عنوان البحث :

رفع كفاءة محطات توليد الطاقة بإعتماد نظام ادارة الطاقة (ايزو 50001) : نتائج وتحليل دراسة ميدانية

Increase the Performance of Power Station by adopting ISO 50001 Energy Management, Results and Analysis of an Empirical Study

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الوظيفة : 1- مهندس أقدم و رئيس قسم التشغيل والتحكم في وزارة الكهرباء العراقية

2- استاذ محاضر بكلية الهندسة الميكانيكية – بغداد

3- باحث مشارك بجامعة UTeM الماليزية

الشهادة : ماجستير بهندسة التوربين وطرق الحفاظ على الطاقة.

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محور المشاركة : وسائل وحلول حول انتاج الطاقة والحفاظ عليها (تطبيقات عملية)

الملخص

قضايا رفع كفاءة انتاج الطاقة والمحافظة عليها اصبحت مهمة جدا لكل المؤسسات العامة بقطاع الطاقة وان اعتماد معايير الإدارة الفعالة للطاقة والحفاظ عليها يمكن ان يوفر للمؤسسات والحكومات المتطلبات الاساسية لخلق بيئة مستدامة في مجال انتاج الطاقة .

المشكلة الرئيسة التي يعاني منها قطاع انتاج الطاقة في مختلف البلدان هو زيادة الطلب على الطاقة يصاحبها خسائر مستمرة بكميات الطاقة المنتجة بسبب مجموعة من المشاكل لعل اهمها هو عدم اعتماد أنظمة ومعايير ادارة الطاقة .

الهدف الرئيسي من هذه الورقة هو تحديد وتهيئة العوامل التي تساعد الحكومات والمؤسسات العاملة بمجال انتاج الطاقة على اعتماد انظمة ادارة الطاقة (آيزو 50001) ثم تحليل هذه للعوامل بدراسة ميدانية في محطات انتاج الطاقة الكهربائية في العراق .

هذه الدراسة اعتمدت في مضمونها البحثي على أداتين من أدوات البحث العلمية لاعتماد أنظمة ادارة الطاقة وهما :

- المسح الميداني : الطريقة البحثية الاولى كانت عبر مسح ميداني شمل مختلف الشرائح والاقسام ذات العلاقة مع انظمة ادارة الطاقة في محطات انتاج الطاقة وصولا الى نتائج علمية و تحليلها عبر برنامج (SPSS) (Statistical Package for the Social Sciences) مستخدما اهم ادوات هذا البرنامج التي تساعد محطات انتاج الطاقة على الحفاظ على كميات الطاقة المنتجة واهم الادوات البحثية التي استخدمت في هذه الطريقة هي (قياس الانحدار , عوامل الارتباط , الانحراف المعياري , الرسوم البيانية ... الخ).
- التجارب العملية : الطريقة البحثية الثانية كانت عبر اجراء مجموعة من التجارب والاختبارات الميدانية على مواقع عمل متعددة لتحقيق افضل وسيلة لاعتماد انظمة ادارة الطاقة .

تهدف الدراسة الى تحقيق مجموعة من معايير ادارة الطاقة اهمها هي (رفع كفاءة الطاقة , تحسين الجودة, تقليل الكلف , تحسين الاداء البيئي , توفير الاستدامة الاقتصادية) . لذلك يأمل الباحث ان تساعد هذه الدراسة العديد من المؤسسات والحكومات في الحفاظ على الطاقة وتوفير افكار جديدة في تقليل الكلف والوقت .

النتائج المسحية اظهرت أن 95.1% من المشمولين بالمسح أكدوا أن تنفيذ معاير ادارة الطاقة سيؤدي الى رفع كفاءة انتاج الطاقة والمحافظة عليها .

نتائج التجارب العملية قادت الى ان اعتماد انظمة ادارة الطاقة سيؤدي الى توفير بيئة انتاجية مستدامة ومحافظة على مصادر الطاقة وطرق توليدها .

Abstract

Today, energy efficiency issues are becoming more and more important within organizations. The international standard ISO 50001 defines general requirements for the operational and organizational structure for companies. ISO 50001 provides benefits for organizations large and small, in both public and private sectors, in manufacturing and services, in all regions of the world. ISO 50001 will establish a framework for industrial plants; commercial, institutional, and governmental facilities; and entire organizations to manage energy.

The main problem that facing the power production is the decline in the amount of energy produced because of a set of problems, one of them not- adopting ISO 50001.

The main objective of this study is to identify the factors that help the Ministries of Electricity to adoption ISO 50001 in the power stations and then analyze these factors to the suggestion adoption ISO 50001.

The data were used for this study that was generated through structured questionnaires with close-ended questions by the survey in Iraqi Ministry of Electricity at AL- Dora power station. Statistical Package for the Social Sciences (SPSS) was used to test the research hypotheses.

This study has been used two methods to check the adoption ISO 50001 first method was through survey and analysis by SPSS software this method used the tools of SPSS software of parametric test like the correlations, mean, standard deviation, regression analysis, histograms and P–P plot. The second method was by conducting experiments at the workplace to prove the validity of the results that have been obtained by used the SPSS software.

