An-Najah National University

Faculty of Graduate Studies

Techno-economic Evaluation of Applying Energy Management System Requirements in Industrial Sector in Palestine according to ISO50001 Standard

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Dedication

To my father and my mother

To my lovely wife (Hala)

To my son (Kareem) and daughter (Reem)

To my brothers and sisters

To my teachers

To my friends

To my colleagues

I dedicate this work

Acknowledgments

The first thing is to thank Allah for helping me to accomplish this work and make it easier to me.

Special thanks to the supervisor Dr. Imad Ibrik for his instructions and supporting me in my thesis and to the teachers of the Master of Clean Energy Engineering and Energy Conservations for their efforts.

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Also special thanks to my family father and mother, my other family father-in-law and mother-in-law.

Thank you to my friends and colleagues.

Thank you to everyone share to accomplish this work.

الإقرار

إنا الموقع أدناه مقدم الرسالة التي تحمل عنوان

Techno-economic Evaluation of Applying Energy Management System Requirements in Industrial Sector in Palestine according to ISO50001 Standard

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Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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List of abbreviations

AW	Annual Worth
CFL	Compacted Fluorescent Lamp
CPC	compound parabolic collector
EnB	Energy Baseline
EnMS	Energy Management System
EnPI	Energy Performance Indicator
EMS	Environment Management System
FL	Fluorescent Lamp
GWh	Gigawatt hour
GHG	Greenhouse gases
HVAC	Heating, Ventilation and Air Conditioning
ISO	International Organization for Standardization
IEC	Israeli Electric Corporation
JDECO	Jerusalem District Electricity Company
JDECO	Jerusalem District Electricity Company
kWh	kilowatt hour
LPG	Liquefied petroleum gas
MWh	Megawatt hour
MH	Metal Halide
PENRA	Palestinian Energy and Natural Resources Authority
PW	Present Worth
QMS	Quality Management System
SEU	Significant Energy User
SPBP	Simple Payback period
SME	Small and Medium-sized Enterprises
SWH	Solar Water Heater
SCADA	Supervisory Control and data acquisition
TWh	Terawatt hour
yr.	year

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Abstract

The energy sources, their generation, and use are considered the most important subject nowadays that pay attention of all stakeholders and researchers. This is due to increasing the cost and decreasing amount of conventional energy sources, and the corresponding environmental impact of using such sources.

This thesis discusses energy management in industrial sector in both sides; administrative and technical, taking into consideration the ISO50001 energy management system (EnMS) standard.

This thesis introduces study for the effect of implementation EnMS requirements for three case studies from industrial sector in Palestine, it shows how far is the industrial facilities from getting ISO50001 certification. Then, the results of three cases are generalized to another nine industrial facilities.

Implementing EnMS requirements will lead to energy saving opportunities of about 65.3MWh/yr., 441.1MWh/yr. and 312.2MWh/yr. from Royal Company, Siniora Company and Jerusalem Pharmaceutical Company, respectively. That savings equals about 39195NIS/yr., 264660NIS/yr. and 187336NIS/yr., respectively.

The costs of applying the requirements of EnMS based in ISO50001 standard on three case studies 104283NIS/yr., 101250NIS/yr. and 102185NIS/yr. for Royal, Siniora and JPC, respectively.

In addition, it was found that annual saving from applying EnMS requirement in the 12 industrial facilities was about 5.711GWh/yr. from all energy sources. The costs of applying the requirements of EnMS based in ISO50001 standard on all 12 facilities will be about 1229273NIS/yr.

Energy saving from EnMS implementation will lead to reduce the GHGs emissions in the atmosphere.

For CO_2 reductions, there are 45.4Ton /yr., 135.3Ton/yr. and 103.3Ton/yr. from Royal, Siniora and JPC companies, respectively.

For SO_2 reductions, there are 111.1kg/yr., 107.6kg/yr. and 104.3kg/yr. from Royal, Siniora and JPC companies, respectively.

For NO_x reductions, there are 117.6kg/yr., 189.7kg/yr. and 160.8kg/yr. from Royal, Siniora and JPC companies, respectively.

In addition, it was found that annual reductions in GHGs from applying EnMS requirement in the 12 industrial facilities was about 2265.34Ton/yr. of CO_2, 3.319Ton/yr. of SO_2 and 4.269Ton/yr. of NO_x.

