

## Application of the environmental pillar within the world-class manufacturing methodology for the purpose of achieving environmental sustainability

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### Abstract:

Environmental sustainability is one of the main dimensions involved in achieving sustainable industrialization through the application of practices reduction the consumption of environmental resources, and reduce the volume of waste and emissions, so the study aims to apply the environmental pillar associated with the methodology of (World Class Manufacturing – WCM) in one of the Iraqi manufacturing organizations for the purpose of achieving its environmental sustainability. The study site lacks knowledge of modern scientific theories related to these practices. The results of the study indicate that there are a number of gaps in the application of environmental procedures within the study site, and the extent of compliance with them, and the study concludes that the success of achieving environmental sustainability depends on the extent of commitment to achieve the study proposals, the most prominent of which were internal environmental goals, the application of the environmental training program, the extent of application of energy management standards, as well as the conformity of the international standard (ISO 14001 2015) of the Environmental Management System.

### Key words:

World Class Manufacturing, Environmental Pillar, Sustainable Manufacturing, Environment Management System.

## 1. Introduction

The concept of World Class Manufacturing refers to the achievement of operational differentiation in manufacturing processes, using a number of methods and tools that help the organization in constantly improving its processes, and setting a goal for itself to achieve its desired differentiation, as a study (Ingle, 1999) dealt with how to apply world class manufacturing practices, and what are the reasons for the application? The study focused on the application of three key WCM concepts, including Total Quality Management (TQM), Just In Time (JIT), and Employee Engagement (EI), and proved that the application of WCM practices is one of the best ways to support the process of

sustainability, survival and continuity in keeping up with competitors.

The study (Girona, 2018) reviews how to apply the WCM methodology in Fiat Chrysler Automobile Plants, in order to standardize the methods or classify them into pillars (technical, managerial), and the study has used a number of methods used in the Toyota production system (TPS), comprehensive production maintenance (TPM), agile production, and total quality management (TQM), and thus presented its model of the concept (WCM), which contained ten technical pillars, and ten administrative pillars, the goal is These include analyzing irregular situations inside or outside the factory, and working to improve them. The study (Lorenzo, 2018) considers that the WCM methodology is an important tool in

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assessing the organization's current performance, its conformity with established standards, and working to take corrective actions for the purpose of conforming to those standards, and using a data-driven method. The current study discusses initiatives to achieve environmental sustainability in manufacturing processes, and focuses in particular on the application of the environmental pillar of the world-class manufacturing methodology at the study site, as the WCM methodology based on pillars is one of the appropriate ways to improve the areas of waste management, energy consumption, environmental impact, and the availability of pillars (WCM) in general, typical steps leading to the achievement of sustainable manufacturing, and this has proven many industrial organizations the effectiveness of these practices, and achieved. Indeed, sustainable manufacturing according to its environmental, economic and social aspects. Environmental sustainability is one of the most prominent dimensions contributing to the achievement of sustainable industrialization, as it focuses on improving waste management procedures, energy consumption, and environmental impact. A study (Moreli, 2011) noted that the concept of environmental sustainability means meeting the needs of the present without compromising the needs of future generations, i.e. the preservation of natural capital, and as a concept separate from but linked to social and economic sustainability, it focuses on five main dimensions including: (societal needs, biodiversity conservation, capacity for regeneration, reuse and recycling, and restrictions on non-renewable resources and waste generation). Accordingly, work should be done to identify best practices that help achieve environmental sustainability at the study site, and implement them in a way that contributes to the improvement of procedures associated with manufacturing processes, and the development of an environmental management system in accordance with the international standard (ISO 14001 2015). Therefore, the current study will be mainly concerned with the application of environmental pillar procedures within the WCM methodology for the purpose of supporting opportunities for the conservation of natural resources, reducing potential environmental risks, improving the internal working environment, emphasizing the importance of applying environmental regulations, and developing human competencies within the environmental field. The study includes four axes, the first axis of which

is presented (the methodology of the study), its second axis (the theoretical aspect), and its third axis focuses on the presentation (practical aspect), and reviews its last axis (conclusions, recommendations of the study).