The results of this study to prove that the adoption ISO 50001 Leads to an efficiency in energy management, reduce costs, create a sustainable environment in the field of energy production in power plants .

1. Introduction

In the few last years, the power sector has witnessed large motivations to go to implementation energy management system standards. The one that is the most popular standard is the ISO 50001 Energy management systems [1].

The standard ISO 50001 identifies the requirements for maintaining, implementing, and adoption, establishing and improving an energy management system [2].The standard ISO 50001 aims to enable an organization to follow a systematic energy to ensure continual improvement in sector energy performance, as well as it helps the organizations to reduce the energy use and reduce the energy costs [3].

The International Organization for Standardization (ISO) developed a new set of standards that addresses the use of energy in businesses, which is called the ISO50001:2011[4].

ISO 50001 is derived from the usual elements present in ISO's management systems, which practically guarantee miscibility with ISO 9001 (quality management) and ISO 14001 (environmental management). The standard works by combining energy efficiency and

management practices via the utilization of the current energy-consuming processes. The standard is mostly predicated on the Plan-Do-Check-Act (PDCA) cycle, combining technical and managerial perspectives. The objectives of the standard are:

i. Assist organizations in improving the current energy-consuming assets.

ii. Create transparency and facilitate communication between the management of energy resources and the promotion of energy efficiency throughout the supply chain.

iii. Reduce energy cost, greenhouse gas (GHG) emissions, and other environmental effects. Industries that adopted an Energy management systems used 10-20 percent less energy within the first half decade.

iv. Implement superior practices related to energy management and complement excellent energy management behaviors.

v. Help facilities assess the implementation of state-of-the energy-efficient technologies.

vi. Combine other organizational management systems, such as environmental, and health and safety, in the event it is miscible with other performance improvement approaches [5].

1.2 Research Motivation

The main purpose of this study is to investigate and analysis the factors that have an effect on adoption ISO 50001 In power station and then going to implementation IOS 50001 . This study aims to contribute to research by identifying the issues that have the relation with adopting ISO 50001 in power stations in Iraq. The study has following practical significance:

i. The optimal solution generated will result in a significant cost saving of power generation.

ii. Improve the efficiency of energy management and improve energy in the ministry of electricity.

iii. Reduce the degree of difficulty in implementing an energy management system in accordance with the ISO 50001 and hence help plants reap the benefits of managing energy which include cost benefits and increased business due to certification.

iv. Developing the processes that identify steps to be followed by a ministry to meet the requirements of the standard that which would help ministry electricity to implement the ISO 50001.

This study will help the ministries of electricity by providing new ideas about reducing the loss of the cost and time.

1.3 Problem Statement

The main problem of this study is continuing losses in the production of energy in addition to the loss of time and costs, leading to weakness in energy management due to not application of ISO 50001.

1.4 Research Questions

In order to complete the study and meet out the objectives, a set of questions have raised, which are to be solved and based upon the output of answers for the questions all objectives will be framed. The questions raised are as follows:

i. What are the factors that can help power station to improve the energy?
ii. How to analyze the factors that support to adopt ISO 50001?
iii. How can increase the efficiency of energy in power station?

1.5 Research Objectives

The major objective of the study is to help the Ministries of Electricity in to adoption ISO 50001 in their stations by taking into account the operational and organizational structure and measures taken during the adopting it. The objectives of this study are:

i. To identify factors that help the Ministries of Electricity to adoption ISO 50001 in the power stations.

ii. To analyze the importance of the factors in adoption ISO 50001.

2. Conceptual Framework Model to adoption ISO 50001 in power stations

This paper presents framework model to understand the most factors important in the sectors of power stations.

The conceptual framework model was built in this paper according to a set of concepts that have the relationship with energy efficiency by the physical, descriptive and qualitative model without any calculations [6]. The framework model in this paper creates a correlation between different variables that have relation with the ISO 50001 in any power stations. This framework consists of set of variables (dependent and independent) to implementing ISO 50001 in the power station including 5 independent variables as shown:

i. Reduction Costs
ii. Improvement Quality
iii. Performance Environmental
iv. Sustainability Economic
v. Reduction Energy

This model has many hypotheses and one variable as (a dependent variable) to implementing ISO 50001 as shown in figure 1.