Introduction

The industrial sector uses more energy than any other end-use sectors, which is about one-third of total global energy consuming sectors. This thesis will introduce study for impact of applying EnMS standards on industrial sector in Palestine.

At first, the EnMS is defined as a set of elements that interrelated or interacting with each other to establish an energy policy and energy objectives. The processes and procedures to achieve those objectives are also considered as elements of EnMS.

The energy policy is the statement by the organization of its overall intentions and directions, which related to its energy performance, it is formally issued by top management. [1]

These international standards related to energy management aim to enable organizations to establish processes and systems necessary to improve energy performance including energy efficiency, use and consumption.

Implementation of these EnMS standards is intended to reduce energy cost and reduce GHGs emissions and other related environmental impacts through systematic management of energy use.

In the first chapter of this thesis, the importance of applying energy management system in industrial companies in Palestine will be shown, with showing the current energy situation in Palestine, and then, some experiences from other countries will be detailed.

In the second chapter, the content of ISO50001 and ISO50006 standards will be discussed, and energy laws and regulations in Palestine will be detailed also.

In chapter three, the current situation in industrial sectors with regard to applying the requirements of EnMS based on ISO50001 standard will be analyzed by taking the results of three industrial case studies. After that, gap between the optimum implementation of EnMS and current situation must be will be analyzed in chapter (4).

Chapter (5) will discuss the economic feasibility of applying the requirements of EnMS by analyzing costs and benefits for every case study and then generalizing the results for 12 industrial factories.

Chapter (6) will discuss environmental impact of applying the requirements of EnMS through reduction the GHGs emissions by saving energy in the industrial facilities.

The objectives of this thesis as will be shown will be summarized as following:

- Determine the importance of implementing EnMS requirements for industrial sectors in Palestine.
- Determine the administrative requirements for implementing EnMS requirements for industrial sectors in Palestine.
- Analyzing the gap between the current situation of energy management in industrial sectors and the requirements of EnMS based on .requirements of ISO50001 standard
- Determine the technical requirements for implementing EnMS.

- Show economic feasibility of implementing EnMS.
- Show environmental impact of implementing EnMS.

Chapter (1) Literature review

1.1.Global Energy Situation

Applying EnMS standards have great influence in industrial sector all over the world, to see this influence we must look to size of industrial sector globally and locally in Palestine.

According to the international energy reports for 2016, it has shown that the industrial sector forms an important portion in the energy consumption all over the world, which is about 31% from all energy sectors.

Table (1.1) and figure (1.1) show the consumed energy distribution by sector globally from all sources of energy; electrical, renewable, different types of fuel …etc. [2]

Table (1.1): Global distribution of energy consumption sectors in 2016

Energy Sector	Total Energy Consumption (TWh)
Residential	5990.37
Commercial	5295.79
Industrial	9155.54
Transportation	8361.32
Unspecified Sector	205.15

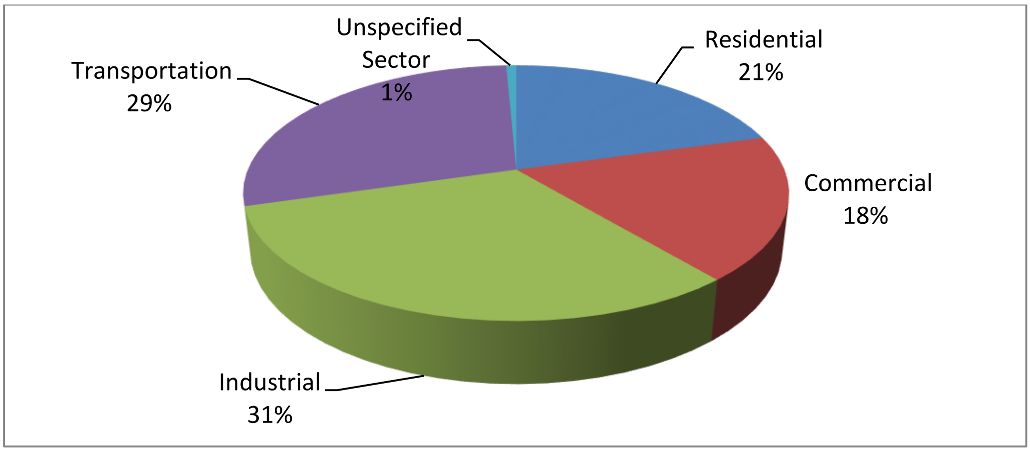

Figure (1.1): Global distribution of energy consumption sectors in 2016

However, these values is the total energy generated in their fields, it contains two parts, the delivered energy and the losses. Table (1.2) is showing the exact energy values and losses.

