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Scientific Platform

Balanced scorecard integration and green process re-engineering to optimize the performance of economic units

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Abstract: There are several ways that economic units can become more efficient in energy use and reduce carbon emissions. Through re-engineering processes and the development of a systematic approach to the management of resources, environment, and individuals, economic units can achieve the same results as their competitors by reducing costs and increasing revenues, as the re-engineering of green processes aims to prevent the use of resources in an unsustainable way. Taking a comprehensive approach to achieving sustainability and integrating the Balanced Scorecard (BCS) with green process re-engineering can help improve the overall performance of economic units. This study aims to identify the theoretical concept of the balanced scorecard and re-engineering green processes. Improving the performance of the plant research sample through integration between the balanced scorecard ling technology and the process re-engineering technology. The study relied on the main hypothesis that the application of the steps of integration of the balanced scorecard technology and the re-engineering of green processes has a role in improving the performance of the factory sample of the study. The study reaches several conclusions, the most important of which is that the application of integration steps contributes to improving the overall performance of the factory sample of the research from 63% to 75% and that there is a low, uneven, and significant imbalance of performance

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according to the balanced scorecard perspectives, where the performance of the financial perspective 83%, and the environmental and community perspective by performance 33%.

Keywords: balanced scorecard, performance improvement, green process re-engineering, integration

1. Introduction

Improving the performance of economic units is a vital mission to ensure the continuity of success in the market, which is why managers and industrial engineers seek to improve the performance of production processes continuously. Balanced Scorecards and Green Process Engineering are modern tools that can be used to achieve this goal. This study will discuss how these technologies can be used to improve the performance of economic units and preserve the environment simultaneously.

The problem of this study is the low overall performance in the study sample factory and most Iraqi industries, and to achieve the objectives of this study was divided into four sections. The first includes the theoretical aspect of the balanced scorecard and re-engineering green processes. In contrast, the second section addressed the integration between them, the third section dealt with the practical application of integration in the study sample factory, and the fourth section included the conclusions reached and the necessary recommendations to help the study sample achieve its objectives.

2. Methodology of the study

The problem of the study is the poor performance of the Iraqi economic units on the one hand and the lack of compliance with the regulatory legislation on environmental protection on the other hand to improve the reality of the performance of the Iraqi economic units.

2.1. Study objectives

- Recognize the theoretical concept of the balanced scorecard and re-engineer green processes.
- Improving the performance of the research sample plant through integration between the balanced scorecard technology and the green process re-engineering technology.

2.2. Importance of the study

The integration of the balanced scorecard and the re-engineering of green processes have a great place in modern industry, as they can be used to improve the performance of economic units. These technologies help improve quality and productivity, reduce costs, and improve the environmental performance of industrial economic units. This study aims to review the benefits of balanced scorecard integration and green process re-engineering in improving the performance of economic units.

2.3 Study hypotheses

The application of the integration steps of the balanced scorecard technology and the re-engineering of green processes has a role in improving the performance of the study sample plant.

2.4. Description of the study sample

The practical part of the research is conducted at the sulfuric acid factory, part of the Euphrates General Company for Chemical Industries and Pesticides, and falls under the Iraqi Ministry of Industry and Minerals. Balanced scorecard technology is being used to extract data from the factory and study sample, enabling the identification of weaknesses in the overall performance of economic units.

3. Balanced scorecard definition and green process re-engineering

The Balanced Scorecard (BSC) is one of the basic contents of management accounting (Tuan, 2020:71), and since its invention before (Kaplan & Norton, 1992) as a framework for measuring and evaluating the performance of economic units and their development. It added strategic non-financial performance measures to traditional financial measures to give managers a more accurate and comprehensive view of organizational performance. According to this development, the concepts mentioned by the writers and researchers of (BSC) are numerous.

It is a method that translates the strategy of the economic unit into clear objectives, using a set of financial and non-financial metrics, which change with competition and significant changes in foreign markets, and the joint evaluation of short-term operational performance in light of long-term strategic performance (Ojah et al., 2019), It is a concept of how to transform the vision and strategy into objectives and its metrics so that it comprehensively covers not only the areas of financial performance of the economic unit, but also non-financial areas, It is a tool to communicate the message and strategy between the various levels of management and ordinary workers, and is used to keep all workers informed about the processes or activities that affect current and future success (Benková et al., 2020), a strategically oriented management technique designed to evaluate and manage performance through a set of coherent and balanced financial and non-financial measures, and also designed to translate the vision, mission and strategy of the economic unit into strategic objectives, objective standards and values, and clear and coherent logical initiatives, to help management by providing feedback to internal operational processes and external products in order to continuously develop performance and achieve strategic objectives (Ali Page, 2021; Żywiołek et al., 2022).

The Balanced scorecard is a management tool used to set key performance goals and measure work progress in achieving these goals. The card includes six perspectives: financial perspective, customer, internal processes, learning and growth, environmental, societal, and risk perspective.

As for the term green process re-engineering (GPRE), it is a new term to describe the application of the concepts of process re-engineering (P-RE) coupled with a contemporary performance scale for environmental impact (Schatzberg et al., 1997), and like all restructuring efforts, the green re-engineering initiatives (GPRE) challenge the basic organizational values and culture by changing them in operations. Green process re-engineering (GPRE) mainly improves the operations of the economic unit from an environmental aspect. The community and natural environment around an economic unit are high-value categories (Speshock, 2010). They are defined as an approach by (Nowak et al., 2011). This approach involves redesigning the economic unit's operations, infrastructure, and organization to create an energy-efficient environmental system. It also includes process re-engineering that considers environmental impact. The manufacturing, packaging, and distribution processes are redesigned and improved to be more sensitive to the natural environment (Funk et al., 2013). That provides concepts and methods to support operations considering the environmental impact (Maciel, 2017).

Green process re-engineering refers to redesigning production and service processes to improve environmental efficiency and reduce waste and energy consumption. Green process re-engineering involves using modern technologies, environmentally friendly materials, and improved waste and waste management.