## 2. Literature review

### 2.1. World Class Manufacturing Concept

The concept of (WCM): Over the past decades industrial organizations have been constantly looking for new ways to help them achieve a competitive advantage, and this has put these organizations under great pressure to review their traditional manufacturing practices, and to consider adopting new practices represented by (WCM) (Krishnan, 2016). WCM refers to different production processes, organizational strategies that are all flexible. In short, we can say that the term WCM means the application of best practices in the manufacturing system. Schonberger defines it as a common language for the concepts of total productive maintenance, total quality management, timely production, agile manufacturing, and worker participation in modern production systems (Black, 2008; Mendes & Mattos, 2017). Midor and Pela added that manufacturing according to the global model focuses on the overall organization of the plant, starting from the occupational safety and health management system, passing through the quality management system, workplace organization, maintenance system, logistics, and environment (Midor, 2012; de Felice et al., 2013).

### 2.2. World Class Manufacturing pillars

The world-class manufacturing concept is depicted in the form of a temple based on ten columns or technical pillars, each representing a specific area of focus within a particular area of the factory (Pela, 2015). The main idea behind its adoption is to strive to develop the competitiveness of organizations, to gain a global position in differentiation, and to reach the highest level in global manufacturing. Therefore, organizations should demonstrate their outstanding performance in quality and productivity metrics, which confirms the competitive aspect of this strategy (Svensson, 2011). Technical pillars include: (Safety, Cost deployment, Focused Improvement, Autonomous Activities, Professional Maintenance, Quality

Control, Logistics, Early Equipment Management, People Development, Environment) (Makedonskiy & Belyaeva, 2016; Łyp-Wrońska, 2016; Sari, 2018; Malindzakova and Malindzak, 2020).

### **2.3. Environmental Pillar Concept**

The final technical pillar of the WCM methodology is dedicated to the environmental aspect, and its main concern is to assess the impact of plant activities on the environment, taking into account their impact in the short and long term. It is one of the main tools in assessing the performance of resource consumption, the extent of compliance with environmental regulations, and the continuous improvement of internal working conditions for the purpose of achieving environmental sustainability (de Felice et al., 2013).

### **2.4. Sustainable Manufacturing Concept**

Sustainable manufacturing is defined as “the production of goods and services using processes and systems that seek to reduce pollution, conserve energy and natural resources, improve the economy, and ensure the health and safety of workers, communities, and consumers (Singh et al., 2016; Salvadora et al, 2017). Sustainable manufacturing combines the ideas of agile manufacturing, green manufacturing, corporate social responsibility (CSR), and total quality management (TQM), and to include processes that reduce waste, while maintaining and focusing on ethical obligations to communities and workers (Carley et al., 2014). The main keys success to achieve the concept of contemporary sustainable manufacturing can be identified through a range of key elements that include design, participation, oversight, support, and policies. Sustainability assessment depends on how to find indicators that can provide an accurate representation of sustainable manufacturing, and therefore opportunities to apply the sustainable manufacturing approach can be reflected in other indicators, including these indicators (energy consumption, manufacturing costs, waste management, environmental impact, and health and safety), as these indicators are linked to the three trends of sustainable industrialization (environmental, economic and social trends), and it should be noted that the interaction between these trends is necessary to meet the requirements of human activities, and the level of use of natural resources, as well as the improvement of environmental indicators (Abubakr et al., 2020).

### **2.5. The concept of environmental sustainability and its relationship to other dimensions of sustainable manufacturing**