Table (1.2): Distribution of delivered energy and losses in different sectors

Energy Sector	Total Energy Consumption (TWh)	Delivered Energy (TWh)	Energy Losses (TWh)
Residential	5990.37	3206.19	2784.17
Commercial	5295.79	2622.98	2672.80
Industrial	9155.54	7238.83	1916.68
Transportation	8361.32	834077	20.51
Unspecified Sector	205.15	-	-

As shown in table (1.2), for industrial sector, the losses in energy is about 21% from total industrial energy consumption, which means a good investment in energy efficiency and conservation projects in this field. [2] The energy efficiency and conservation projects are already taking place all over the world due to economic and environmental considerations. The framework for these projects is EnMSs with specific requirements, which must be fulfilled to get the benefits of these projects.

1.2. Energy Situation in Palestine

It is important to know the situation of energy in Palestine to see the possibility and feasibility of implementation EnMS.

According to the past studies and reports, Palestine is suffering from very limited sources of energy due to the political situation.

Palestine produces a small amount of electrical energy from Gaza power plant which is only 140MW capacity, but it was affected after Israeli 2014 war on Gaza and affected from Israeli siege and control on entering the fuel, so it not working at full load nor full time.

From solar energy, it has been calculated during 2015 that the amount of energy taken from solar panels and solar water heaters was about 1500 GWh.

Palestine imports the energy from neighboring countries, mainly from Israel, which is about 89%, and very small amount from Egypt and Jordan, about 2% from each, this situation is considered unsafe and unsecure due to Israeli control on these resources. [3]

The energy consumed in 2015 in Palestine is shown in table (1.3) from the main energy sources by energy consumption sectors. [4]

Table (1.3): Energy sources and sectors distribution in Palestine in 2015

Sector	Electricity (GWh)	Solar Energy (GWh thermal)	Diesel (1000 Liter)	Gasoline (1000 Liter)	LPG (Ton)
Industry	567.2	0	17887	401	8445
Transportation	0	0	614694	268086	4855
Household	3273.7	749	6125	0	139024
Agriculture	39.4	0	10003	5159	3004
Commerce and Public Service	1327.1	0	2883	2861	11885
Loss in Transportation & Distribution	711.3	0	1832	2247	0

From energy transformation equations between the different sources, the distribution of energy sources percentages in Palestine is shown in figure (1.2): [4]

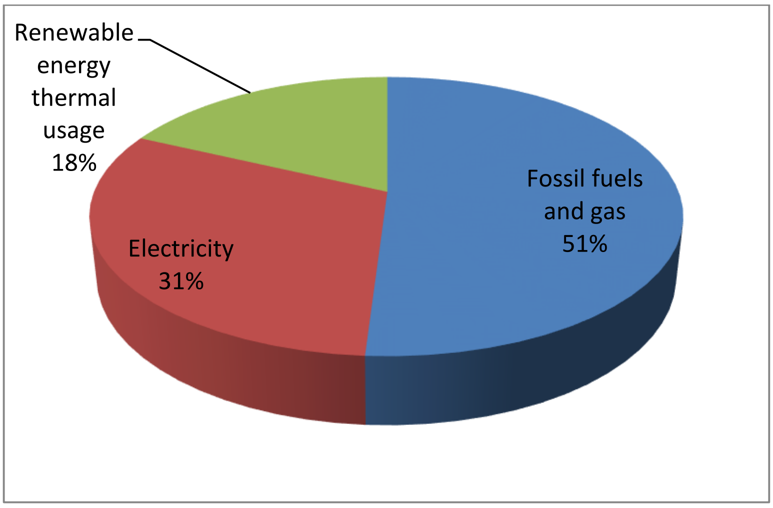

Figure (1.2): Distribution of energy sources in Palestine in 2015

1.3. Importance of EnMSs

The adopting of EnMS in the facilities requires the systemization of energy saving methods. This will result in measurable energy savings and costs related improvements and efficiency in processes as long-term advantage.

