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Green Value Chain Costs and Their Role in Achieving Sustainable Competitive Advantage

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Abstract

Iraqi companies suffer from a significant waste of resources and an increase in the costs of operations and materials for producing the 2-ton window air conditioner. The reason is that these Iraqi companies did not apply green technologies in their activities and operations. The research aims to develop a 2-ton window air conditioner through the use of green value chain technology, focusing on the activities of green research and development, and green design through (replacement, redesign) to achieve the dimensions of sustainable competitive advantage represented by (cost, quality, flexibility, and concern for the environment). . In his study, the researcher relied on the company's data for the year 2023, in addition to repeatedly visiting the factory and conducting personal interviews with relevant parties. The researchers reached several conclusions, including that redesigning the heat exchanger from 4 rows to 3 rows will lead to reducing costs by an amount of 20,306 dinars for materials and production processes and increasing the efficiency of cooling performance, in addition to reducing the time of production operations from 45 minutes to 35 minutes, and replacing the gas is unnecessary. Environmentally friendly using environmentally friendly gas will lead to increased performance efficiency, reduced costs, and preservation of the environment due to the inability of environmentally friendly gas to deplete the ozone layer.

Keywords: *Green value chain; green research and development; green design; sustainable competitive advantage.*

Introduction

The concept of the value chain first appeared in the 1950s at the hands of the American merchant Lawrence Mills, who divided the economic unit into activities that add value to the product (the main ones). This concept was developed by Porter in 1985 through his book "Competitive Advantage." Which divided the activities into main activities that contribute to manufacturing the product and other non-main activities (support) for production processes (Boughzara, 2017: 12).

Porter presented a model of the value chain that explains the profit margin achieved by the economic unit, which represents the difference between the revenues generated from practicing activities and the costs of completing these activities. He also divided the value chain activities into two parts: the first part is the basic activities, which are five activities, and the second part is the supporting activities. Or support, which are four activities.. (Nguyena, 2020: 686)

The green value chain concept represents a contemporary approach that prioritizes sustainable development and environmental conservation. It integrates the principles of sustainability and environmental protection into all stages of production, supply and distribution. This concept is a response to global environmental challenges such as climate change, resource depletion, and rising levels of pollution. A green value chain includes a series of economic activities from research and development to product recycling and disposal, focusing on environmental considerations throughout the product life cycle to reduce resource waste and avoid unnecessary costs. (Srour and Abdel Qader, 2019: 55)

The First Research: Research Methodology

Research Problem

The value chain has undergone radical changes as a result of the increasing responsibility of economic units. Today, these units face increasing pressure from various stakeholders to improve their economic, environmental and social performance. These pressures are reinforced by public authorities who stress compliance with environmental and legal requirements. At the same time, customers are looking for green and friendly processes and products. Accordingly, the sustainable competitive advantage of industrial economic units is closely linked to concern for the environment and society. Therefore, many economic

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units have joined the concept of the green value chain, which ensures the integration of environmental, economic and social aspects into their operations and decisions. The following question can be asked:

Does applying the green value chain in the window air conditioner factory contribute to achieving the dimensions of sustainable competitive advantage represented by (cost, quality, flexibility, environment)?

Research Objectives

A- Introducing the concept of the green value chain, sustainable competitive advantage and its dimensions.

B- Clarifying the role of the green value chain in achieving the dimensions of sustainable competitive advantage.

T- Providing an applied study in the research sample company on implementing the green value chain.

The Importance of Research

The importance of measuring the costs of producing green products according to green cost management techniques represented by the green value chain compared to traditional costs and its role in achieving the dimensions of sustainable competitive advantage, while presenting an applied study in the economic unit of the research sample.

Research Hypothesis

The research is based on the hypothesis that measuring costs according to the green value chain contributes to achieving a sustainable competitive advantage for these units. Represented by (cost, quality, flexibility, environment).

Research Limitations

A- Spatial boundaries: The window air conditioner factory was chosen in Al-Waziriya, which is one of the factories of the General Company for Electrical and Electronic Industries.

B- Time limits: The time limits for the research were limited to cost data for the fiscal year ending on 12/31/2023, as it is close to the year of research.

Search Model:

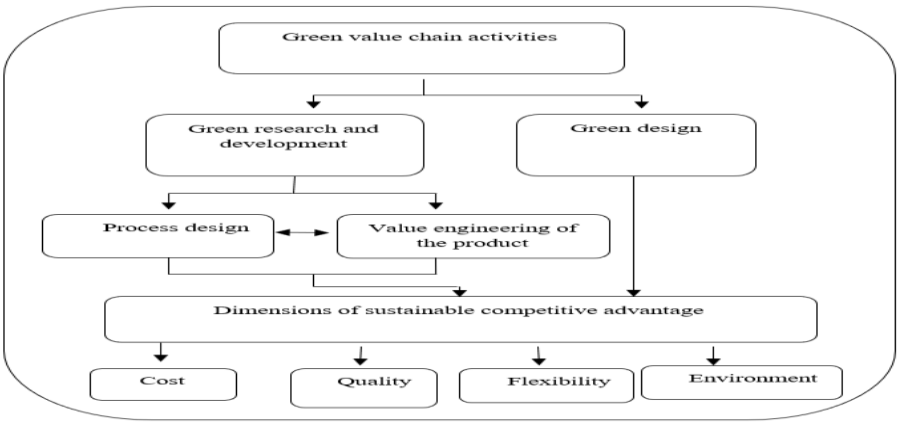

Figure 1. Default search form.