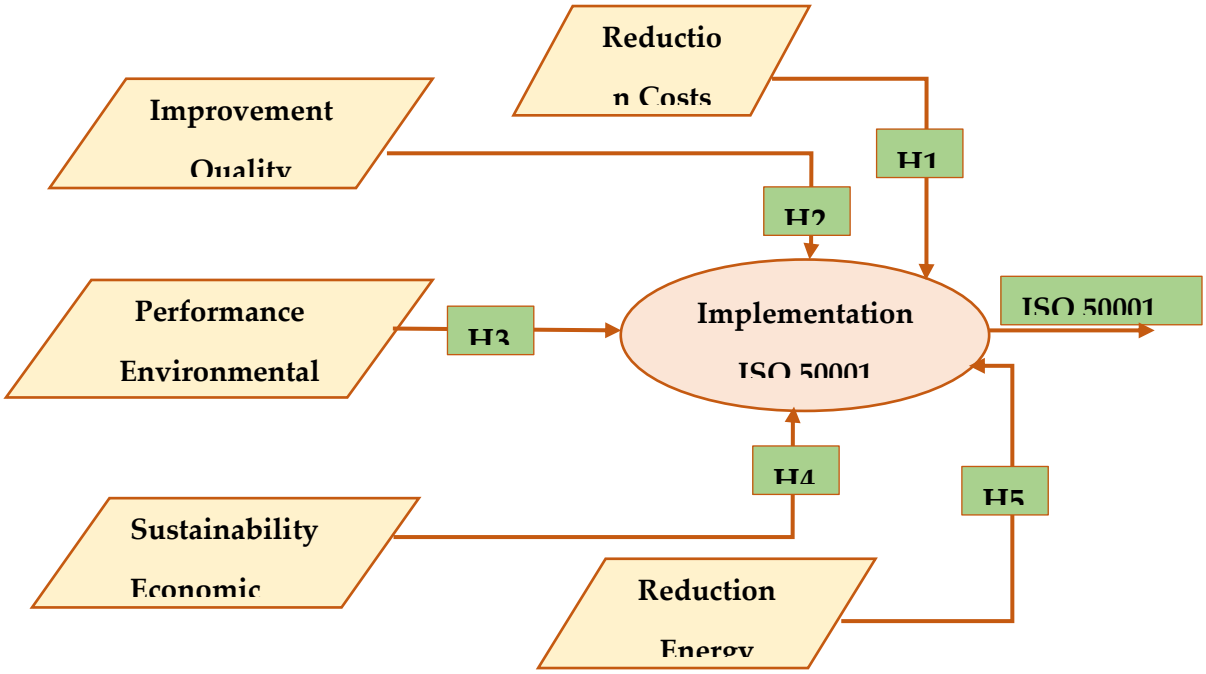


Figure 1: Conceptual Framework Model to adoption ISO 50001 in power stations

2.1 Research Hypothesis

1- **Hypothesis 1 (Reduction Costs):** The relation between reduction of costs and implementation ISO 50001 in the power plants is positively related to implementing ISO 50001.

2- **Hypothesis 2 (Improvement Quality):** The relation between improvement Quality and implementation ISO 50001 in the power plants is positively related to implementing ISO 50001.

3- **Hypothesis 3 (Performance Environmental):** The relation between Performance Environmental and implementation ISO 50001 in the power plants is positively related to implementing ISO 50001.

4- **Hypothesis 4 (Sustainability Economic):** The relation between Sustainability Economic and implementation ISO 50001 in the power plants is positively related to implementing ISO 50001.

5- **Hypothesis 5 (Reduction Energy):** The relation between Reduction Energy and implementation ISO 50001 in the power plants is positively related to implementing ISO 50001.

3. Methodology

This research took about 5 months to finish collecting data from the power station in Iraq. The data of survey, including (managers and engineers who have a decision about adoption to standards ISO 50001 in their power station.

The questionnaire was distributed to respondents in the power station, and the questionnaire has been designed according to the objectives of the study.

The questionnaire was divided into three sections:

(1) Section A: (demographic profile).

(2) Section B: (explained the reasons applying the standard ISO 50001).

(3) Section C: this section includes Independent and dependent variable.

The questionnaire has been distributed to 163 samples, including Managers and engineers as shown in figure 2.

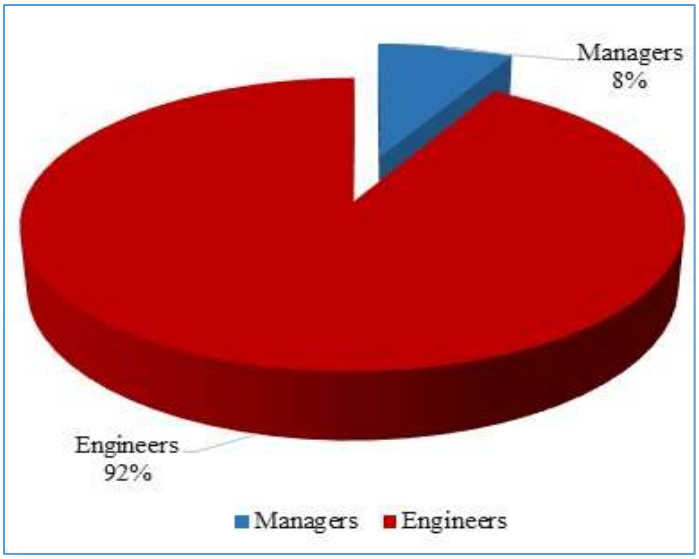


Figure.3. Population of study

The research process requires a sequence of steps that has been used as shown in Figure 3.

This study has been used two methods to obtain the correct results first method by the survey in power station, and the second method came to confirm the results that were obtained by the SPSS software by doing some experiments that have high impact in power station. Figure 3 shows the study development planning in completing this paper.