Environmental sustainability is defined as a set of constraints on the four main activities that regulate the metrics of the subsystem of the human economy (use of renewable resources, use of non-renewable resources, pollution, and waste absorption) (Moldan et al., 2012). He adds (Sekar, 2017) that environmental sustainability is the harvest rates of renewable resources, the level of pollution, and the level of depletion of non-renewable resources, which are expected to last indefinitely. If it does not last indefinitely, the process will be unsustainable. The concept of sustainability is generally based on environmental, economic and social trends, and improving these trends will help to better achieve sustainability requirements through the effective use of available resources. Each direction of sustainability has specific objectives, which must be achieved in order to build and implement the term effective sustainability. When looking at environmental sustainability, it will enhance the availability of fresh air, good water, clean soil, the implementation of environmental regulations, and the efficiency of ecological balance. In terms of economic sustainability, it will enhance the process of product and process development, proper recruitment, and large-scale new business opportunities. While social sustainability focuses on improving the health and safety of workers, improving the quality of life, and raising awareness of environmental protection (Robinson, 2004; Pathak et al., 2017; Kishawy et al., 2018). Thus, the dimensions of sustainable manufacturing are determined according to the Triple Bottom Line-TBL approach, which involves environmental, economic and social trends, and thus environmental sustainability can determine the amount of energy consumption, other resources and the impact of their footprint, and environmental sustainability is often associated with reducing waste and pollution, reducing emissions, reducing the consumption of hazardous, harmful or toxic substances, reducing the frequency of environmental accidents, and improving energy efficiency. Economic sustainability can be determined according to the reduction of production or manufacturing costs, by reviewing the efficiency of manufacturing processes, and detecting associated losses. Social sustainability means that industrial organizations are able to provide equitable opportunities for all members of the society to which

they belong by (encouraging diversity, promoting interdependence within and outside society, ensuring the quality of life, providing democratic processes, and determining and developing responsibility for organizational structures (Gimenez et al., 2012; Sartal et al., 2020).

### 3. Methodology

The current study focuses on the application of the technical pillar of the environment within the methodology of manufacturing according to the global model, and the method of this pillar is based on the application of seven steps distributed over three stages, which contribute significantly to the improvement of environmental sustainability performance indicators associated with the achievement of sustainable manufacturing, and the study has used a number of indicators used in the applications of (WCM) and sustainable manufacturing for the purpose of evaluating the environmental actions taken at the study site, and working to improve them by the application of the environmental pillar within the methodology (WCM). In addition, the researcher used a number of statistical indicators related to the evaluation of some of the steps of the environmental pillar for the purpose of determining the level of gap in the process of conformity with environmental requirements, and these indicators were represented by determining the weighted arithmetic mean, the percentage of the level of conformity, and the percentage of the gap between the actual performance and the requirements for achieving sustainable performance. The sample of the study was represented by the factory of hydraulic elements for the manufacture of hydraulic cylinders in the General Company for Hydraulic Industries,

which is located within the headquarters of the company in the province of Baghdad. The study deals with the historical data of indicators to assess the reality of environmental performance in the factory of hydraulic elements, and this period starts from 1/1/2019 until 31/12/2019, and the manufacturing process during this period is characterized by a state of stability, as well as the availability of data related to the environment for the purpose of analyzing the variables of the study.

The study aims to Evaluate the reality of environmental performance in the factory of hydraulic elements. And Achieving environmental sustainability based on the application of the environmental pillar within WCM.

#### 3.1. Assessment of the reality of environmental performance in the factory of hydraulic elements

When evaluating the environmental aspects of the hydraulic elements plant, the researcher is based on the main environmental indicators associated with the concept of sustainable manufacturing, and the evaluation process aims to improve the indicators of environmental performance assessment that include (waste management, energy consumption, and environmental impact). Table 1 presents the indicators of environmental performance assessment in the hydraulic elements factory during the year 2019, with an indication of its sub-indicators, and methods of measuring them, and the researcher relies when measuring these indicators on the available factory records, and in coordination with the director of the production department in the company for the purpose of providing assistance in the audit of

**Table 1.** Evaluation of the reality of performance in the hydraulic elements factory (2019).

Main Indicators	Sub-indicators	Measuring method	Data Entry	environmental performance
waste management	Consumables	$\frac{\text{Recycled consumables quantity}}{\text{Total consumables quantity}}$	$\frac{1250 \text{ kg}}{4500 \text{ kg}}$	27.7%
	scrap parts	$\frac{\text{Recycled scrap quantity}}{\text{Total scrap quantity}}$	$\frac{2000 \text{ kg}}{5500 \text{ kg}}$	36.3%
energy management	Energy consumption	$\frac{\text{Quantity of electricity consumed in the factory}}{\text{Number of hydraulic cylinders made}}$	$\frac{13500 \text{ kW}}{600}$	22.5
Environmental Impact	Waste disposal	$\frac{\text{Quantity of waste disposed of}}{\text{Number of hydraulic cylinders made}}$	$\frac{3000 \text{ kg}}{600}$	5

Source (Kishawy et al., 2018) based on factory data.

these indicators and the process of analyzing them, and determining any indicators that have significant effects on the environment, given his field of competence and long experience within this field.