The second Research: The concept of the green value chain and sustainable competitive

Advantage.

First: Definition of the Green Value Chain

It is a set of activities that are practiced to ensure optimal consumption of natural resources, in addition to increasing the share of recycled and renewable resources on the input side to maximize resource and energy efficiency at every stage of the value chain operations and reduce negative environmental impacts as outputs at all points of the chain. (Wijesekera, 2022: 55-56)

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Second: Green Value Chain Objective

The green value chain seeks to achieve the following goals: (Abdulkadhim, 2023: 4)

1. The green value chain aims to reduce resource and energy consumption and reduce waste and pollution.

2. Supporting the economic unit's capabilities in producing green products in a more innovative way by translating customers' needs into technical summaries that describe the problem that needs to be solved, then presenting these problems to specialists for the purpose of devising a solution to them.

3. Strengthening the health requirements of workers in the economic unit by transforming its activities into environmentally friendly ones.

4. Contributing to re-engineering processes to reduce waste and recycling or disposal of both production waste and used products.

5. Establish a separate, independent business unit to develop new ideas that support the unit's long-term economic strategy.

6. Improving the quality of products by contracting with suppliers who take into account environmental requirements and controls, as well as improving quality and efficiency.

Third: Green Value Chain Activities

Green value chain activities consist of seven green activities:

. *Green R&D*

The resources and capabilities of the economic unit are vital concerns regarding environmental performance. To enhance greening efforts, green research and development (R&D) will play a pivotal role (Ganda, 2017: 3). Environmental R&D is an essential element of modern industrial activity, as the strategic decisions of economic units depend on R&D. However, it can be difficult to manage if desired outcomes are not clearly defined (Ganda, 2017: 2). Green R&D activities provide significant benefits to both society and the economy by contributing to the reduction of environmental pollution and industrial emissions. Moreover, economic units that benefit from experience and research can enhance operational efficiency, reduce operating costs, and achieve high levels of performance (Tang, 2020: 3). Green R&D is defined as the establishment of a set of principles and tests for green design, enabling economic units to support designers in developing and testing products according to life cycle assessment (Kung & Huang, 2012: 114).

Green Design

From a design perspective, "green design" can also be referred to as ecological design, economic design, sustainable design, or e-design. Green design aims to take into account considerations such as quality compliance, where minimizing the use of non-renewable resources and maximizing the use of available resources can increase the functionality and quality of the product/service, which automatically leads to cost reduction. The impact of green design is not limited to reducing land pollution but extends to manufacturing and its processes to align with green principles for efficiency and sustainability. These factors play a crucial role in the market, helping industries remain competitive (Kadam, 2022: 31).

Green product design is defined as a set of project practices aimed at creating environmentally friendly products and processes. Its goal is to design and develop environmentally friendly products to reduce environmental impact through product life cycle analysis. It represents a new approach to product design, which involves identifying environmental aspects associated with the product and integrating them into the product design and development process (Okunuga et al., 2022: 10).

Green Manufacturing

Green manufacturing emerged as a new concept in the 1990s, stemming from Germany, and with roots in the principles of waste reduction in lean manufacturing. It aims to meet the growing environmental awareness in the markets by enhancing resource efficiency, reducing waste and pollution, and addressing health and environmental issues. This concept has gained global importance, which is evident in legal mandates in various countries to promote sustainable practices in various industries. The momentum for

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green manufacturing arises from cost constraints, evolving customer demands, intense competition, and industry disruptions, all of which drive the need to enhance it. Focusing on green manufacturing is pivotal for industries to improve operations, reduce costs, enhance their image, mitigate environmental risks, and enhance competitiveness, and it involves strategies such as research, innovation, process improvement, and supporting renewable energy to produce environmentally friendly products (Al-Zalzali and Surour, 2022: 230).

Green Marketing

Also known as environmental marketing, social marketing, economic marketing, or sustainable marketing, it was first introduced in the early 1970s by the American Marketing Association. The goal was to promote products that were supposed to be safe and environmentally friendly. Green marketing has evolved over the years and has different names that all emphasize its focus on environmentally responsible and sustainable practices in marketing and promoting products (Adbaidainya, 2021).

Green marketing is defined as a marketing practice that addresses environmental issues through a set of actions that aim to ensure that the exchange of products has the least possible negative impact on the environment and to make the activities of the economic unit more harmonious and harmonious with the environment. (Correia et al., 2023: 2).

Green Distribution

Distribution is generally defined as economic intermediaries that aim to make products available for consumption or use (Al-Bakri and Ismail, 2016: 66). On the other hand, green distribution is defined as "one of the important activities in the green value chain that contributes to adding value to green products by reducing energy consumption and pollution by transporting finished products to customers using environmentally friendly transportation methods and choosing healthy and environmentally safe distribution channels" (Abdel-Kadhim, 2023: 5).

There are a set of procedures that must be followed to achieve green distribution, including (Sinambela et al., 2022: 158):

Adopting and developing central distribution methods that achieve environmental benefits, such as reducing vehicle movement and recharging them.