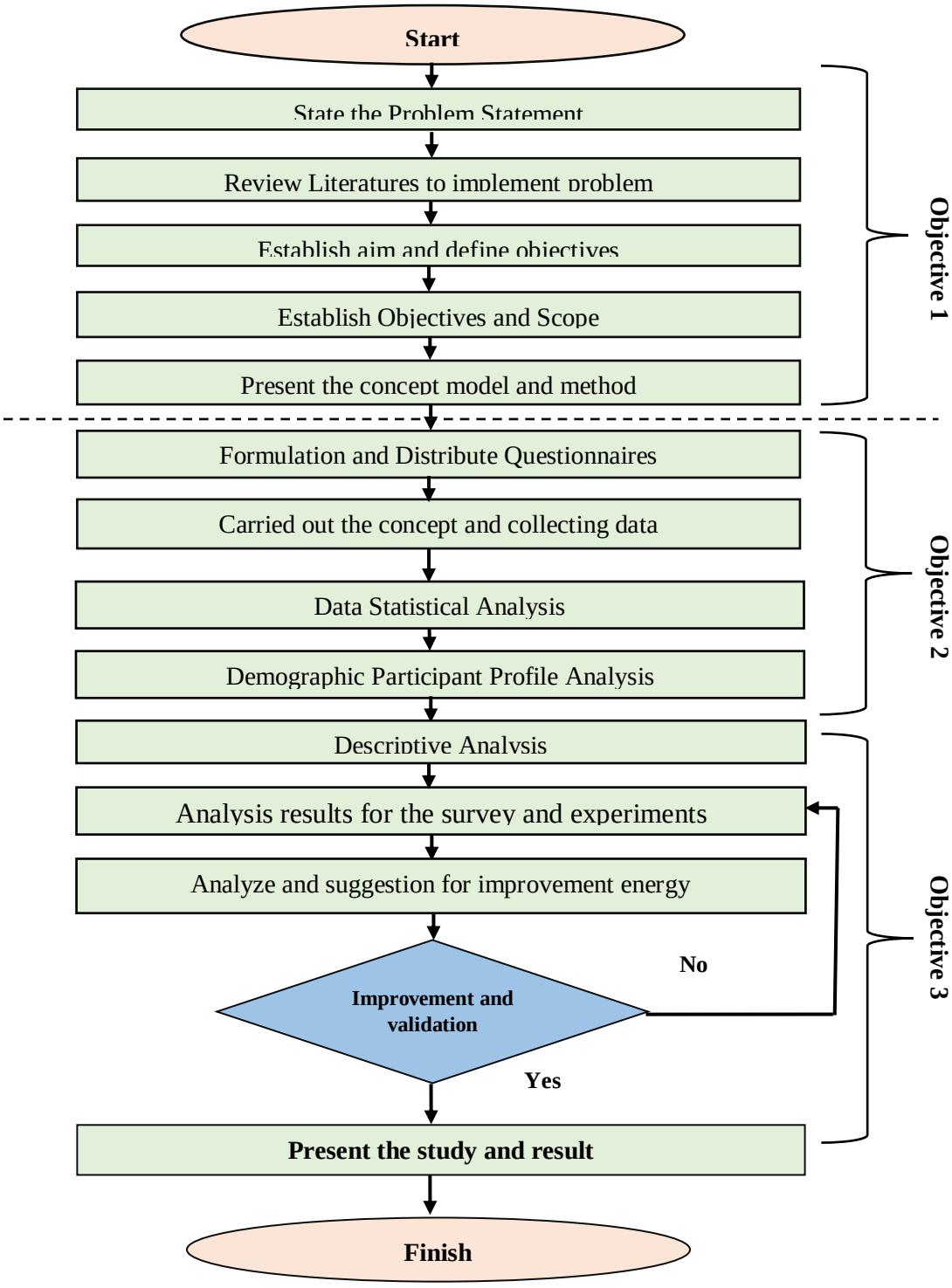


Figure 3: Study development Planning and Relationship between Methodology and Objectives

4. Research Results and Discussion

4.1 Results of First Experiment

The first experiment was about the improve energy consumption and raising the efficiency of the flow of fuel pumps in the power station as shown:

a) Process: Fuel Pumps.
b) Energy Source: Electricity.
c) Objective: Reduce from 3 to 2 pumps and Maintain flow rate of 520 m3/h.
d) How to solve: Change the valve configuration after the supply pumps and change the diameter of pipe 1 & 3 to use as a standby.
e) Results: The achievement of all the hypothesis and factors that have been proposed in this study as a shown in the tables and figures.

Overview of Experiment 1

I. Flow rate of 2 pumps before adopting ISO 50001 was 500 m3/h.
II. Flow rate of 3 pumps before adopting ISO 50001 was 520 m3/h.
III. Flow rate of 2 pumps after adopting ISO 50001 was 520 m3/h.
IV. Objective achieved with 2 pumps.
V. The price of one KW/h = 20 Iraqi Dinar (DI) Or 0.16 USD ($).
VI. Consumption Energy for 1 Pump per hour = 13.73 kw/h.
VII. Consumption Energy for 3 Pump per hour = 41.19 Kw/h.
VIII. Consumption Energy for 3 Pump per year = 41.19 x 24 x 360 = 355881.6 Kw/ year.
IX. Consumption Energy for 2 Pump per year = 27.4 x 24 x 360 = 236736 Kw/ year.
X. CO2 emission for each pump per hour according to the plate name = 6.87 Kg/h.