4. Benefits and methodology of integration between the balanced scorecard and green process re-engineering

4.1. The benefits of integration between the balanced scorecard and green process re-engineering

The integration between the balanced scorecard (BSC) and green process re-engineering (GPR) gives economic units the benefit of their advantages and objectives achieved and avoids the disadvantages and disadvantages of each technology alone, concerning the balanced scorecard technology (BSC), as a comprehensive system for evaluating and measuring strategic performance in economic units. It seeks to provide a framework for comparative work and translate the objectives of the strategic economic unit into a coherent and coherent set of measures (Al-Masoudi, 2018). One of the most critical activities is performance evaluation, which has many benefits and advantages: (Christinian & Beiman, 2007; Al-Masoudi & Al-Susair, 2019; Al Khafaji, 2019; Benková et al., 2020; Alotaibi et al., 2021).

1. Correct the limitations and limitations in traditional measurement tools and techniques, and lead to the satisfaction of administrative needs as they combine in one report multiple parts of the strategies of economic units.
2. Clarify the economic unit's vision and strategy, and provide a comprehensive framework for translating strategic objectives into metrics.
3. Helps reduce profit sub-maximization issues by forcing managers to consider all important operating metrics.
4. Linking and communicating financial and non-financial performance goals and measures.
5. Enhancing and strengthening feedback on the economic unit's vision and strategy.
6. Expressing the performance of the economic unit in its full dimensions (finance, operation, marketing, growth, environment, and society).
7. Contribute to the integration of various technologies and programs of the economic unit, such as (quality, re-engineering, and customer service initiatives).

Green Process Re-engineering (GPR) in pursuit of sustainable and energy-saving growth and reducing emissions from operations, brings benefits to the economic unit by reducing costs, improving the image of the economic unit, eliminating non-green, erroneous, and repetitive processes that lead to inefficient work, and generating a high percentage of environmental pollution, as well as assisting economic units in obtaining sustainable operations and determining the level of emissions resulting from their operations (Nowak et al., 2011a), thus enabling economic units to achieve the benefits of:

- Sustainable redesign of its operations based on environmental dimensions.
- Integrate infrastructure improvement techniques and process re-engineering techniques.
- Avoid organizational deficiencies by incorporating the 'human factor'.
- Improving energy consumption beyond the limits of economic units. (Nowak et al., 2011a).

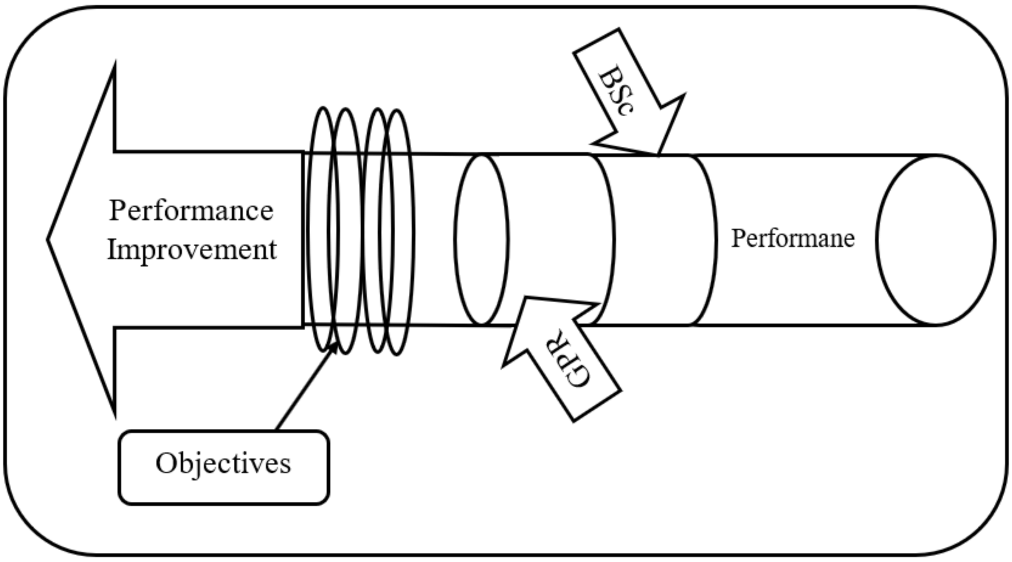
To take advantage of the advantages, characteristics, or benefits of these two technologies, in addition to enhancing their strengths and avoiding weaknesses, it requires the adoption of a certain methodology through which the integration between the balanced scorecard and green process re-engineering technology is achieved, in a way that provides the economic unit with the ability to exploit its resources on the one hand better and adhere to the legislative and legal requirements for environmental protection and pollution reduction on the other hand, and thus the unit ensures the reasons for providing competitive advantage as well as continuity in the contemporary business environment.

4.2. Integration methodology the benefits of integration between the balanced scorecard and green process re-engineering

The integration between the balanced scorecard technology (BSC) and the green process re-engineering technology (GPR) contributes to the implementation of the economic unit strategy and the achievement of strategic objectives and the achievement of the best performance of total productive maintenance (TPM). This performance is coupled with compliance with the legislative and regulatory requirements of the environment by implementing the green process re-engineering technology (GPR) and the balanced scorecard (BSC) BImage of the complementary relationship between both the balanced scorecard technology (BSC) and the green process re-engineering technology (GPR) by extracting the indicators and measures of the balanced scorecard from the overall performance objectives in the economic units. The measures extracted from the objectives collectively provide financial and non-financial information that is used as inputs to the balanced scorecard and in the form that contributes to the evaluation of strategic performance and then improves the overall performance in the economic units by applying the steps of the green process re-engineering technology. This represents the essence of the integration between the two technologies.