Establish an appropriate policy to reduce emissions from vehicles when distributing products. This stage also refers to the distribution of finished products from manufacturing to customers. The transportation system is one of the systems that has the most impact on the environment, as it affects the environment through transportation networks, means of transportation, and transportation waste such as spare parts and vehicles. This results in noise, air pollution, harmful emissions and increased congestion.

Green Services

Green services are an essential part of the green value chain, with a focus on providing environmental and sustainable solutions to customers. The service industry has gained increasing importance in recent decades due to the high rate of economic activity, resulting in increased resource consumption and emissions. Therefore, developing green services becomes crucial after the product is delivered to customers. Most economic units still believe that there is a positive relationship between sustainability and costs, as their competitive advantage increases through the provision of green services. This means that services create value when they provide benefits to customers and enable cost reductions (Ganzb & Cocca, 2015: 181).

Green services aim to provide technical support and maintenance for green products after they are purchased and delivered to customers. It also aims to improve product quality, improve its environmental performance, reduce resource consumption and extend product life. After-sales services typically include maintenance, repair and replacement of green products. In addition, it includes providing technical support and training to customers on the proper and environmentally friendly use of the product. Economic units can enhance the efficiency of green after-sales services by adopting preventive maintenance methods and other preventive measures that reduce maintenance and repair costs while improving the quality of green products. The increasing environmental focus has led to increased responsibility of economic units towards the environment, and they have invested in this direction to gain competitive advantages. Hence the

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concept of green services emerged. Green services are defined as services in which the target criterion for their provision or use is environmental sustainability. To be more precise, a service is considered green when it adheres to a pre-defined set of environmental sustainability criteria (Ganzb & Cocca, 2015: 181).

Green Recycling

Purchasing instead of repair has a negative impact on environmental resources. According to figures published by the Swedish Waste Management and Recycling Association, the production of a new laptop and a mobile phone results in 210kg and 110kg of carbon emissions, respectively. In addition, electronic devices contain a large amount of heavy metals, which would cause severe environmental pollution if disposed of indiscriminately. Therefore, despite the current rapid turnover of electronic and electrical products and the willingness of many consumers to pay for new features, there are still many people who prefer repair to purchase to conserve resources and protect the environment. A recent survey showed that almost 80% of European consumers support economic units that manufacture products designed for easy repair. Another expert stated that enabling consumers to repair products themselves is a highly desirable goal. In order to promote "repair rather than buy", the European Commission adopted implementing regulations in October 2019 relating to the eco-design of ten types of electrical equipment. The detailed regulations specify design, production and maintenance standards for electrical appliances such as refrigerators, washing machines and screens. The regulation stipulates a minimum service life for these appliances, such as 7 years for refrigerators and 10 years for washing machines. The economic units that manufacture these products must take into account ease of maintenance when designing them and ensure the availability of appropriate spare parts at the right time. The European Commission estimates that this measure will save 167 TWh of energy annually by 2030 (Liu et al., 2021: 1).

Green recycling (GR) is a step towards achieving long-term environmental sustainability in manufacturing processes. This activity leads to various opportunities by reducing the consumption of natural resources and reducing environmental pressure as much as possible. In addition, waste has been recognized as a resource for recycling efforts. From this perspective, this issue affects the use of natural resources in the manufacturing process through waste, pollution and carbon emissions. All environmentally concerned business owners, stakeholders and consumers are encouraged to participate in sound waste management through recycling (Hasan et al., 2019: 335).

Fourth: The Concept of Sustainable Competitive Advantage

In light of the rapid development witnessed by the business world, it has gained utmost importance. The spread of economic entities has led to intensified competition in the field of business. To effectively meet the challenges posed by this dynamic landscape and fierce competition, economic entities must continue to innovate and generate new and innovative ideas to enhance their product or service offerings. This innovation is critical to the survival of these entities. Failure to innovate may lead to stagnation or even bankruptcy, as customers tend to lose interest in the products or services provided by entities that fail to adapt to modern changes. Experts stress that the ability to achieve sustainable competitiveness is indispensable for long-term success. This permanent competitive advantage is embodied in the unique advantage that the economic entity possesses over its competitors. It means that this entity excels in a specific field where others stumble (Abdel-Rahim et al., 2022:201).

Competitive advantage is defined as the process of creating greater customer value at the same or lower cost than competitors, or creating superior or equivalent value at a lower cost than that offered by competitors. (Sorour and Abdel Reda, 2018: 438)

Competitive advantage consists of two basic elements. The first is the ability to excel in price, quality, timeliness of delivery, after-sales services or innovative technology. The second is the ability to quickly meet customer needs, which leads to increased customer loyalty. (Sarour and Muhammad, 2019, 388).

To achieve competitive advantage and obtain economic advantage, there are a group of factors: (Sorour et al., 2019:229)

1. Human resources: This includes numbers, educational level, and labor costs, as about half of business failures are the result of management inefficiency.

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2. Natural resources: abundance, quality, accessibility, land and water costs, and mineral resources by maintaining suppliers, using interpersonal skills, and continuing to seek information to reduce raw material and labor costs.

3. Capital resources and level of capital cost to finance any industry.

Sustainable competitive advantage (SCA) is defined as implementing an environmental strategy that cannot be easily imitated by economic competitors of the same entity. This leads to achieving lasting goals and benefits. This definition emphasizes the importance of SCA as a critical goal that an economic entity must achieve by leveraging its diverse resources in order to outperform its competitors (Bintara, 2023: 2).