**Table 1** refers to the assessment of the environmental performance of the hydraulic elements factory within the sustainable manufacturing approach, and in relation to the determination of the amount of waste, energy consumption, and environmental impact associated with the manufacturing process, and the evaluation process helps determine the level of environmental performance in the hydraulic elements factory for the purpose of preparing improvement methods for its manufacturing processes, and in a way that helps protect its external environment by making improvements according to the levels of product, process, and system. It requires the plant to improve the level of these indicators for the purpose of reducing waste, energy and resource consumption, and emissions. The researcher chose these indicators due to the strength of their impact on the performance of environmental sustainability in the hydraulic elements plant.

In order to improve the reality of environmental performance in the factory, the researcher will apply the environmental pillar, in order to reach the achievement of zero waste at the work site, and by reviewing the environmental management system in the hydraulic elements factory. Then prepare a proactive plan that includes building a green plant, and obtaining sustainable operating levels. The level of environmental sustainability achieved is accepted by looking at the level of reduction or improvement in these indicators.

### **3.2. Application of the seven steps of the environmental substrate in the factory of hydraulic elements**

The Environment Pillar seeks to prepare a comprehensive three-phase plan (defensive phase, preventive phase, and proactive phase), all of which constitute seven main steps. Below is the application of these steps:

#### *3.2.1. Identify environmental goals and verify the level of compliance with them*

This step requires, first, the identification of internal environmental objectives to be applied in the factory

of manufacturing hydraulic cylinders, and these goals are one of the important tools in achieving sustainable manufacturing, and are associated with the methodology of 6R, and they contribute significantly to the preservation of environmental resources, and protect them from pollution. Thus, 6R elements can be included as internal environmental objectives that the factory should apply to achieve environmental sustainability. The following are the objectives presented:

- a- Application of Reduce activities: These activities aim to simplify current product designs in order to help facilitate post-use activities.
- b- Application of reuse activities: These activities aim to reuse the same components in the manufacturing process of product parts for the purpose of using relatively fewer processes, and thus reducing the occurrence of harmful environmental impacts.
- c- Application of recycling activities: These activities aim at introducing the product parts to other uses instead of getting rid of it.
- d- Application of recovery activities: These activities aim to collect expired products from users, or from previous manufacturing processes for the purpose of dismantling them and recovering some of their parts.
- e- Application of re-design activities: Redesign activities aim to increase the useful life of products, as well as simplify post-use processes to reduce the amount of materials and energy lost at waste sites.
- f- Application of Remanufacture activities: It aims to reuse the parts of products used in a manufacturing process.

After determining the internal environmental objectives to be applied in the hydraulic elements factory in order to preserve the environment and its resources, the researcher prepared a checklist related to determining the level of commitment of the hydraulic elements factory to those goals, and reconsidering them by conducting improvements in both the efficiency of the use of resources, and the opportunities to reduce the consumption of energy, water, waste and others, and the audit process will help to find some opportunities that may be within reach. **Table 2** presents the checklist of specific environmental objectives. The researcher has identified a number of statistical indicators for the analysis of checklist data in **Table 2** for the

**Table 2.** Review of the level of commitment to internal environmental objectives.

Category	Procedures	Applied	Partially applied	not applied
Reduce	The factory reduces the parts involved in the manufacture of the product for the purpose of reducing the volume of solid waste		✓	
Reuse	The factory uses the same materials in the process of manufacturing hydraulic cylinder parts more than once or without any change in them for the purpose of reusing them again	✓		
Recycle	The factory treats damaged or consumed parts of the products for the purpose of using them in other manufacturing fields and not putting them as waste		✓	
Recovery	The factory has the qualifications to help it renew the consumed products for the purpose of being used again in the manufacturing process.		✓	
Redesign	The factory continues to introduce new designs that help increase the useful life of the hydraulic cylinder.			✓
Remanufacture	The factory applies reverse logistics services for the purpose of recovering and remanufacturing consumed products.			✓
Weights		2	1	0
Frequencies		1	3	2
Result		2	3	0
Average			0.83	
Percentage			0.41	
Gap			0.59	