The integration between the two technologies consists of two aspects. The first aspect, which reflects this integration, is a translation of the objectives of the economic units and their reflection in the form of metrics included in each perspective of the balanced Scorecard (BSC). The second aspect reflects the improvement of performance by applying the green process re-engineering (GPR) technology, noting that integrating these two aspects is a methodology that leads to achieving the ultimate goal of improving performance in economic units. Figure 1 illustrates this relationship between the balanced scorecard and green process re-engineering.

Figure 1: Integration between the balanced scorecard and green process re-engineering



Source: Prepared by the researcher

5. Evaluating performance by applying the balanced scorecard

BSC was first developed by Kaplan & Norton as a performance management technology. Evaluating the performance of the business and activities of economic units is not only done according to the traditional (financial) perspective but also takes into account other perspectives (customer satisfaction, internal processes, learning and growth, community and environment, and risk perspective). These basic and critical perspectives will determine the success of any system or activity within the economic unit in achieving its objectives and, thus, the strategic objectives of the economic unit. Each perspective of BSC is linked to a set of objectives that, in turn, have the flexibility to meet any applied metrics.

There is a possibility of applying the methodological reference provided by (Kaplan & Norton) Balanced Scorecard (BSC) to evaluate performance according to a **model called the "four-stage model,"** where the model adapts the conceptual base of BSC). It consists of four stages: (Biasotto, 2010):

1. Define strategic vision and specific success factors
2. Identify and link strategic objectives to success factors for each perspective
3. Setting performance measures
4. Consolidation and follow-up

This sequence of stages contributes to the extraction of the strategic objectives of the economic units and that the strategic objectives through which performance can be based are (high contribution return, reducing maintenance costs, reducing lost time costs, reducing administrative costs, reducing quality costs, lack of customer complaints through customer satisfaction, reducing damage in production and production, improving equipment performance and reliability, participation of workers in supporting functions to improve performance, maintaining a clean work environment, reducing work accidents and injuries, reducing sudden malfunctions, finding alternatives in the event of emergency malfunctions (Almeanazel, 2010 ; Biasotto, 2010; Lemma et al., 2013; Majerčák et al., 2013; Vargas et al., 2017; Alhasmon, 2017; da Silva & de Souza, 2020; Fadil, 2020), and by following the four-stage model The objectives are translated into the performance measures of each of the four stages, and that the success factors take into account the critical stage of the objectives, as well as the analysis of the objectives and the result of the performance measures, as shown in the Table below:

Table 1: Performance evaluation metrics

Perspective		Scale	The equation
Financial (F)	**F1**	rate of return on assets %	(Net profit/total assets) x 100
	F2	rate of return on investment %	(Net profit / invested capital) x 100
	F3	Maintenance cost per unit of the product	Maintenance costs/number of units produced
	F4	The ratio of maintenance costs to manufacturing costs	Maintenance costs /production costs
Customer (C)	**C1**	sales growth %	Current year sales - previous year's sales / previous year's sales
	C2	Marketing Expenses Growth Rate %	Current year marketing costs - Previous year's marketing costs / Previous year's marketing costs
	C3	The ratio of marketing expenses to manufacturing costs	Marketing expenses/production costs
internal operations (IO)	**IO1**	Production capacity utilization rate	(Actual production achieved/energy available) x 100
	IO2	Inventory turnover	Cost of goods sold/inventory
	IO3	The average daily performance of the worker	Number of units produced/working days
	IO4	Operational efficiency of the equipment	(Number of units produced x optimal time to produce the unit / actual running time) x 100
Growth And Creativity (GC)	**GC1**	Growth in training expenses	Current Training Expenses - Previous Training Expenses / Previous Training Expenses
	GC2	The rate of employee training expenses to total expenses	(Employee training expenses / total expenses) x 100
	GC3	The rate of incentive bonuses to total expenses	(Incentive bonus/total expenses) x 100
Societal Environment (SE)	**SE1**	The growth of social expenses	Social Expenses for the current year - Social Expenses for the previous year/Social Expenses for the previous year
	SE2	The ratio of social expenses to total expenses	(Social expenses/total expenses) x 100
	SE3	Expenses growth of the environment department	Expenses of the Environment Department for the current year - Expenses of the Environment Department for the previous year / Expenses of the Environment Department for the previous year
	SE4	The ratio of environmental department expenses to total expenses	(Environment department expenses / total expenses) x 100
Risks (R)	**R1**	Percentage of a work stoppage to total work	(Number of working days off / number of planned working days) x 100
	R2	The change in the volume of demand	Current year demand - previous year's demand
	R3	Percentage change in product selling prices	(Current Selling Price - Previous Selling Price / Previous Selling Price) x 100

Source: Prepared by the researcher based on the above.

The role played by the balanced Scorecard (BSC) in evaluating the performance according to the integrated approach between it and the green process re-engineering (GPR) shown in the Table above is the first aspect of the integration approach, and this approach is complemented by the application of green process re-engineering technology to improve the year's performance in economic units.

6. Improving the performance by applying green process re-engineering

By improving the technological path of production processes by applying the green process re-engineering (GPR) technology, the performance of the activities and processes is improved, and as a result, the overall performance of economic units is improved, and this is done by following the steps of the green process re-engineering technology, and these steps are: (Lan, 2011; Ganesh, 2012; Unhelkar, 2016; Maciel, 2017; Hashmi & Choudhury, 2020)

- (Examine processes with green process characteristics).
- (Integration of non-conforming processes with environmental dimensions).
- (Green Process Re-engineering)
- (Development of training programs and change management).

- (Performance monitoring and continuous improvement).

In the first step, all production processes are examined, and their conformity to the specifications of green processes is determined (necessary, efficient, effective, agile, and measurable; (Lan, 2011).

In the second step of re-engineering green processes, the activities of production processes are integrated with environmental dimensions by preparing a program that harmonizes environmental specifications and dimensions (Lan, 2011).