Fifth: The Importance of Sustainable Competitive Advantage

Sustainable competitive advantage is vital for any economic unit that wants to succeed and survive in a particular market in the long term. Sustainable competitive advantage means the ability to achieve a unique competitive advantage that enables the unit to achieve success and growth in the future. This importance can be stated as follows: (Ribeiro & Neto, 2021:2; Barcelona et la., 2023; Bari & Amzil, 2023)

1. Obtaining a market share: A positive indicator that pushes economic units to take a strong position in the market by obtaining a greater market share than that of other competitors.

2. Excellence in innovation and development: The economic unit can invest in innovation and development to achieve more sustainable competitive advantages, which leads to the development of its new advanced products or services that better meet customers' needs.

3. Increased profitability: If the economic unit has a unique competitive advantage, it is likely to be able to achieve the highest levels of revenues and profits, as the economic unit can offer its products at higher prices if it is unique.

4. Improving quality: Sustainable competitive advantage stimulates economic units to improve the quality of the products and services they provide, in order to remain continuous in the market and achieve sustainable success.

5. Attracting customers: If the economic unit has a sustainable competitive advantage, it will be able to attract new customers and maintain current customers.

Sixth: Dimensions of Sustainable Competitive Advantage

1. Cost: Cost is one of the most important dimensions. Economic units that compete directly on price will have costs as their main goal, as the prices of products provided to customers decrease as the costs of products and services decrease. It can be said that economic units also compete for things other than Price will be concerned with maintaining and reducing costs. (Lewis & Slack, 2018: 59-60)

2. Quality: Many definitions of quality refer to the specifications of a product or service, usually meaning high specification as in the case of the Mercedes S-Class, and quality can also mean appropriate specifications, meaning that the products and services are "fit for purpose or use, i.e. they work as they do." They are meant to do by nature. (Lewis & Slack, 2018: 56)

Quality is defined from the customer's point of view as the set of characteristics that the product or service has such that it is able to meet the needs and desires of customers (Jahanshahi, et al, 2011: 255), but from the point of view of the economic unit, it is the characteristics of the product that match several dimensions, which are (Performance, advantage, reliability, reliability, durability, utility ability, aesthetics, customer perceived value, safety) (Jakper, et al, 2012: 221)

3. Flexibility: It is one of the dimensions of sustainable competitive advantage through which the economic unit can quickly enter and exit activities and maximize its ability to deal with the fluctuations of events that it encounters in its internal and external environment. Flexibility is defined as demonstrating a wide range of capabilities. For example, they may be able to produce a wider range of products or services, or operate

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at different production levels. The same word, flexibility, is also used to mean ease of moving between its possible states. A process that moves quickly, smoothly, and inexpensively from doing one thing to doing another should be considered more flexible than a process that can only achieve the same change at greater cost and/or organizational disruption. (Morden, 2007: 67)

4. Concern for the environment: The first goal of economic units is to work to reduce input costs and increase returns. Therefore, these economic units do not spend any amounts on their environmental performance in order to get rid of or reduce environmental pollution, for fear of increasing the cost of their products, and to avoid problems. Environmental, and some industrialized countries have established various laws and procedures in order to preserve the environment by getting rid of pollutants, and this has forced economic units to spend large sums of money on the environmental waste treatment unit and use devices to reduce environmental pollution, which has led to high production costs. Here, the need arose to reconsider environmental issues, study them, and work to manage them in a way that the economic unit could achieve its economic and environmental goals. (Abbas, 2019: 61).

Seventh: The Relationship Between the Green Value Chain and Sustainable Competitive Advantage

With increasing competition, rapid technological development, and consumers' desire for renewable products of high quality and price, economic units are looking for new strategies to reduce the cost of production operations in addition to improving their competitiveness in the market, increasing their market share and ensuring their survival. This is now a strategic goal and path for economic units, and achieving this depends on It depends on several factors, including the ability of the economic unit to produce and market renewable products that meet the needs of consumers. Requirements in terms of question and price. In other words, sustainability from the point of view has requirements, which are profit growth rates, achieving a competitive advantage, acquiring and maintaining customers, improving the quality of production and operations, achieving employee satisfaction and loyalty, and optimal use of resources. The application of the value chain method in the units The industrial economy meets green requirements, as the value chain analyzes the activities through which the production process takes place with the aim of developing value-added activities and eliminating non-value-added activities. In other words, the strategic role of the value chain is to reduce costs, reduce waste, limit operations that do not increase value, and study cost driving factors and link them to revenues with the aim of improving the ability of the economic unit to make decisions. Reducing costs also positively affects gaining a larger customer base by providing Low cost products, reasonable prices, high quality, efficient delivery and making the economic unit's products more attractive to customers in such a way that they gain more customers, choose the unit's products, and reject competing products, which improves their competitive position, increases their market share, and thus reflects positively on profits (Jeejan , 2021: 306)

The researcher believes that the green value chain and sustainable competitive advantage are closely linked, as the successful adoption of the green value chain can contribute to enhancing the sustainable competitive advantage of economic units. The green value chain aims to improve the environmental performance of products and processes, while at the same time achieving a balance between environmental, economic and social performance. By applying green value chain concepts, economic units can achieve sustainability at different levels. They can improve resource efficiency, reduce harmful emissions, manage waste better, develop environmentally friendly products, and adopt more sustainable production methods.