At the macro-level, the EnMS widely contributes to improving the environmental situation.

The main advantages of introducing an EnMS will be discussed as following:

1. Cost reduction

   Increasing energy costs will lead to reduce overall profit in every company, the potential of reducing energy consumption is exist despite of the nature of enterprise; industrial, commercial, residential…etc.

   By introducing an EnMS, we can save up to 10% of energy costs in initial years after implementation by systematically identifying the weak points in energy consumption and addressing them with basic measures. Also, the investment in the energy efficient technologies is worthwhile; such as investments in pump systems, compressed air systems, ventilation systems, refrigeration, material handling technology, and other energy consumption sectors, we will see 5-50% reduction in in energy consumption and an average payback time of less than 2 years. [5]

2. Environmental protection

   The problem of climate change that it is already considered one of the main causes of the natural catastrophes like drought and floods. However, the results of increasing temperature is greater, such as flooding of coastal regions and low laying island nations, increasing desert areas, melting of glaciers,… etc.

While climate change is occur worldwide, the protection of climate must be locally manipulated. Only when all companies and households are working together, the risk of climate change can be mitigated.

An efficient energy management is therefore an important element, because it reduces the consumption of energy sources and then reduces GHGs emissions. [6]

3. Sustainable management

Resources efficiency in energy sector is a much-discussed issue nowadays, because the limitation in the fossil fuels reserve. Efficient energy management, new energy concepts, and innovative energy technologies are keys to operating in the market successfully in the coming years and decades. [7]

4. Improvement of public image

With certified EnMS, the enterprise can credibly show that it works sensibly with respect to energy efficiency and thus it protects the environment.

Environmental requirements are increasingly an important factor in public proposals, including climate friendly purchasing. EnMS supports the measurement of CO_2 from the perspective of supplier and the procurer. [8]

5. To benefit from financial incentives

   In many countries, the implementation of EnMS is a prerequisite for energy intensive companies to be exempted from some fees and tariffs. [9]

6. Creating full picture for the status of current energy use, based on which new goals and targets can be set. [10]
7. Evaluating and prioritizing the implementation of new energy-efficient technologies and measures.
8. Providing a framework to promote energy efficiency throughout supply chain.
9. Providing guidance on how to benchmark, measure, document and report facility energy use. [11]
10. Making better use of energy consuming sectors, thus identifying potentials to reduce maintenance costs or expand capacity.
11. Fulfilling the associated regulatory requirements and responding with confidence to green trade barriers in global market.

1.4. EnMS examples from some countries

The energy management systems and energy efficiency projects had taken place widely in many countries compared with others.

In total, the number of certification in the EnMS based on the standard ISO50001 was increased by 69% in 2016 compared with 2015, which is 20216 certificates were issued all over the world in 2016 compared with 11985 certificate in 2015. [12]

These figures reflect the awareness of the importance of implementing EnMS and energy efficiency procedures, beside the existing European directive 2012/27/EU, which oblige facilities to apply energy audits and to comply with requirements of EnMS.

1.4.1. Germany

Germany is the country which is pioneer in the field on implementing EnMS, this is referred to the exemptions in taxes for enterprises which prove that they have a certified EnMS, 9024 certifications of EnMS were issued in 2016 in Germany which constitute about 45% of total EnMS implemented all over the world. [12]

The costs of energy in Germany are high comparing with international costs; they are about 14% higher than the European countries for example. The reason of this increment is especially is a high tax component known as Renewable Energy Act (EEG).

The electricity tax accounts in Germany was 20.5€/MWh in 2007. Some exemptions was made until 2012, like firms paying more than 1000 € electricity tax per year can apply for 90% reduction, list of energy intensive processes is also excluded from the tax, and the industry-specific voluntary CO_2 reduction targets have to be achieved.

In 2013, to get benefit from these exemptions, the requirement for the companies was to prove that they have an EnMS certified by ISO50001 is implemented to receive tax discounts or alternative systems for SME's including audits at the latest of 2015.

Many programs had taken place in Germany to help companies to get benefit from these exemptions, one of them was the German Energy Audit Program, and it was established in 2008 as stand-alone voluntary program for SME's.