The environmental dimension of operations can include planning to reduce energy and material consumption, as well as the efficient use of resources and thus reduce environmental pollution (Sari et al., 2015), as well as the selection of production materials that do not cause environmental pollution, that is, reliable and environmentally friendly materials, and materials with a low coefficient of friction lead to reduced energy consumption (Ajukumar & Gandhi, 2013).

In light of this program, the third step, which represents the implementation of this program, is the re-engineering of green processes. This step determines the environmental impact of the activities constituting the processes. The procedures required to modify the activity or replace it with another activity are determined by following procedures and methods that lead to low pollution and energy consumption, i.e., re-engineering or finding an activity that replaces it and causes less harm to the environment (Ganesh, 2012), and the resources, time and budget required for these alternative activities are verified, and thus the processes will be developed to obtain alternative green processes, with minor damage to the environment (Unhelkar, 2016).

The environmental effects of production processes are (toxic emissions, waste production, energy consumption, defective production, and scrap re-production, other chemicals that represent an environmental challenge to the processes) (Ararsa, 2012), and the ways and procedures to avoid these effects are the modification or replacement of current activities, including:

- The use of advanced and modern technologies, machinery and equipment to achieve high efficiency and less consumption of resources and energy and thus reduce environmental pollution (Ibrahim,2021).
- The type of fuel used in operations has changed as the use of natural gas as a fuel leads to little environmental pollution as well as less cost (Al-Asadi, 2021).
- Using modern technologies as unique computer programs concerned with organizing the dates and mechanism of operations and activities.
- The use of robots in production processes and the use of types of spare parts and production materials with little environmental impact.

Based on the above, we can say that the most appropriate production processes, energy saving, and less pollution to the environment contribute to significant savings in production and energy consumption and, thus, the cost of total production.

After implementing the operations program, the third step moves to the fourth step of developing training and change management programs to sustain the procedures and development during the implementation. This step is considered the feedback of the green process re-engineering technology. This step is implemented to develop, continue and sustain the previous steps.

This step includes additional actions, the most important of which is preparing and equipping training programs for the management and continuity of operations (Engemann & Henderson, 2012).

In the fifth step, performance monitoring and continuous improvement, where:

- Monitor performance and continual operations improvement by updating related services and facilities (Maciel, 2017).
- Establish a formal performance reporting mechanism to maintain continuous improvement to reduce emissions from operations carried out by economic units (Ganesh, 2012).

It includes monitoring performance in this step in two aspects: (Lan, 2011).

First: It records the emission measurement for each green process regularly to ensure that the reading is similar to the initial measurement after the redesign phase of the green process. This is to verify the implementation of redesigned processes according to the specifications.

Second: Evaluate new equipment and devices and introduce them to achieve the objectives of operations while minimizing emissions.

After completing the steps of re-engineering green processes, the second aspect of integrating the technologies of the balanced scorecard and re-engineering of green processes to evaluate and improve the performance in the industrial economic units has been completed. However, this integration may be hypothetical and theoretical only. It is challenging to know and determine its results or predict them without doing the applied study and considering this integration a course of action for application in the practical aspect, which will be addressed in the next part.

7. Practical application of balanced scorecard integration and green process re-engineering in factory study sample (strategic performance evaluation of sulfuric acid plant)

The balanced Scorecard (BSC) and all its strategic perspectives will be used to evaluate the sulfuric acid plant's strategic performance. As for the sub-measures for each perspective, they were selected in the light of the data and information available in the factory to be used in evaluating performance in the factory, the study sample.

Measures are applied to determine the strategic performance level of each balanced scorecard perspective. Performance is compared to standard levels, and differences are identified. Improvements are made to enhance high performance and address low-performance areas. Performance importance is determined using a scale from 10 (lowest) to 30 (highest). Table 2 displays the strategic performance evaluation of the sulfuric acid plant.

Table 2: Strategic performance evaluation of sulfuric acid plant

Perspective	Scale	Scale application	result	level of performance			total	%
				10	20	30		
Financial (F)	F1	227997000/1341287000× 100	17%	0-5%	-10%	-15%	30	
	F2	227997000/6972132000× 100	3.27%	-1%	-2%	-3%	30	
	F3	82089000/6565	12,504 IQ	18,000 IQ	12,000 IQ	6,000 IQ	20	
	F4	82089000/2,770,932,000	2.96%	-3%	-2%	-1%	20	
Financial Perspective Score (120)							100	83%
Customer (C)	C1	8248-5150/5150	60%	0-20%	-40%	-60%	30	
	C2	18990000-16901100/16901100	12%	0-30%	0-20%	0-10%	20	
	C3	18,990,000/2,770,932,000	0.69%	-1%	-2%	-3%	10	
Total Customer Perspective Score (90)							60	67%
internal operations (IO)	IO1	6565/13200× 100	49.73%	0-20%	-40%	-60%	20	
	IO2	2770995000/4128080	671 time	0-200	-400	-600	30	
	IO3	6565/251	19.89 tons	-10	20-	30-	20	
	IO4	6565×0.5/5271[1]	62.27%	0-40%	-60%	-80%	20	
Internal Operations Perspective Score (120)							90	75%
Growth and Creativity (GC)	GC1	6459000-7200000/7200000	-10.29%	0-5%	-10%	-15%	10	
	GC2	6459000/2770995000× 100	0.23%	0-1%	-2%	-3%	10	
	GC3	79810000/2770995000× 100	2.88%	0-1%	-2%	-3%	20	
Learning and Development Perspective Score (90)							40	44%
Societal Environment (SE)	SE1	21,096,000-23,770,000/23,770,000	-11.25%	0-1%	-2%	-3%	10	
	SE2	21,096,000/2770995000× 100	0.76%	0-1%	-2%	-3%	10	
	SE3	54000000-57,000,000/57,000,000	-5.26%	0-1%	-2%	-3%	10	
	SE4	54000000/2770995000× 100	1.95%	0-1%	-2%	-3%	10	
Societal environment perspective score (120)							40	33%
Risks (R)	R1	79[2]/365× 100	-31.23%	-10%	-5%	0-1%	10	
	R2	8248-5150	3098 tons	0-2000	-4000	-6000	20	
	R3	400,000-390000/390000×100	2.56%	0-1%	-2%	-3%	20	
Risk Perspective Score (90)							50	56%
The total points of perspectives (630), the final score for performance evaluation							380	60%

Source: Preparation of the researcher using financial statements and planning department information.