Given that the economic unit has adopted a green value chain strategy, it can be a pioneer in providing value-added products and services to customers, while at the same time achieving balance with the environment. This approach can contribute to building a good reputation for the business unit and increasing its ability to attract customers interested in sustainability. In addition, economic units that adopt the green value chain have the ability to innovate and adapt to environmental changes and increasing environmental legislation. They gain in-depth knowledge of clean technology and sustainable processes, enhancing their ability to survive in the market and achieve competitive advantage in the long term.

The Third Section: Applied Study

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In pricing the 2-ton window air conditioner, the General Company for Electrical and Electronic Industries adopts the traditional method of cost plus a profit margin. Table (1) shows the parts, exchange rates, cost, and price of the 2-ton window air conditioner. Table 1

Table 1. Parts, function, exchange rates, cost and selling price of the traditional 2-ton window air conditioner for the year 2023.

Seq	Materials	Function	measuring unit	Exchange rate	Cost Iraqi Dinar
1	Compressor	One of the main parts of the refrigeration cycle is pumping the refrigerant gas	number	1	125000
2	Thermostat	To regulate the required temperatures	number	1	12000
3	Selection buttons	Start and end playback	number	1	1500
4	Air distributor motor(Super wave motor)	Air distribution	number	1	7500
5	Compressor mounting bolts	Installing air conditioner parts	number	3	1500
6	Intake tube(Suction pipe)	One of the parts of the refrigeration cycle (gas extraction)	meter	1	5000
7	Payment tube	One of the parts of the refrigeration cycle (gas propulsion)	meter	1	4000
8	Charging gas(Refrigerant R22)	Refrigerant gas in the cycle	kg	1.3	12000
9	Capillary tube(Capillary tub)	Reducing the pressure between the condenser and evaporator	meter	2	6500
10	Welding wire	Copper pipe welding	number	12	1000
11	Plastic granules material	Plastic parts are made from it	kg	1.5	6000
12	candidate	Air purification	number	1	2000
13	Fish plate(0.7, 0.8) mm	Manufacture of iron parts in the air conditioner	kg	13.6	25000
14	Fish plate(1.0) mm	Manufacture of iron parts in the air conditioner	kg	1.46	12000
15	Fish plate(1.2) mm	Manufacture of engine base parts	kg	1.382	16000
16	Fish plate(1.5) mm	Manufacture of air conditioner base	kg	6.064	19000
17	Intake pipe insulator	Insulation pipe insulation	poison	30	500
18	Foam insulators	Copper pipe insulation	layer	1	1500
19	Air conditioner window	Air conditioner face	number	1	7000
20	Thick copper tube(0.5) mm	Copper pipes for refrigeration cycles and heat exchangers are made from it	meter	7.5	33000
21	Thick copper tube(0.61) mm	Copper pipes for refrigeration cycles and heat exchangers are made from it	meter	4.5	22000

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22	Aluminum foil	To manufacture heat exchangers	kg	4	17000
23	Evaporator fan bushing	Installing the fan shaft (spring)	number	1	2000
24	Condenser fan bushing	Install the fan shaft	number	1	2000
25	Air conditioner motor(Fan motor)	To move the fan and serps	number	1	30000
26	Dye (powder)	Painting iron parts	Liter	1	9000
Cost of raw materials					380000
Cost of labor wages					+84000
Total initial costs (materials + wages)					=464000
Indirect costs					+98000
Total costs					562000
The profit margin is 21% of total costs					+118000
Traditional selling price					680000

Source: Cost calculations in the company.

It is noted from the table above that the selling price of the window air conditioner is 680,000 dinars, while the company's profits amounted to 118,000 dinars, while the operational costs amounted to 562,000 dinars, and the indirect costs amounted to 98,000 dinars, according to the records of the Costs Division.

Based on the company's data, it turns out that the number of air conditioners sold by the company is 200 window air conditioners during the year 2023, which means that it is operating at 7% of its available production capacity, which amounts to 3,000 units. This leads to disguised unemployment in the company and the burden of high costs per unit of product, because Operational costs will lead to cost inflation.

Ninth: Applying green research and development and green design activities to the research sample

This study aims to apply some green value chain activities to the research sample product represented by a 2-ton window air conditioner. These activities are represented by the two phases of green research and development on production processes and green design on product processes and design using green value engineering technology during the green design phase. My agencies are:

Green R&D:

This activity at the General Company for Electrical and Electronic Industries is represented in the traditional research and development department, which is considered the first activity of the green value chain activities. The researcher believes that this department did not pay any attention to the green activities and processes that can be followed to develop production processes.

When tracking the workflow and activities that add value to the product, it was found that the number of workers in the factory is not proportionate to the amount of air conditioners produced, which causes a waste of material and human resources resulting from the additional costs borne by the factory as a result of the increase in the number of actual workers above the standard because it is a non-value-added activity.

In order to determine the number of workers redundant in the factory departments, the workflow was monitored at all stages of production, and Table 2 shows the actual number of workers, the standard number of workers, the number of non-value adding workers, and the percentage of reduction in the number of workers.