Table 1 explains the details of energy consumption per year and the total cost for each pump as well as to the most important technical specifications for the pumps.

Item	Energy KW/Year	Capacity M^3/h	Speed RPM	Cost of kWh/year	CO2 Kg/ year
Consumed per year	355881.6	520	2950	7117632 DI	178070.4

before adoption ISO 50001 of 3 Pumps				Or 56941.056 $	
Consumed per year after adoption ISO 50001 of 2 Pumps	236736	520	2950	4734720 DI Or 37877.76 $	118713.6
The difference before and after adoption ISO 50001	119145.6 Kwh/Year	-	-	2382912 DI /year 19063.296 $ / year	59356.8

Table 1: Summary of fuel Pump Savings

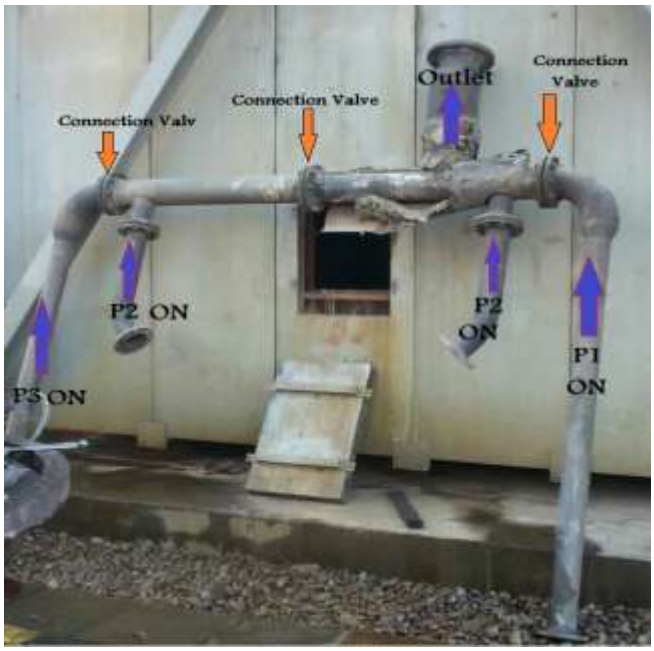


Figure 4: Pipes of fuel pumps before Configuration (profile of company, 2016)

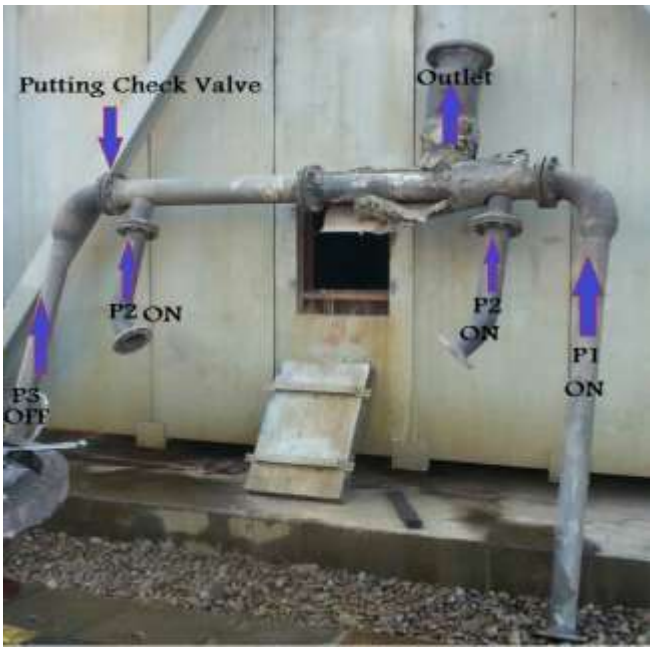


Figure 5: Pipe Configuration (pr

From the case study can see the results of experiments confirmed the validity of the results that conducted by SPSS and achieved all the factors that have been proposed in the conceptual model as shown:-

a) Cost Reduction

In this case study, the cost reduction has been achieved by reduction of cost from

7117632 to 4734720 Iraqi Dinar per year.

b) Quality Improvement

The quality improvement has been achieved by maintaining quality and shortcut the number of pumps from three to two while maintaining the natural capacity of the flow rate at 520 M3/h and 2950 RPM.

c) Organization environmental performance

Organization environmental performance has been achieved by reducing the CO2 emission from 178070.4Kg per year to 118713.6 Kg per year

d) Economic Sustainability

This experiment has been achieved the economic sustainability by reducing the number of pumps, kWh per year and CO2 as well as reduce the costs.

e) Energy Reduction

This experiment contributed to reducing energy consumed for pumps from 355881.6 kW / year to 236736 kW/Year.