The total impact of this program during 2 years (March 2008 – June 2010) was calculated in both sources of energy, electricity and fuel, about (1921GWh) of energy was saved, with total CO_2 reduction amount of (624Kt CO_2). The cost of investment in saving measures was (666 million euros) with total energy cost saving (122 million euros) and with audit cost of (32.7 million euros), this means 5.7 years payback period in average for all program. [13]

1.4.2. United States

In 2007, United States of America had established a program for energy management called Superior Energy Performance (SEP) program. It is a strategic energy management program offers a comprehensive approach to energy efficiency and promotes continues, sustained improvement in energy performance from the operation of industrial facilities. This program was based on ISO50001 standard.

It was found in US that the industrial companies are seeking to manage energy costs and consumption to lower risks related to energy, and to introduce transparency into reports of their energy performance achievements.

The US department of energy (DOE) was found that there is 7% saving potential of total US industrial energy consumption through the application of proven best practice, these opportunities are available with simple paybacks of less than two years.

To assess the costs and benefits of the SEP program, a study was conducted for 9 facilities which are SEP certified, this study include both quantitative and qualitative analyses to show the comprehensive impact of this efficiency program in industrial facilities. The annual baseline source energy consumptions for these nine facilities were ranging from 22 GWh to 990 GWh.

The study covered the energy cost saving in both sides; capital and operational energy performance actions.

Energy saving percentage was calculated quarterly as average of every 3 months, during analysis for all 9 facilities, it had shown that there is 7.4% energy saving in first 4 quarters due to SEP program and 13.7% in the following two quarters from the second year.

The costs related to participation in the SEP program and implementing ISO50001 was about 319000$ per facility in average, and these costs are grouped in many parts; EnMS development cost was about 192000$ with 22000$ for preparation to certification audit, these two costs considered as internal staff time which represent 67% of total cost.

The other costs are distributed in external technical assistant (58000$), EnMS metering and monitoring equipment (28000$) and third party certification audit cost (19000$).

The energy saving due to SEP program implementation in average in next two years for nine facilities which were covered by this study was 498GWh/yr. and energy cost saving 503000$/yr. on average. The payback period for the nine facilities was calculated on average for all of them and it was about 1.7 years. [14]

1.4.3. Italy

In Italy, despite of the economic crisis, the impact of sharing of industrial sector on the total energy demand is still significant. This obvious from the certification of companies for EnMS based on implementing ISO50001 standard, this make Italy took 4th place in the world in the number of certified facilities.

The European Member States had agreed on the climate and energy targets included in the Climate-Energy Package 20-20-20 as a result of greater environmental awareness, which comes from the growth of energy consumption. This package providing 20% reduction of GHGs emissions, 20% of renewable energy sharing, and 20% increase in energy efficiency by 2020 compared with the indicators in 1990.

In response of this demand Italy had developed the new National Energy Strategy; it is based on a wide and articulated national program of energy efficiency that allows reaching the 2020 level of consumption about 24%, which is lower than in the European baseline scenario.

The interventions activated by 2007 Action Plan on Energy Efficiency enabled Italian Government to save about 46520GWh/yr. of final energy in the 2010, which is exceeding the targets set for that date 40705GWh. The survey was made on the already certified companies and found that about 38% of them had received benefits of in terms of cumulative energy saving more than 5% of total energy consumption. [15]

1.4.4. Russia

Russia is considered a very late country in the field of systematic EnMS, this can be noticed from the slow growth of number of certified enterprises compared with the other countries. In 2016, 174 certified EnMS in Russian facilities compared with 20216 certificates all over the world. The reasons of low interest of Russian Enterprises in applying the EnMS were analyzed in many studies. [12]

The first reason was the absence of the integrated domestic information resources, which allowing to receive complete information about the EnMS implementation on the enterprises and the efficiency of its application.

The second reason was the certification of EnMS does not ensure the efficiency of its functioning, certificating but not functioning of the system was stressed in the majority of cases.

The last reason found is the attitude of the majority of top management level, and their opinion that the system can be efficiently implemented only by third party organization, which needs more and more additional cost. [16]

1.4.5. Jordan

As case study from Jordan, the first ISO50001 certified power plant was Amman East Power Plant (AES Jordan PSC), it is 400MW combined cycle power plant located east of capital, Amman. It had got the certification in April/2016.