Table 2. The actual and standard numbers of employees and the percentages of reduction in the number of employees

Department	**Actual number of employees**	**Standard number of employees ( )**	**Number of non-value adding employees**	**Percentage reduction in the**

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				number of employees
Subjectivity	1	1	0	0%
Planning and Follow-up	6	2	4	67%
Pistons	29	16	13	45%
Exchanges	35	22	13	37%
Dyeing	17	9	8	47%
Final assembly	43	26	17	40%
Assembling the electrical board	15	9	6	40%
Shipping and inspection	22	18	4	18%
Maintenance and services	4	3	1	25%
Plastic	4	3	1	25%
Encapsulation	2	2	0	0%
Total	178	111	67	38%

Source: Based on the Planning and Follow-up Division and a study prepared by experienced engineers.

It is noted from the table above that the number of redundant workers (non-value adding) is 67 workers, or 38%, which is a very high percentage. This surplus of workers also represents additional costs that must be disposed of in order to reduce the share of one unit of the product, as follows:

A - Each traditional window air conditioner needs 360 minutes to be produced, which is equivalent to 6 hours (360 minutes ÷ 60 minutes).

B - Average wage per minute = labor costs ÷ number of minutes required for the manufacturing and assembly process = 84,000 ÷ 360 = 233.34 dinars / minute

In the above equation, the worker's average wage per minute was calculated

The amount of reduction in work wages = 84,000 x 38% = 31,920 dinars

The cost of labor wages after excluding non-value adding workers = 84,000 – 31,920 = 52,080 dinars.

Average cost of labor wages after getting rid of non-value adding workers = 52,080 dinars ÷ 360 minutes

= 14.67 dinars

Green Design Stage

This stage focuses on developing the process and product design in a way that maximizes resource and energy consumption, reduces costs, and improves the efficiency and performance of the product. After studying the product design with the engineering team, it was found that there is a possibility to develop the design of the traditional 2-ton window air conditioner through a change in the design method. And the production of a heat exchanger consisting of 4 rows to the design and production of a heat exchanger consisting of 3 rows.

The function of the heat exchanger (condenser) in the 2-ton window air conditioner is to convert the condensed gas in the refrigeration unit into liquid, by cooling the high-temperature gas and converting it into a high-pressure liquid. This is done by passing air from outside through the heat exchanger, which helps in cooling The gas is converted into a liquid, which allows the window air conditioner to use this liquid in the cooling cycle again, noting that reducing the number of rows in the heat exchanger from 4 to 3 rows leads to an increase in cooling efficiency because it will take more time to cool the gas and turn it into a high-pressure liquid.

As for the components of the heat exchanger (condenser), which consists of 4 rows, they are as follows:

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A - A short copper U-pipe with a number of (33) tubes according to the design of the condenser. The short copper U-pipe is used to close the long copper tubes to complete the closure of the refrigeration cycle.

B - Long U-pipe copper tubes, numbering (34) tubes, including (19) unfinned copper tubes and (15) internally finned copper tubes.

T - Corrugated fin aluminum foil with (14) thins per ang (ang = 25.4 mm) in order to increase the effectiveness of the surface area for transferring heat from the hot surface to the external surroundings.

D - The side plate supporting the exchanger, the right and left, is made of galvanized iron, thickness (0.8) mm, and consists of four rows of holes.

C - Welding rings are placed on the short copper U-pipe for the purpose of performing the welding process with the long U-pipe and closing the copper tubes.

The costs of the 4-row heat exchanger were as follows:

Table 3. 4-row heat exchanger costs

Seq	Cost Elements	The cost of a 4-row heat exchanger	Details
1	Materials	48780	4400x 5m + 4890 x 2m + 4kg x 4250
2	Operating costs	10500	45Minute233.34 ×
3	Total industrial costs	59280	
4	Marketing costs	1186	2% of industrial costs
5	Administrative costs	2964	5% of industrial costs
6	Total costs	63430	

Source: Cost calculations

It is noted from the table that the cost of the 4-row heat exchanger is 63,430 dinars, and the purpose of the calculations is to make a comparison with the design of the new 3-row heat exchanger. The figure below shows the heat exchanger consisting of four rows.

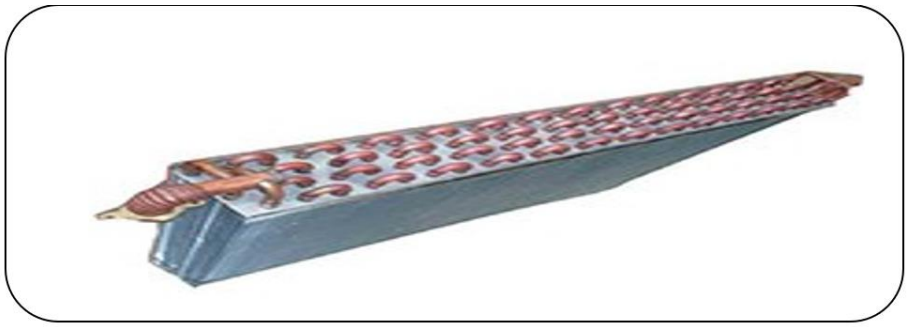

Figure 2. The heat exchanger (condenser) has four rows

Source: Technical Department.

