sciences and Humanities, 5(10), 49–65.
9. Abboud, A. R., Al-Jabri, M. D. S., & Da'wah, A. N. A. (2024). The role of value stream cost technologies and continuous improvement in cost reduction. Journal of Sustainable Studies, 6(2), Suppl. 1, 2415–2432.
10. Slack, N., Chambers, S., & Johnston, R. (2010). Operations management (6th ed.). Pearson Education Limited.
11. Wahed, H. A., & Aletaiby, A. A. (2024). The role of change management in improving the quality of maritime logistics services through continuous improvement: An exploratory study in the port of Umm Qasr. The Gulf Economist, 41(62), 89–128. https://doi.org/10.33762/1287-000-062-004
12. Al-Shafeay, K. M. (2024). Green value engineering and green Kaizen technologies and their role in reducing costs: A theoretical study. International Journal of Transformations in Business Management, 14(1), 1–13. https://doi.org/10.37648/ijtbm.v14i01.001
13. Rash, A. T. H., & Al-Jubouri, M. I. A. (2023). The effect of continuous improvement according to the Kaizen methodology on the level of environmental performance. Journal of Business Economics, 4(4), 337–352.

14. Atrill, P., & McLaney, E. (2009). Management accounting for decision makers (6th ed.). Pearson Education Limited.