This plant start working in efficiency projects from year 2013 but without certification, from that year it was achieving most of requirement of EnMS, so it was easy to adopt ISO50001. That means 4 years was taken to reach the certificate.

As summary, the period of energy performance improvement was about 4 years. Over that improvement period, the energy performance improvement was 1.7%. The total energy cost saving was 1568700 $ with cost of implementation of 1264452 $.

Total energy saving over 4 years was estimated 400000GJ and the total reduction in CO_2 emission was 34330Mtons. [17]

Chapter (2) Existing International Standards and Directives for Energy Management

2.1. Introduction

As mentioned in the first chapter, EnMS was standardized by International Standard Organization in 2011, and other supplementary standards were published after that in 2014 and 2016.

The "standard" term referred to agreed way of doing something. It can include producing products, managing processes, delivering services or supplying materials. It can cover a wide range of activities undertaken by facilities and used by their customers.

The purpose of EnMS standards is to provide guidance for facilities to integrate energy efficiency measures into their management practices.[18]

ISO50001 is the first standard developed to be a systematic way to control the energy efficiency activities in the facilities and provide a guide to implement energy efficiency measures, other standards in the same series was developed to describe other activities related to energy management. The following list shows all relating standards. [19]

ISO50001: Energy Management Systems – Requirement with guidance for use.

ISO50002: Energy Audits – Requirements with guidance for use.

ISO50003: Energy Management Systems – Requirements for bodies providing audit and certification of energy management systems.

ISO50004: Energy Management Systems – Guidance for the implementation, maintenance and improvement of an energy management system.

ISO50006: Energy Management Systems – Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI) – General principles and guidance.

ISO50015: Energy Management Systems – Measurement and verification of energy performance of organizations – General principles and guidance.

ISO50047: Energy savings – Determination of energy savings in organizations.

In addition to these standards, European directive was adopted in 2012 on Energy Efficiency (2012/27/EU) and it was mandatory from the date of enforcement for all facilities in European Union.

The directive is a formal document developed and published by government and containing the requirements that a product, process, or service must comply with, and it includes administrative provisions for its implementation. The compliance with directive is mandatory; the corresponding document in Palestine is called Technical Regulation.

Palestinian Standard Institution has Technical Regulation committee, which is responsible for drawing up Technical Regulations on the basis of European Directive.

Until now, no Palestinian technical regulation had been issued in the energy efficiency field, but in the future, there is plan to issue a lot of technical regulations concerning of energy efficiency and eco-design for the electrical appliances.[20]

There is a Palestinian law on renewable energy and energy efficiency was issued in August 2015. It regulates renewable energy market and it defines the responsibilities of competent authorities in different activities related to renewable energy generation and distribution and the activities of energy efficiency projects. [3]

The standards are talking about the requirement of EnMS and they are based on continual improvement framework called Deming Cycle. It is an iterative management method depends on four essential steps; Plan – Do – Check – Act (PDCA).

“Plan” stage involves in preparing energy review for the facility and identifying energy baseline, energy performance indicators, objectives, targets and action plans. “Do” stage is starting implementation of these plans.

“Check” stage is to monitor and measure processes and key characteristics of operations to determine energy performance against the energy policy and objectives, and report the results. Then continual improvement of energy performance and EnMS is “Act” stage of the management cycle. [5]

2.2. Energy Efficiency Directive (2012/27/EU)

2.2.1. Scope of directive, objective and target

This directive establishes a framework of measures to promote energy efficiency within EU in order to ensure the achievement of its headline target in 2020 – 20% target on energy efficiency to pave the way for further energy efficiency improvements after that date.

Palestinian Energy and Natural Resources Authority (PENRA) had prepared the National Energy Efficiency Action Plan (NEEAP), this action plan is divided in 3 phases (2012-2020). The aim of this action plan is to save about 5% of total energy consumption in 2020, which equal about 384GWh through execution of some procedures and energy audits on different energy consuming sectors.

The EU also set the target of using oil fuel by 2020 to be no more than 17142 TWh as primary energy consumption or no more 12537 TWh of final energy consumption. [21]

2.2.2. Article (8): Energy audits and Energy management systems

In this article, the European countries are obliged to promote the availability to all final customers of high quality and cost effective energy audits. These audits must be carried out independently and by qualified and/or accredit experts.

PENRA had carried out a lot of energy audits in different sectors in Palestine in order to find energy saving opportunities in every facility, and then to reach to the target.