Based on the opinions and experience of the engineering team, there is a set of approved principles that should be followed in order to change the heat exchanger of the 2-ton window air conditioner from 4 rows to 3 rows, which are as follows:

A - Changing the specifications of copper pipes from (19) non-finned copper tubes and (15) finned copper tubes to (25) finned copper tubes only, as the percentage of increase in the number of finned copper tubes was (40%) and the percentage The decrease in the number of total copper tubes is approximately (26.5%). Figure (16) shows finned and non-finned copper pipes.

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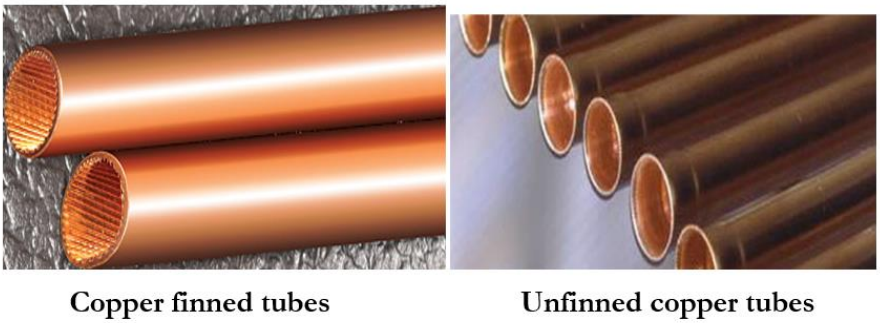

Figure 3. Finned and unfinned copper pipes.

Source: Technical Department

B - Changing the design of aluminum foil from the Corrugated fin (Sine wave rippled edge) type to the Straight fin edge Louvered fin type, as this change led to a reduction in the exchange rates of aluminum foil from 4 kg to 3 kg, at a rate of 10 foil per inch instead of 14 thin per inch. Figures 17 and 18 show the shapes of aluminum foil of the above types.

Figure 4. Straight fin edge Louvered fin green aluminum foil.

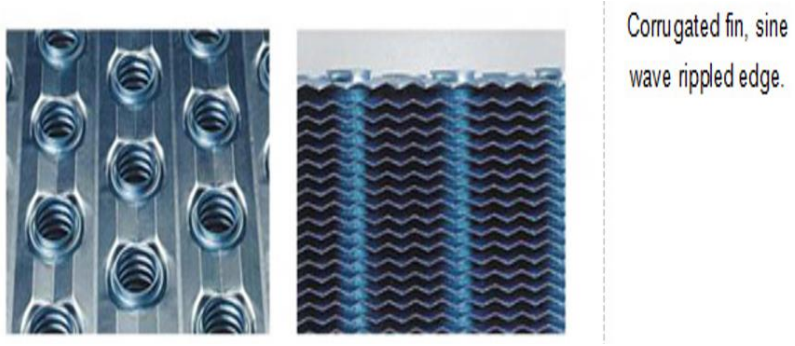

Figure 5. Conventional Sine wave rippled edge aluminum foil

Source: Technical Department.

T - Reducing the number of rows also leads to a reduction in the compressor capacity consumed due to a decrease in the pressure drop in the pipes.

The following table shows a proposal for designing a heat exchanger consisting of 3 rows instead of 4 rows and the time required for each process, with a comparison with a heat exchanger consisting of 4 rows:

Table 4. Design process of a 3-row heat exchanger and process time.

Seq	Process	The time required for the process of designing and	The time required for the process of designing and

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		manufacturing a 4-row heat exchanger	manufacturing a 3-row heat exchanger
1	Design a program on the (NC) machine to manufacture side plates consisting of three rows of holes instead of four rows and made of galvanized iron of the same thickness.	14 Using handmade metal molds	10
2	Cutting the raw material into thick galvanized iron (0.8m) according to the required measurements.	1	1
3	Assembling copper pipes with FIN kit manually.	5	3
4	Determine the method of distributing copper pipes in accordance with the number of rows (3).	2	1
5	Pressing a set of aluminum foil (fins 10 per ang) and copper tubes with side plates using an Expander press.	6 (14) thin per inch	4
6	Wash the heat exchanger using a special washing machine.	5	5
7	Leave the heat exchanger for drying purpose.	4	4
8	Return bend – A copper pipe assembly is welded with the heat exchanger by Exy – acetylene welding electrode.	6	4
9	Complete the process of assembling the heat exchanger completely so that it is ready for inspection.	2	3
Total minutes		45	35

Source: Technical Department

It is noted from the table above that the manufacturing process time for the heat exchanger has decreased from 45 minutes to 35 minutes. The following table shows the total cost of the heat exchanger (condenser), which consists of (3) rows.

Table 5. 3-row heat exchanger costs.

Seq	Cost Elements	The cost of a 3-row heat exchanger	Details
1	Materials	35240	4400x m4 + kg1 x 4890 + 3kg x 4250
2	Operating costs	5063	
3	Total industrial costs	40303	
4	Marketing costs	806	2% of industrial costs
5	Administrative costs	2015	5% of industrial costs
6	Total costs	43124	

Source: Itsab Researcher and Technical Department.