The source is prepared by the researcher based on the internal environmental objectives specified in the first step.

purpose of determining the level of achievement of internal environmental goals in the study sample, and included measuring the rate of conformity of environmental goals, the percentage of the level of conformity, and the percentage of gap in the level of conformity). It is calculated (Dawai, 2010) as follows:

$$\text{Average} = \frac{\text{sum (frequencies} \times \text{weight of each Frequency)}}{\text{sum of Frequencies}} \quad (1)$$

$$\text{percentage} = \frac{\text{Average}}{\text{The highest score on the scale}} \quad (2)$$

$$\text{gap ratio} = (1 - \text{The percentage of compliance level}) \quad (3)$$

### 3.2.2. Take appropriate corrective action to achieve internal environmental goals

This step aims to assist the hydraulic elements factory in improving the level of compliance with the internal environmental objectives specified in the first step of the environmental pillar by taking appropriate corrective actions for the non-performing activities, it should be noted that the checklist prepared by the researcher in Table 2 indicates a gap in the level of application, especially the application

of remanufacturing and redesign activities, This calls for considering the activation of these activities, and the development of appropriate procedures for these specific aspects of manufacturing activities for the purpose of conserving resources, reducing waste, prolonging the life of the product, as well as activating the administrative and supervisory commitment to those activities. Table 3 presents the appropriate corrective actions to improve the level of application.

### 3.2.3. Training and involvement of employees in the application of environmental standards

The key to the successful implementation and maintenance of the Environmental Management System (EMS) is through the training of workers, activating their participation, and submitting their proposals, and in return the daily activities practiced by workers can lead to positive effects towards the environment. Therefore, it is necessary to define a training program that covers all aspects of the factory. Accordingly, the researcher lists a number of steps for the preparation of an effective training program that complies with the standard (ISO 14001 2015), and increases the effectiveness of employees to

**Table 3.** Corrective Actions for Achieving Unapplied Domestic Environmental Objectives.

Activities	Take appropriate corrective measures
Redesign	<p>The researcher points out that there are a number of factors that should be reconsidered in order to increase the useful life of the hydraulic cylinder. and should be taken care of for the purpose of avoiding errors in the design process: a- Observance of fast: For works that require high operating speeds, friction-resistant Seals are the most suitable option. The faster the hydraulic fluid, the higher its temperature. Therefore, the effect of high temperatures on the entire hydraulic system should be taken into account. b- Observance of high temperatures: Solid and liquid components in hydraulic cylinders are affected by high temperatures, especially when they are more than (30 ° C), which necessitates the need to provide information on the conditions of the operating environment for the purpose of improving the performance of components to work at temperatures that may reach (50 ° C) and above.</p>
Remanufacturing	<p>Hydraulic cylinders are subjected to constant stress and harsh conditions in most industries, and this will lead to corrosion in some parts of them, and therefore will greatly affect their performance, and the process of replacing damaged cylinders with new ones may be very expensive. This requires the manufacturer of hydraulic elements to conclude purchase contracts for spent or unwanted cylinders from other business companies, and to carry out the process of separating parts and good raw materials, and introducing them into the new manufacturing processes. This procedure requires the equipping of machines specialized in repairing the damage contained in these cylinders, according to the specifications of the manufacturer. Computer machining, laser processing, welding techniques, and cylinder assembly machines can be used. Establishing special facilities for testing cylinder loads through a computerized test unit.</p>

The source is prepared by the researcher based on the consultations of some experts specialized in the field of redesign and remanufacturing in the hydraulic system.

possess the necessary skills and competencies when completing their work. Below is the application of the steps of the environmental training program in accordance with the framework (ISO 14001 2015) of the Environmental Management System:

- a- Evaluation of training requirements: Requires identifying the gap between the level of current competencies of employees and the competencies required in accordance with the Environmental Management System (EMS) for the purpose of revealing the level of qualifications of employees in terms of their compliance with environmental regulations.
- b- Define the goal of the training: It requires setting a clear, realistic, achievable, and time-bound goal setting. This is because managers with multiple roles, may use different procedures that affect the environment negatively, so the training should focus on solving problems in certain areas and for specific individuals, and hearing the opinions of all participants when determining the goal of this program.
- c- Preparation of an environmental training plan: The environmental training plan includes determining the appropriate training time to apply, and choosing the best training method, for example to have a lecture on the job? -Where will the training site be?, as well as identifying the resources required to accomplish this purpose.
- d- Implementation of the Environmental Training Program: The implementation of the training program at the factory begins by creating records specific to the environmental management system, for example the creation of records for the assessment of the level of awareness and efficiency, records for determining operational controls, records for assessing the level of compliance... Etc.
- e- Measuring the effectiveness of environmental training: The process of measuring the effectiveness of environmental training is carried out by following up the employees, the level of improvement achieved in the performance of their work towards the protection of the environment, identifying failures such as not applying the instructions of environmental impacts during work, as well as determining the reasons for not training operators as required.
- f- Improving the environmental training program: The adoption of the evaluation results of the environmental training program, will lead to the achievement of the principle of continuous improvement, so when the level of evaluation is low, this will require the search for other new techniques and methodologies for training, which will help in achieving the objectives of training according to the Environmental Management System.

3.2.4. Save energy resources

The move aims to minimize emissions, as well as the possibility of improving efficiency in total energy consumption, and reducing the costs of consumption. This requires a review of all energy-consuming aspects, such as production line equipment, heating, cooling, lighting and others. Reducing energy consumption needs to define regulations that include a number of strategies, and urge the plant to apply them for the purpose of reducing energy consumption. The researcher identifies a number of criteria for energy policies. The most prominent of these is the (ISO 50001 2018) standard for the Energy Management System, which includes a number of procedures including: (formulation of energy policy for the purpose of achieving effective use, setting energy goals, goals and policies, reviewing energy data for decision-making, evaluating results, and reviewing and improving energy policy). Below the researcher shows in (Figure 1) an energy management scheme approved in accordance with the international standard (ISO 50001: 2018).

3.2.5. Prepare a plan to build an environmental management system that complies with the concept of (WCM)

The factory of hydraulic elements is characterized by obtaining the certificate (ISO 9001) during 2015, which will stimulate the development of another input that contributes to the support of the quality

management system in the factory by developing new means of environmental protection, and under this the researcher presents a plan that helps the factory in achieving the requirements of the international standard (ISO 14001 2015) of the Environmental Management System, and this plan depends on the mechanism of work of this standard, and can be explained as follows:

- a- Conducting the initial environmental analysis: This stage aims to start analyzing the manufacturing activities in the factory in order to identify the strengths and weaknesses associated with environmental protection, and can include manufacturing activities that affect energy, water and air within the external environment. The low use of water in hydraulic element manufacturing processes is a positive factor compared to other manufacturing processes. The factory should conduct a survey of the opinions of the concerned dealers and local authorities located within the workplace for the purpose of taking appropriate corrective actions for manufacturing processes directly or indirectly.
- b- Environmental Management System Program Study: This stage includes conducting a systematic assessment of the requirements of the environmental management system in accordance with the standard (ISO 14001: 2015) for the purpose of identifying requirements that do not conform to this specification, and this evaluation should include a review of (scope, environmental