[1] Calculated (number of working days x daily working hours) = (251 days x 21 hours = 5271 hours)

[2] Calculated (number of days in a year - number of days in actual operation) = (365-251) = 79 days.

Notes from Table 2:

1. The percentage of the factory's performance when applying the balanced scorecard measures for the year (2021) data and for all binoculars is (60%), which indicates a weakness in the factory's overall performance, which requires taking measures to improve this performance.
2. The financial perspective has achieved a performance rate (83%) when applying the measures of these perspectives, which is the highest percentage compared to the rest of the perspectives, indicating that there are strengths in the financial aspect of the availability of liquidity and financial possibilities and achieving good returns can be used to improve the performance of the rest of the perspectives and thus achieve the objectives of the factory.
3. The customer's perspective has achieved (67%), and here the factory must exploit the advantage it has over competitors (private factories) in the field of sulfuric acid industry and pay attention to the field of marketing by providing several services of delivery to the beneficiaries of the factory's tanks as well as providing the product in large quantities in addition to selling on credit, which competing factories cannot provide, advertising and marketing those services to them, investing in these services and improving the performance of this perspective.
4. In the year (2021), the factory achieved an excellent performance of (75%) in internal operations. This does not include compliance with the performance regarding the financial and customer perspectives. This indicates that the internal processes are going correctly, but they are not ideal processes that achieve a high performance rate and meet all the required processes of efficiency and effectiveness.
5. As for the prospect of growth and innovation in the year (2021), it has achieved a performance ratio (of 44%), which is a poor performance ratio from the perspective, and this affects the overall performance of the factory, which requires taking measures to address performance in this perspective.
6. The lowest percentage recorded by the factory is from the environmental and community perspective (33%). This percentage is very weak and indicates the lack of interest of the factory in the aspects of the environment and society in which its activity is practiced, and this leads to the failure to achieve the basic objectives of the factory in supporting and developing society and preserving the environment, as well as its endeavor to keep pace with global developments and implement environmental obligations and meet them.
7. The risk perspective in (2021) achieved a performance rate (of 56%), which is a performance year that needs to reconsider the risks resulting from operations to correct operations and avoid them.

According to the above analysis of the factory's performance for the year (2021), it can be said that the strategic performance of the factory is witnessing a decline, disparity, and a significant imbalance between the perspectives of the balanced Scorecard (BSC), where we find the financial perspective with a performance ratio (83%), and the environmental and community perspective with a performance ratio (33%). It needs improvement in order to achieve the best results. The required improvement in the factory's performance can be achieved by increasing the efficiency and effectiveness of activities that affect the overall performance of the sulfuric acid plant in the study sample by applying an essential and contemporary technology that improves the performance of production processes in the factory to increase efficiency and effectiveness in the factory's activities on the one hand and contributes to compliance with environmental requirements on the other hand, which is the green process re-engineering technology (GPR).

8. Improved performance in the light of green process re-engineering

The technological path of traditional production processes in a sulfuric acid plant will be reformulated to improve the overall performance of the plant to help it meet the legislative and legal requirements for environmental protection against contaminants, using the Green Process Re-engineering (GPR) steps.

8.1. Examine the processes with the characteristics of the green process

In this step, we inspect the processes of the plant sulfuric acid and validate them, and compliant them to the characteristics of the five green processes (necessary, efficient, efficient, agile, and measurable), and we convert those that do not have the characteristics of green processes only to the next step and are reported to the factory executives for review. Table 3 shows the results of testing the processes of the technological path of production in the factory in terms of compliance with the specifications of green processes.

Table 3: Testing the plant's sulfuric acid operations and their compliance with the specifications of green processes

Specifications / Operations	Necessary	Efficiency	Effectiveness	Agile...	And measurable	Test result
Dissolving unit (Chem.)	✓	✓	✓	✓	✓	Compliant
Incineration unit	✓	✓	✓	✓	✓	Compliant
Chemical contact unit (Chem.)	✓	✓	✓	×	×	Non-conformance
Unit of absorption	✓	✓	✓	✓	✓	Compliant
Unit of equation (Maths.)	✓	✓	✓	✓	✓	Compliant
Filtration unit	×	×	×	×	×	Non-compliant
Sludge treatment	×	×	×	×	×	Non-compliant

Source: Prepared by the researcher using the information of the production department.

It includes the technological path of production processes in the factory from a set of stages and processes, namely:

8.1.1. Dissolving unit

This unit is one of the necessary and basic processes in manufacturing sulfuric acid. It is one of the most effective and efficient processes where water vapor generates energy to dissolve solid sulfur and turn it into a liquid. This process is agile and measurable, and through this process is not produced any materials harmful to the environment, whether liquid, solid or gaseous. Hence, this process can be characterized by the qualities of green processes.

8.1.2. Incineration unit

One of the necessary processes for manufacturing sulfuric acid is the incineration unit. This unit is also characterized by high efficiency and effectiveness, where water vapor is used to generate energy in order to burn liquid sulfur and convert it into gas, and that this process is measurable and agile and through this process does not leak sulfur dioxide gas (SO_2), as it consists of the union of oxygen with sulfur liquid without any other additives, surplus or excess and is transferred through a pipeline to the chemical contact unit. Therefore, this process can be considered characterized by the qualities of green processes.