It is noted from the table above that a heat exchanger (condenser) for the window air conditioner with a capacity of (2) tons was designed in a new form consisting of (3) rows instead of the current heat exchanger, which consists of (4) rows, with the necessary changes made by using finned copper tubes from inside instead of unfinned copper tubes, which increase the process of heat exchange and transfer, and changing the type, shape and quantity of aluminum foil, which increases the surface area of heat exchange and thus increasing the efficiency of the cooling process, taking into account the method of distributing the copper tubes and the quality of the raw material involved in manufacturing the heat exchanger so that it is compatible The company has the capabilities available to reduce the cost of the raw materials involved in

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the production of the heat exchanger (copper tubes and aluminum foil) while reducing the mechanical operations and operating time required to produce the heat exchanger and thus reducing operating costs. This design contributes to reducing the cost of the heat exchanger (condenser). per unit, thus reducing the total cost of manufacturing the Iraqi window air conditioner with a capacity of (2) tons and an amount of (20,306) dinars per exchanger (63,430-43,124), by (6,766) dinars for production operations, of which (5,437) dinars are direct costs and (1,329) dinars are indirect costs, while (13,540) dinars) dinars for raw materials. This design also contributes to reducing the time required for the manufacturing process from 45 minutes to 35 minutes, thus reducing the manufacturing time of the 2-ton window air conditioner from 360 minutes to 350 minutes. Figure 4 shows the heat exchanger (condenser) consisting of 3 rows.

Figure 5. Heat exchanger (Condenser) 3 rows.

Source: Technical Department

The General Company for Electrical and Electronic Industries still uses Freon R22, which is not environmentally friendly, in many of its products, including the 2-ton window air conditioner. This gas is a chemical compound consisting of chlorine, fluorine, carbon, and hydrogen atoms. The environmental problem of this type of gas is its ability to destroy the ozone layer when It leaked into the atmosphere, and as a result of the Montreal Convention in Canada, the use of this type of gas was banned in many countries and the use of alternative refrigerant gases that were less harmful to the environment.

Based on information from the Research and Development Department, there is an alternative gas to R22 Freon, which is R410, to be environmentally friendly. This type of gas has the following advantages:

1) Efficiency in energy use, as this type of gas is characterized by a higher capacity and efficiency than R22 Freon gas, as the compressor that uses R410 gas transfers greater pressure to the system and pipes than the compressor that uses R22 Freon gas, which leads to an increase in the efficiency of the cooling system. Improving it, reducing energy consumption and thus saving costs.

2) This type of gas is considered environmentally friendly, as it works to reduce the effect of global warming and the inability to deplete the ozone layer and reduce carbon dioxide emissions by 95% in order to produce a green product that preserves the environment and enhances its sustainability.

3) This gas is considered non-flammable and non-toxic, which makes it a safe option for use in commercial and residential spaces. It is also compatible with a wide range of air conditioning systems.

The prices of environmentally friendly R 410 gas vary according to international origins and the degree of purity. The price of the French Friojet gas is 180,000 dinars and weighs 11.3 kg, while the price of the Chinese gas type Shingchem is 100,000 dinars and the weight of 11.3 kg, while there is another American gas (Honeywell). For 125,000 dinars, for the same weight, the cost of Freon R22, which is not environmentally friendly, is 104,000 dinars, with a weight of 11.3 kg.

The researcher believes that replacing R410 gas with R22 Freon, which is not environmentally friendly, will lead to a reduction in costs by 500 dinars in the case of using Chinese gas for each window air conditioner, and 9,000 dinars at the cylinder level of 11.3 kg, noting that the amount of gas needed for a 2-ton window air conditioner is 1.3. kg.

Using R410 gas instead of R22 gas will lead to achieving a sustainable competitive advantage because it will preserve the environment, reduce costs, and improve the quality and efficiency of the window air conditioner's performance. The table shows the cost of the window air conditioner after applying green research and development and green design activities.

Table 6. The cost and selling price of a 2-ton window air conditioner before and after implementing the green value chain.

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Seq	Details	Costs before implementing the green value chain	Costs after implementing the green value chain	the difference
1	Raw materials	380000	365960	14040
2	Wages	84000	46643	37357
3	Indirect costs	98000	96671	1329
4	Total costs	562000	509274	52726
5	The profit margin is 21% of costs	118000	106948	11052
6	Selling price	680000	616222	63778
7				

Source: The researcher's calculation based on the stages of research and development and green design.

It is noted from the table above that costs decreased from 562,000 dinars to 509,274 dinars, a difference of 52,726 dinars. This reduction will lead to a reduction in the selling price of one unit from 680,000 dinars to 616,222 dinars, and this will lead to an increase in the number of units sold.

Conclusions

1. The green value chain is considered one of the strategies that supports the competitive advantage of the economic unit by focusing on the economic, environmental and social aspects, and reflecting this on the tangible value to customers, which leads to growth in the competitive business environment.

2. Using the green value chain leads to preserving the environment by replacing the environmentally unfriendly gas R22 with environmentally friendly gas R410, which contributes to preserving the ozone layer, improving the efficiency of cooling performance, and reducing costs by 500 dinars.

3. Using the green value chain will lead to reducing labor costs and indirect costs by 37,357 and 1,329 dinars, respectively, due to the elimination of non-value-added workers and the development of the heat exchanger design from 4 rows to 3 rows.

4. Redesigning the heat exchanger from 3 rows to 4 rows will reduce costs, increase the efficiency of cooling performance, and reduce raw material consumption rates.

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