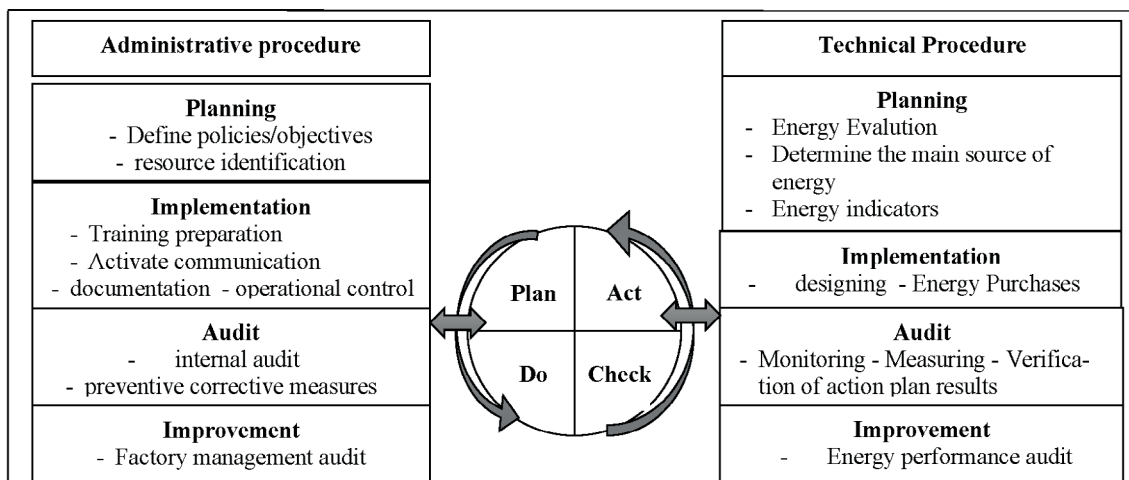


Figure 1. Energy Management Scheme (Source prepared by the researcher based on the framework of the international standard (ISO 50001: 2018).



policy, goals and how to achieve them, responsibilities and powers, planning operations within the company, procedures for dealing with threats and opportunities, environmental aspects, legal obligations, required resources, training of responsible persons, communication inside and outside the company, emergency response, Documentation, monitoring and measurement procedures, internal audit, and continuous improvement).

- c- Taking corrective actions: After conducting the internal evaluation of the environmental management system in the factory, and identifying the most prominent weaknesses, comes the third stage of taking corrective actions and following them up by measuring the environmental performance in the factory, and finding the root causes of environmental problems for the purpose of detecting the required preventive and corrective cases, and these procedures are saved with records of environmental performance.
- d- Conducting external audit: This stage includes coordination with the competent authority to grant certificates of conformity to international standards, and the role of this body is to audit the environmental management system in the factory by sending auditors specialized in auditing all the requirements of this system, and then submitting a special report to the above-mentioned body for the purpose of granting the prescribed certificate to the factory.

### *3.2.6. Preparation of a plan to prevent the environmental impact resulting from the manufacture of hydraulic cylinders and their uses*

The factory of hydraulic elements faces difficulty in dealing with machines with hydraulic systems in terms of balancing their efficiency to accomplish their tasks and their observance of environmental issues, although it is possible to pay attention to improving the efficiency of their use of fuel, and the level of their consumption of raw materials, and the identification of appropriate hydraulic fluids that make hydraulic systems work perfectly. As well as performing maintenance on a regular basis. Within this step, the researcher offers a number of means that reduce the impact of hydraulic systems on the environment by reconsidering the purchase of raw materials, manufacturing, distribution, and use:

- a- Control of logistics processes: Requires coordination between the management of the hydraulic elements factory and suppliers, through the construction of an electronic database that records all data related to the process of manufacturing, distribution, and use in order to control the movement of these products in terms of their locations of use and production life, as well as contribute to increasing the accuracy of the demand forecasting process.
- b- Selection of raw materials: The purchase process in the factory should be based on the selection of environmentally compatible raw materials, for the purpose of reducing environmental pollution resulting from the process of manufacturing hydraulic cylinders, as well as the occurrence of negative effects on the environment in the use and post-use phase.
- c- Rehabilitation and recycling: This method is one of the best ways to contribute to the reduction of waste, by reusing the parts of undamaged cylinders in new manufacturing processes. The remanufacturing process is easy and cost-effective, as well as qualifying hydraulic cylinders to work as quickly as possible, however, the factory should use new technologies to help detect the causes of failure in the cylinders used and not repeat them again.
- d- Selection of the best quality hydraulic fluids: The factory management should determine the appropriate quality of hydraulic fluids in terms of their ability to extend the life of the machine used. As well as the biodegradability of the liquid used, the more the hydraulic system is in good condition and clean, the more this will reflect positively on the environment. The plant's management can conduct scientific research and consider current explorations for the manufacture of hydraulic cylinders for the purpose of finding options with better environmental sustainability.
- e- Design of hydraulic cylinders for certain purposes: Hydraulic cylinders designed for a particular purpose are characterized by their high efficiency, and last for a longer period of time than others, and this will provide significant economic benefits to the beneficiaries of these products, as well as the acquisition of benefits associated with the environment. These cylinders will reduce waste and energy consumption, because they are durable and highly efficient, and resist difficult conditions within different fields of work.