4.2 Results of Second Experiment

The Second experiment was about the improve energy consumption and raising the efficiency of the compressor air in the power station as shown:

a) Process: compressor air.
b) Energy Source: Electricity.
c) Objective: improve the compressors to run only when required.
d) How to solve: Set up a sequence of the compressor to load and unload according to the air demand from the valves through putting pressure switch that has controls on the operation of the compressor.
e) Results: The achievement of all the hypothesis and factors that have been proposed in this study as a shown in the tables and figures.

Overview of Experiment 2

I. This is the first time that has been to synchronize the compressor.
II. Before adoption ISO 50001 the compressor runs continuously and thus causing a continuous loss in the energy and costs

III. The compressor now set to work when the need for air or when reducing the pressure in the air tank.

IV. Objective achieved.

V. Period time one month.

VI. The price of one KW/h = 20 Iraqi Dinar (DI) Or 0.16 USD ($).

VII. Consumption Energy for compressor per hour before = 7.5 kw/h.

VIII. Consumption Energy for compressor per hour after change setting = 5.5 kW/h.

IX. Consumption Energy for compressor per year = 7.5x24 x360 =64800 kw/h.

X. CO2 emission for compressors per hour according to the name plate before = 3.75 Kg/ h.

XI. CO2 emission for compressors per hour plate after change setting = 2.75 Kg/ h

Table 2: Summary of Compressor air Savings

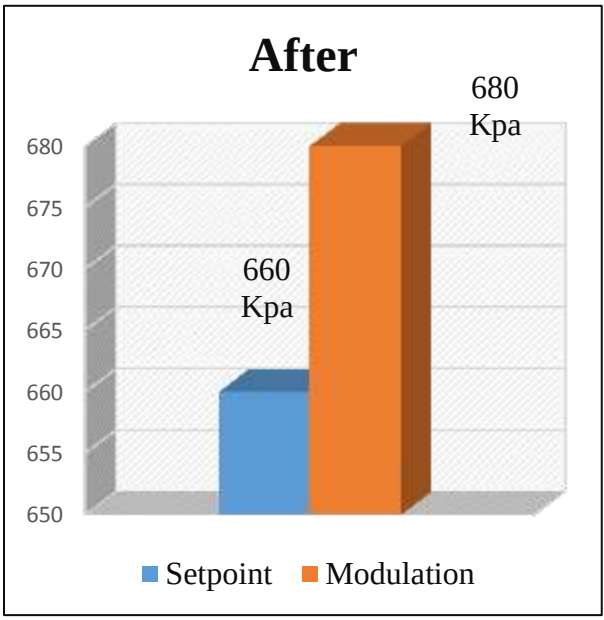
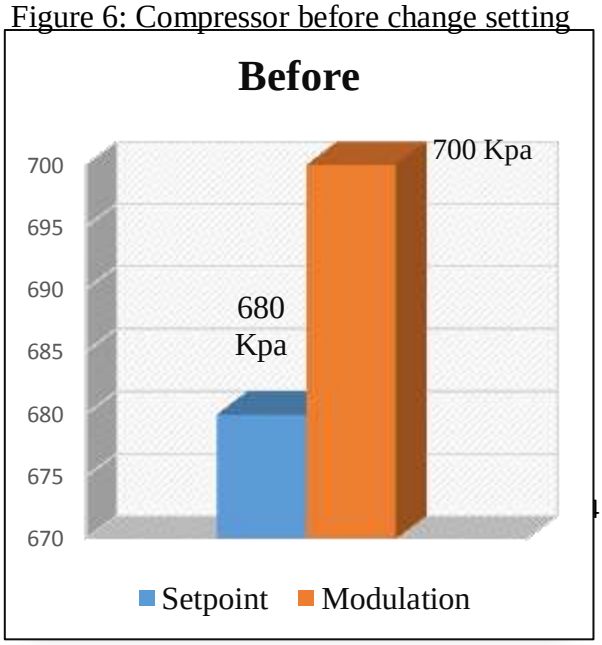


Figure 7: Compressor after change setting

Figure 6: Compressor before change setting



Item	Energy KW/Year	Cost of kWh/year	CO2 Kg/ year
Consumed per year before adoption ISO 50001 of compressor air	64800	1296000 DI Or 103680 $	32400
Consumed per year after adoption ISO 50001 of compressor	47520	950400 DI Or 7603.2 $	23760
The difference before and after adoption ISO 50001	17280 kWh/Year	345600 DI /year 96076.8 $ / year	8640

From the experiment, the results confirmed the validity of the results that conducted by SPSS and achieved all the factors that have been proposed in the conceptual model as shown:-

a) Cost reduction

In this case study, the cost reduction has been achieved by reduction of cost from

1296000 to 950400 Iraqi Dinar per year.

b) Quality Improvement

The quality improvement has been achieved by maintaining quality and reduce the kW/h and reduce the work time of compressor.

c) Organization environmental performance

Organization environmental performance has been achieved by reducing the co2 emission from 32400 Kg per year to 23760 Kg per year

d) Economic Sustainability

This experiment has been achieved the economic sustainability by providing a sustainable operation of the compressor and starting to work when lower air level in the tank.

e) Energy Reduction

This experiment contributed to reducing energy consumed for pumps from 64800 kW / year to 47520 kW/Year.