8.1.3. Chemical contact unit

This unit is necessary to manufacture sulfuric acid, which is very effective and efficient. This reaction type is heat-emitting, used to generate energy in the rest of the stages of the technological path of production processes. Moreover, this process is not measurable and is not characterized by agility. Within it, a leakage of sulfur dioxide gas (SO_2) occurs due to the inefficiency of the cofactor vanadium pentoxide (V_2O_5) and the corrosion that occurs to the internal parts of the production equipment, which causes the volatilization of sulfur dioxide gas (SO_2). Therefore, this process is not in conformity with the specifications of green processes and does not have their qualities, and requires action to be taken to re-engineer by converting it to the second step of the application of green process re-engineering and informing the officials in the factory for taking the necessary action.

8.1.4. Absorber unit

This process is one of the basic and necessary processes in this industry, and it is effective, efficient, agile, and measurable. No materials harmful to the environment are produced because this process is carried out in special ovens intended for this purpose, and the production workers use certain means and methods to maintain this unit, so this process can be considered as being characterized by green processes.

8.1.5. Unit of equation

It is a necessary and basic process to equate fuming sulfuric acid and turn it into a product that customers can store, sell, and use. It is characterized by effectiveness and efficiency, where water is used only in this process, and this process is agile and measurable, and through this process, no harmful substances are produced to the environment, so this process can be considered a green process.

8.1.6. Filtration unit

The unit's results do not reflect its effectiveness or efficiency due to various factors. These include using electrical energy for gas withdrawal, high costs associated with using sodium hydroxide solution (NaOH), and health risks to workers due to NaOH's harmful effects. Additionally, the unit causes environmental damage, corrodes iron, leads to work stoppages for maintenance, and incurs high maintenance costs without economic or environmental benefits. Therefore, the filtration unit process cannot be considered a green process and should be re-engineered, and those responsible for it should be informed to take the necessary measures.

8.1.7. Sludge treatment unit

This process is an unnecessary process that does not add any value to the product, it is unnecessary in addition to its environmental damage to the soil and groundwater, and therefore this process is not characterized by the specifications of green processes and should be re-engineered, and inform the executives in the factory of the results of this process.

8.2. Integrate non-conforming processes with environmental dimensions

At this stage, the processes that do not conform to the specifications of the green processes are divided into their component activities to be integrated with the environmental dimensions, and the non-conforming processes are integrated through the preparation of a program that adheres to the necessary environmental determinants and dimensions and then works to implement this program.

The processes that do not conform to the specifications of the green processes within the technological path of the production processes in the sulfuric acid plant are the chemical contact unit, the filtration unit, and the sediment treatment unit. These processes need to link their activities with the environmental dimensions. By coexisting with the production department of the factory, the non-conforming processes consist of a set of activities. As for the environmental dimensions of these processes, all green processes seek to achieve the dimensions of reducing emissions, reducing unclean energy consumption, and disposing of process residues in an environmentally friendly manner by recycling them or using landfills properly. Table 4 shows the processes and their constituent activities, as well as the environmental dimensions that should be met or compliant by these activities:

Table 4: Activities of operations that do not conform to green specifications and environmental dimensions

Operations	Activities	Environmental dimensions
Chemical contact unit (Chem.)	Vanadium pentoxide brushes (V_2O_5)	Reduce emissions and gas leakage. Reduce the heat emitted that causes equipment to corrode.
	Gas puller (Eng.)	
	Disposal of gas	
Filtration Unit	Intake of gases	Reduce power usage. Reduce resource consumption without environmental or economic return or benefit.
	Addition of sediment solution	
	Subtraction of sediment	
Sludge treatment	Sediment withdrawal (Geol.)	Disposal of sediment by recycling or environmentally friendly methods that do not cause any harm to the environment, whether it is soil, water or groundwater
	Add inflorescence material	
	Disposal of plaque in the trocars	

Source: Prepared by the researcher using the information of the production department.

After identifying the activities related to the processes and environmental dimensions required, the next step is to re-engineer the green processes to achieve the required dimensions of these processes and activities related to the technological path of production processes in the sulfuric acid plant.

8.3. Re-engineering green processes

In this step, the environmental impact of the activities constituting the operations, as well as the importance of each activity of the operations and the amount of contribution of this activity to the production processes as a whole, are determined for modifying the non-conforming activity or replacing it with another activity by following methods and procedures that lead to the implementation of environmental dimensions and thus lead to the conformity of the processes to the specifications of green processes, to be less harmful to the environment, while providing the resources required for alternative activities, and thus the processes are developed to obtain alternative green processes.

The activities of non-conforming processes are the activity of vanadium pentoxide (V_2O_5) brushes. According to Ray, the production department official, this activity is the basis of the sulfuric acid production process. This activity is fundamental and essential, but it causes adverse environmental effects resulting from the heat of the chemical reaction, which causes the volatilization of toxic sulfur dioxide gas (SO_2), as well as the erosion of the internal parts of the production furnaces, which leads to the cessation of production as well as increased maintenance periods and increased costs. Table 5 shows the activities and the importance and contribution of each activity to the processes as a whole and the associated environmental impacts:

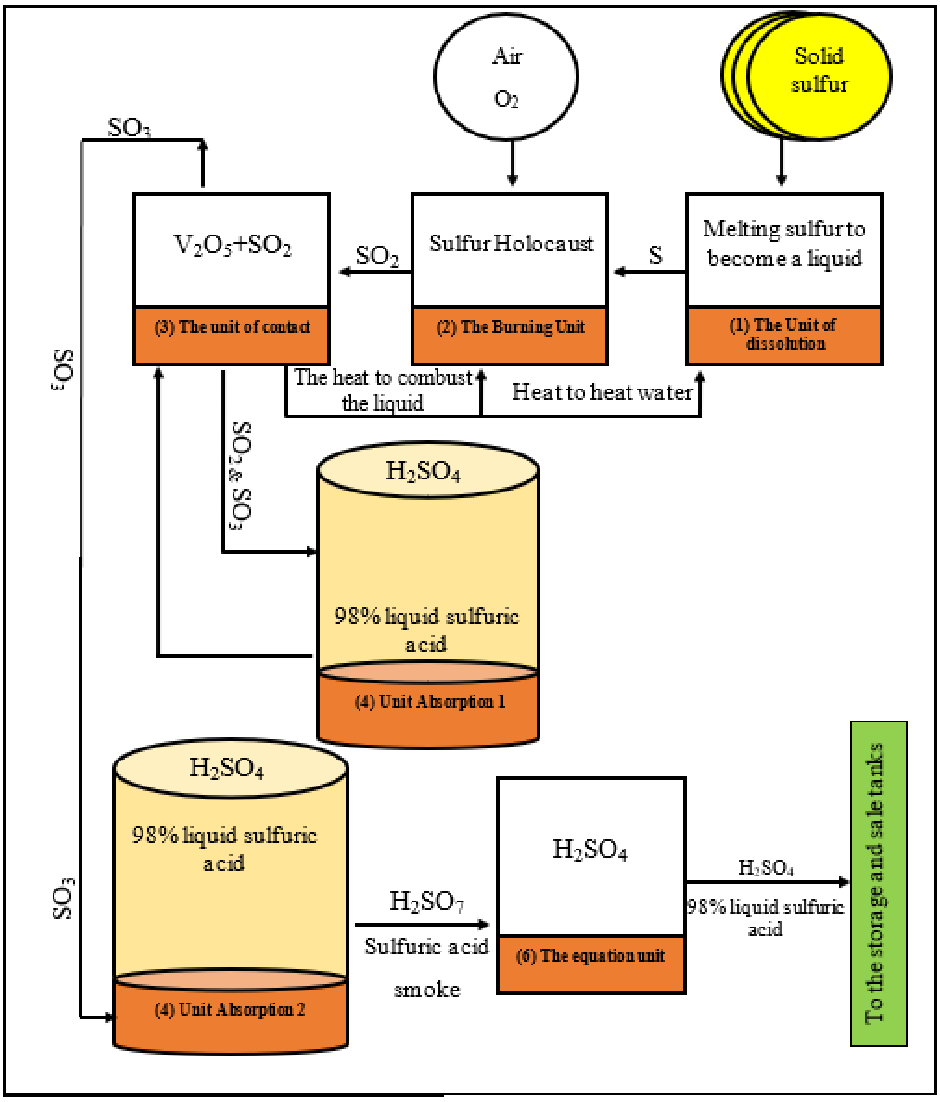
Table 5: Environmental impacts of operations activities and the amount of their contribution

Activities	His Relevance	Environmental effects of the activity
Vanadium pentoxide diffusion (V_2O_5)	Essential and very important	Gas volatilization and equipment corrosion
Gas puller (Eng.)	very important	SO_2 Gas Volatility
Disposal of gas	very important	SO_2 Gas Volatility
Intake of gases	very important	SO_2 Gas Volatility
Addition of sediment solution	Important	Production of toxic substances and gas volatilization
Subtraction of sediment	Important	Environmental pollution and equipment erosion
Sediment withdrawal (Geol.)	Important	Pollution of the environment by acidic substances
Add inflorescence material	Important	Pollution of the environment by acidic substances
Disposal of plaque in the trocars	Important	Soil and groundwater contamination with acidic substances

Source: Prepared by the researcher using the information of the Directorate of Environment of Babil Governorate.

It is noted from Table 5 that all activities are essential and necessary to complete the production process to reach the final product (sulfuric acid). However, they have a significant and negative impact on the internal and external environment of the factory, and through field living in the factory, there is an urgent need to add a unit. An additional unit is designed to achieve environmentally friendly production processes and what is known as green processes, which is known as the double absorption tower method. In this process, the gases that resulted from the contact unit (SO_2 and SO_3) are passed twice in the contact unit to produce more contact to convert sulfur dioxide to sulfur trioxide and produce more sulfuric gas of higher quality, which helps to achieve a high conversion efficiency of sulfur dioxide (SO_2) and produce high concentrations of sulfur trioxide (SO_3). The Figure 1 shows Green Technological Path for Modified Production Processes:

Figure 1: The green technological path for production



Source: Prepared by the researcher

8.4. The dual absorber verifies a set of features, the most important of which are

Reducing two stages of the technological path of the current processes in the factory, and this helps to shorten the production cycle and increase the speed of production and processing, as well as reduce the periods of downtime for maintenance and reduce the causes of environmental pollution and thus improve the overall performance of the plant and units are:

- **Filter Unit**: The processes and activities that cause harm to workers and the environment by producing solid residues that are harmful to the environment.
- **Sediment treatment unit**: and what is included in the disposal of waste in the trocars (sewers), which caused pollution of the environment by soil and groundwater.

Increasing the available capacity of the factory to reach (24,750 tons per year), after it was (13,200 tons).

As for the expected cost of implementing the dual absorption unit, the cost of its implementation is (800) million dinars, and Table 6 shows the details of the required parts and their numbers and the cost of implementing the dual absorption unit:

Table 6: Details of the required parts and their cost to implement the dual absorption unit

Required part	No.	Cost
Pullers	2	150 million
The new absorber furnace cost it.	1	450 million
Spare Toolkit		200M
Total		800 million

Source: Prepared by the researcher based on the information of the production department.

8.5. Develop training and change management programs

Additional measures are needed to sustain the benefits of re-engineering green processes and maximize factory operations' economic and environmental returns. Developing a training program on re-engineering green processes is one of these measures, enabling effective management and maintenance of operations and providing workers with the knowledge needed to carry out such processes.

8.6. Monitoring performance and continuous process improvement

Following a performance monitoring system and continuously improving processes by updating the services and equipment used in order to ensure the continuity of conformity of processes to the specifications of green processes, performance monitoring should focus on the two most important aspects of the implementation of green process re-engineering, namely:

First: Measuring emissions and pollutants from new processes regularly, ensuring that these processes perform the purpose for which they were designed and meet environmental requirements while adhering to the determinants of the sulfuric acid industry within the permissible limits.