3.2.7. Prepare a plan to move to an environmentally friendly factory (green factory)

This step aims to identify the future changes necessary to transform the hydraulic elements factory into an environmentally friendly factory or the so-called green factory, and this procedure includes the inclusion of green environmental plans with the traditional production plans adopted in the factory, as the traditional production plans in the hydraulic elements factory depend on a number of master plans that include a number of tools supporting all the procedures of manufacturing processes, so these plans really need to add other elements that take into account the green environmental perspective. For the purpose of achieving the requirements of the standard planning of the green plant, all the production plans adopted in the factory have been analyzed for the purpose of including their corresponding needs of green environmental plans, which have not been adequately included in the plans of the plant, and these additional plans will allow to affect the improvement of the level of green performance of the factory. Table 4 shows the support of traditional production plans in the hydraulic elements factory with green environmental plans.

4. Conclusion

The results of the application of the environmental substrate according to the practical practice in the

factory of hydraulic elements indicate its assistance in improving all environmental protection measures, and to achieve the principle of zero waste, which is included under the application of the seven steps of the substrate, and the most important of what has been concluded from the application process can be clarified as follows:

- a- The first step of the environmental pillar revealed a gap in the level of achieving internal environmental goals in the hydraulic elements factory, and in connection with the achievement of the 6R methodology, so it requires a main focus on the remanufacturing and redesign processes for the purpose of activating the role of sustainability in an environmental and economic manner.
- b- The second step introduced a number of procedures for the implementation of the process (redesign, remanufacturing), and these procedures included the identification of guidelines, methods, and factors affecting the redesign and remanufacturing process for the purpose of achieving the maximum benefit from its implementation.
- c- The third step provided an effective training program commensurate with the ISO 14001 standard for environmental management, which includes urging workers to participate in environmental protection, and helping them possess the necessary skills and competencies

Table 4. Supporting the traditional production plans of the factory with green environmental plans.

	Factory planning models						
	Production goals and strategies	Processing plans	Machine and equipment selection plans	Material flow plans	Information and human resource plans	layout plans	Technical plans for construction and services
Conventional Production Plans in Hydraulic Elements Factory	Determine product requirements and quantities	Preparation of scheduling production processes	Determine the level of the degree of automation	Determine the average time of completion of the product	Identification of the IT system in the manufacturing	Fixing the main dimensions of the internal arrangement	Determine the design of the building
Green environmental plans to support traditional production plans	Define green goals and strategies	Waste Management and Development of Recycling Methods	Identify asset costs, operating costs, and assess their life cycle	Develop eco-friendly transport ideas	Green IT Development	Development of means of fire protection, isolation of areas of environmental impact	Include green building guidelines

The source is prepared by the researcher based on a study (Muller et al., 2017).

for the purpose of raising their awareness of environmental protection.

- d- The fourth step presented a detailed administrative and technical plan aimed at applying the ISO 50001 2018 standard of the Energy Management System for the purpose of reducing consumption, and this plan is based on the principle of (plans, implement, check, correct) (PDCA).
- e- The fifth step adopts the construction of the environmental management system represented by the international standard (ISO 14001 2015), and the plan included specifying the requirements for the application of the international standard in

the factory of hydraulic elements for the purpose of achieving conformity with this standard.

- f- The sixth step sought to provide a proactive plan by minimizing the environmental impacts associated with the process of manufacturing hydraulic cylinders, and their uses within their operating systems, by choosing the appropriate means to reduce the occurrence of negative effects towards the environment in the future.
- g- The Seventh step presented a blueprint that includes the inclusion of environmentally friendly plans with typical manufacturing plans at the Hydraulic Elements Plant, for the purpose of achieving the Green Plant.

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