4.3 Results of Servy

4.3.1 Demographic Characteristics.

The survey of the demographic Included 163 of respondents who are directly responsible for maintaining the quality management systems including 83% of respondents is male and 17% female.

The age range of respondents on the demographic characteristics was from 35 to 44 years.

The survey included also current employment for the respondents in the power station.

The survey also covered the total cost of the adoption of ISO 50001, the results showed 50.9 % of respondents they confirmed that the implementation of the requirements of ISO 50001 is the high cost. But 47.3 % said the adoption ISO 50001 is no expensive compared with the benefit of their application .

4.3.2 Results of Correlations and Standard Deviation

The correlation coefficient can be defined as a quantitative measure of the kind of correlation and used to examine the statistical relationships between two or more random variables [7].

To check the measure correlation to any two or more random variables the values expected under the model in the correlation coefficient has to be between –1.0 and 1.0 [8]. The results of correlation between dependent and independent variables have been clarified in table 3.

Table 3. Results of Correlation between Dependent and Independent variables

	Mean	Std. Deviation	CR	QI	OEP	ES	ER	ISO 50001
CR	3.1376	0.69187	1					
QI	2.6976	0.81671	0.225**	1				
OEP	2.3304	0.55066	0.099	0.060	1			
ES	2.5620	0.77350	0.172*	0.794**	0.055	1		
ER	3.3415	0.61859	0.402**	0.166*	0.277**	0.145	1	
ISO 50001	2.3808	0.43252	0.342**	0.779**	0.380**	0.605**	0.541**	1

To get the ideal results we must be able to identify "perfectly"(P), the values of P groups can be helpful through using the asterisk system and P value [9]. As it is shown below as:-

P < 0.05 * The significant 95 %

P < 0.01 ** The significant 98%

P < 0.001*** The significant 99%

The results of correlation for dependent and independent variables as a show:-

1) The significant of confident between ISO 50001 and Cost Reduction 98% at 0.342**.
2) The significant of confident between ISO 50001 and Quality Improvement 98% at 0.779**.
3) The significant of confident between ISO 50001 and Organization Environmental Performance 98% at 0.380**.
4) The significant of confident between ISO 50001 and Energy Reduction 98% at 0.541**.

4.3.3 Test Hypotheses by Regression Analysis

1) **H1**. The first Regression Analysis between the reduction of cost (RC) and implementation of ISO 50001 the proven results the confident level between the dependent variable and independent variables is 99% at (0.342, $p < 0.001$). That mean Implementation of ISO 50001 at the power station leads to reduce the costs of production and consumption of energy .

2) **H2**. The second Regression Analysis between the improvement of quality (IQ) and implementation of ISO 50001 the proven results the confident level between the dependent variable and independent variables is 99% at (0.779, $p < 0.001$). That mean Implementation of ISO 50001 at the power station leads to improvement of quality in the power station .

3) **H3**. Third Regression Analysis between the performance of environmental (PE) and implementation of ISO 50001 the proven results the confident level between the dependent variable and independent variables is 99% at (0.380, $p < 0.001$). That mean Implementation of ISO 50001 at the power station leads to improve the performance environmental .

4) **H4**. The fourth Regression Analysis between the sustainability economic (ES) and implementation of ISO 50001 the proven results the confident level between the dependent variable and independent variables is 99% at (0.605, $p < 0.001$). That mean Implementation of ISO 50001 at the power station leads to create the sustainability economic .

5) **H5**. The fifth Regression Analysis between the reduction of energy (RE) and implementation of ISO 50001 the proven results the confident level between the dependent variable and independent variables is 99% at (0.541, $p < 0.001$). That mean Implementation of ISO 50001 at the power station leads to a reduction of the consumption energy .

4.4 Results of Histogram for Variables

6) According to the results extracted from all variables we can see that the distributions of histograms have a normal curve, this means all the data are normal, the histograms distribution has been represented first by Karl Pearson [10]. As it is shown in the following figures:

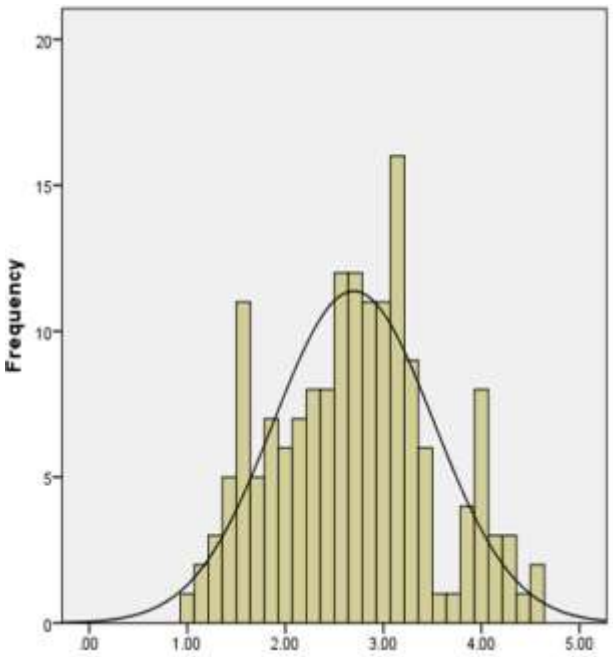


Figure.8. RC Histogram

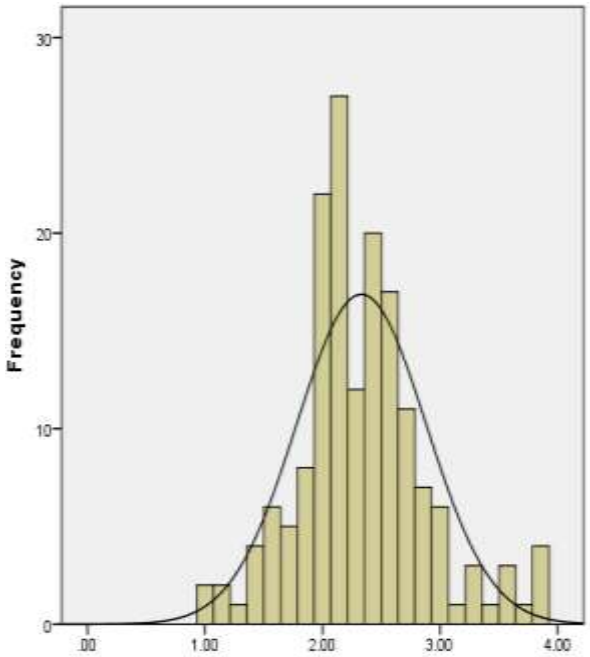
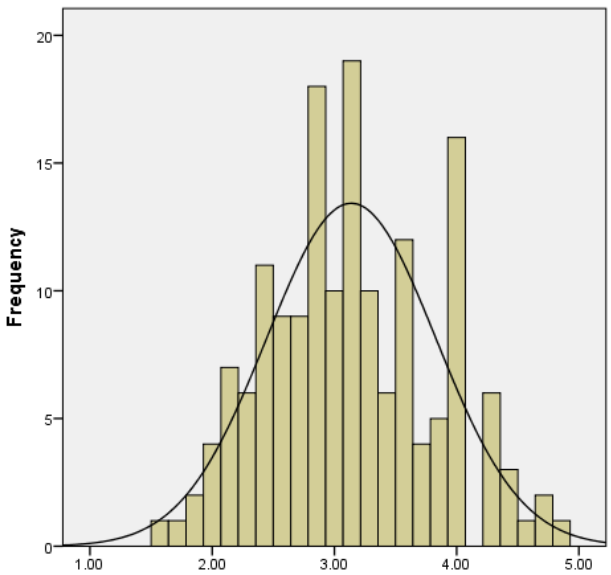


Figure.**9.** IQ Histogram



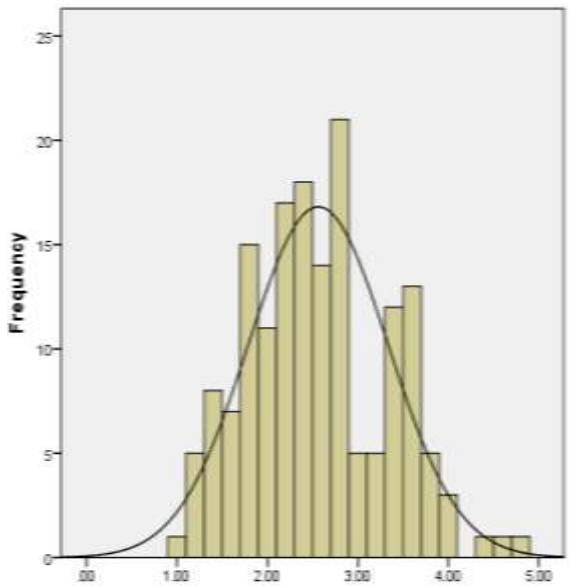


Figure.**9.** EOP Histogram

Figure.**10.** SE Histogram

5. Conclusion

This study presents a potential solution, of an international energy management standard, ISO 50001: Energy management and guidance for use, suitable for any organization, whether industrial, commercial, or institutional. Because of its importance to future climate-change mitigation efforts, particular attention will be given to existing and planned efforts to address barriers to future adoption of ISO 50001 by industries in developing countries.

In this research, the results of a study were held in one of the Iraqi Ministry of Electricity plants for adoption the ISO 50001. This study was an empirical to evaluation possibility of applying ISO 50001 in the power station. The authors took the burden of a customizing survey in the new area in Iraq to implementation this ISO. The author already have used the survey and experiments as their to extract accurate and reliable results from direct contact with decision-makers and executives from the decision to adopt the new ISO as a system at work in their power station. This new trend of this research in the power stations will give other factors to present assist and support those stations for increasing the efficiency energy and reduce consumptions.

References

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