As for the follow-up of adherence to environmental determinants is the competence of the Directorate of Environment in the province of Babylon, and through interviews with officials in the factory as well as employees of the Directorate of Environment in Babylon, we found:

- The Directorate of Environment in Babylon did not set limits for this industry but instead built and based its opinion on the fact that the factory is environmentally contrary due to the expansion of urban housing on the land near the factory.
- The lack of modern sensors or measurements that determine the extent of the factory's commitment to environmental determinants, through which it is possible to determine the amount of sulfur dioxide gas emitted by the factory and the rest of the pollutants, as it is based on laboratory studies only in determining the amount of pollution and at annual intervals or more than about a year.

Second: Evaluate the performance of the newly used equipment for applying green process re-engineering. In the factory, the performance evaluation of the dual absorption unit will be approved and ensure that it meets the objectives of green process re-engineering and reduce emissions to the limit allowed within the international and local determinants.

In order to complete the implementation and implementation of all steps of green process re-engineering, a performance reporting information system is required to achieve continuous improvement to reduce emissions from sulfuric acid production processes. This task is the responsibility of the Chemical Security Division in the Information Department of the Euphrates Chemicals and Pesticides Company.

9. Conclusion and recommendations

9.1. Conclusions

This study reached several conclusions in its theoretical and practical aspects, the most important of which can be listed as follows:

1. After studying several studies related to integrating the balanced scorecard and the re-engineering of green processes, it can be concluded that these tools help significantly improve economic units' performance. Thus, the use of these technologies can have a significant impact on improving performance, reducing costs, and increasing profits in economic units.
2. The application of these techniques needs to consider several fundamental factors, such as the availability of accurate and sufficient data and information, the commitment of senior management to improve performance, and the availability of resources to

implement the required changes. Therefore, achieving improved performance requires a strong commitment from all members of economic units.

3. Overall, integrating the balanced scorecard and the re-engineering of green processes are powerful techniques for improving the performance of economic units while achieving environmental sustainability. Although these technologies can face some challenges and difficulties, the positive results that can be achieved make them worthy of attention and application in different economic units.
4. The balanced scorecard is one of the strategic cost management methods. It works to find a balance in the performance measures of economic units. This balance is achieved through its perspectives as a comprehensive management technique that links performance to the economic unit's strategic vision, mission, and objectives.
5. The evaluation of the factory's performance according to the balanced scorecard determines the low, uneven, and significant imbalance of performance according to the balanced scorecard perspectives, where the performance from the financial perspective was (83%), and the environmental and societal perspective was (33%).
6. Green Process Re-engineering (GPRE) is a system or technology that can improve the overall environmental impact of an economic unit by redesigning its operations, specifically to reduce waste and pollution, optimize the use of energy and resources, and achieve compliance with government and regulatory requirements for environmental protection.
7. The implementation of green process re-engineering (GPRE) involves several steps starting by evaluating existing processes and conforming them to the specifications of green processes and then using various methods to improve the efficiency and effectiveness of processes in environmental aspects.
8. Green Process Re-engineering (GPRE) contributes to the benefits of economic unity by reducing pollution, reducing waste, conserving energy, improving quality, reducing costs, and improving the speed and accuracy of processes, by eliminating environmentally harmful and wasteful production practices or processes in resources and energy.
9. The integration of management accounting techniques contributes and provides benefits to economic units more than the application of one technology to take advantage of the advantages and characteristics or benefits of those two technologies, balanced scorecards and green re-engineering technology with each other to strengthen their strengths and avoid weaknesses. This leads to the best exploitation of resources, and the unit ensures the reasons for providing competitive advantage and continuity in the contemporary business environment.
10. Balanced scorecard integration and green process re-engineering techniques can be applied in various industries and economic units, whether in manufacturing or services like retail, distribution, or financial services. These technologies aim to improve economic units' performance by improving quality and productivity, reducing costs, and controlling the environment.
11. Balanced scorecard Integration is a technique that aims to improve the productivity of economic units by providing a complete view of the production process and identifying problems that affect productivity. This technique relies on identifying the main factors that affect quality and productivity and evaluating them through specific criteria.

9.2. Recommendations

1. The need to create a section for performance evaluation within the organizational structure of the factory and provide special cadres interested in evaluating the strategic performance of the factory.
2. The need to train the employees of the Quality Department on the use of contemporary techniques for performance evaluation to have the ability to conduct a comprehensive evaluation of the factory and use the balanced scorecard because the financial and non-financial measures included and do not overlook aspects and issues of importance in the process of evaluating the strategic performance of the factory.
3. The need to address the weakness in the overall performance of the plant and find a balance between the binoculars of the Balanced scorecard to improve the overall performance of the plant through the use of various methods to improve the efficiency and effectiveness of operations.

4. The need to follow the integration procedures between the balanced scorecard technology and the re-engineering of green processes to reduce the factory's low, uneven, and unbalanced performance.
5. Following the integration steps between the balanced scorecard technology and the re-engineering of green processes to get rid of production processes that do not conform to the specifications of green processes and finding a technological path for production processes that contributes to improving the overall performance in the factory on the one hand and following the regulatory legislation for environmental protection on the other hand.
6. The Babylon Environment Directorate will set pollution limits for the sulfuric acid industry and install modern sensors to accurately measure the plant's environmental pollution. The Directorate's committees will conduct field visits to the plant at short intervals to monitor pollution levels and take appropriate measures based on the amount of pollution detected.
7. Follow the steps of re-engineering green processes to reduce the stages of the technological path of the current production processes in the factory, which contributes to shortening the production cycle and increasing the speed of production and processing, as well as reducing downtime for maintenance and reducing the causes of environmental pollution and thus improve the overall performance of the factory.
8. The need to provide the support of senior management in the company to apply the integration between the balanced scorecard technology and the re-engineering of green processes, as it has a positive role in reducing maintenance costs and total production costs and providing the highest returns to Al Furat Chemical Industries and Pesticides Company.

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