The energy audits done by PENRA was based on the following guidelines as the requirements of the that European directive:

- The audits must be up-to-date, measurable, traceable operational data on energy consumption and load profiles for electricity.
- Comprise a detailed review of the energy consumption profile of buildings or group of buildings, industrial operations or installations.
- The audits must be proportionate and sufficiently representative in order to have a reliable envisage of overall energy performance, and the reliable identification of the most significant improvement opportunities. [21]

2.3. Standard ISO50001:2011

ISO50001 standard specifies requirements of establishing, implementing, maintaining and improving an EnMS. The purpose of EnMS is to enable the organization to follow a systematic approach in achieving continual improvement of energy performance including energy efficiency, consumption, and use.

ISO50001 applies to all factors may affect energy use, which can be monitored and influenced by the facility. It provides a general-purpose system that allows the facility to choose performance standards that they deem best meet their requirements.

The scope of this standard is specific requirements applicable to energy use and consumption, and other activities including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes and personnel that involved in energy performance.[1]

2.3.1. Scope and boundaries

Before starting implementation of EnMS based on ISO50001, the organization must define the scope and boundaries of its management system.

The scope is the extent of activities, facilities and decisions that the organization addresses through implementing EnMS.

The boundaries are defined as physical limits of site, and/or organizational limits, which could be a process or group of processes, a site, an entire organization and multiple sites under the control of organization.[1]

2.3.2. Management responsibility

The top management of the organization has to show the evidence of commitment and active involvement in all stages of implementing EnMS as required by this standard, establishment, implementation, operation, monitoring, review, maintenance and improvement of the system.

The standard requires top management to appoint a management representative with appropriate skills and competence, who will be a responsible for overseeing the development and operation of EnMS.[1]

2.3.3. Energy policy

Energy policy is defined as a statement, which formally expressed from the top management of the organization of its all intentions and directions related to its energy performance.

The energy policy should be appropriate to the scale and nature of the organization's energy consumption and use.

It should include a commitment to continual improvement, commitment to ensure the availability of information and necessary resources to achieve targets and objectives and review these targets and objectives.

The energy policy must support the purchase of energy-efficient products and services, and design of energy performance improvements. [19]

2.3.4. Energy planning

The organization shall establish and document an energy planning process. It must be consistent with the energy policy and it must lead to activities that improve energy performance continually.

Energy review is a process to determine the energy performance of an organization, based on data and/or actual measurements leading to identification of opportunities of improvement. To develop energy review, the organization must take the following steps:

- Analyzing the energy use and consumption based on measurements and other data. It must identify current energy source, and evaluate the past and present situations.

- Identifying significant energy users, based on analysis of energy situation, including equipment, systems, processes, and personnel working for the organization that significantly affect energy use and consumption.
- Identifying, prioritizing and recording the opportunities for improving energy performance.

Documented energy objectives and targets must be established, implemented and maintained in the relevant functions processes or facilities within the organization.

Action plan must be established to achieve those objectives and targets within time frames. They should be consistent with energy policy.

The objectives state what the organization wants to achieve, while target specifying how the organization would achieve those objectives. The objectives and targets must be specific, measurable, achievable, relevant, and time limited.[19]

2.3.5. Implementation and operation

Implementation of EnMS depends on the establishment and maintenance of operational procedures to ensure that the significant energy users (SEUs) are being controlled and the objectives, targets, action plans and energy policy are carried out under specific conditions.

This can be ensured by establishing setting criteria for the effective operation and maintenance of SEUs, because their absence could lead to a significant deviation from effective energy performance.

The design of new, modified, and renovated facilities, equipment, systems, and processes can play an important role in energy performance improvement by considering the opportunities and operational control during the design stage.

The organization shall evaluate all the procurements related to energy services, products, equipment and energy on the basis of their energy performance.

The organization must establish the criteria for assessing energy use, consumption and efficiency over the planned or expected operating lifetime of energy consuming sectors. [19]

2.3.6. Checking

The monitoring of energy performance, measurements and analysis of it must be in planned intervals. These activities shall include, at least, SEUs, the relevant variables related to them, performance indicators, the effectiveness of action plans in achieving objectives and targets, and evaluation of actual energy consumption compared with expected.

In order to enhance the checking requirement of the EnMS, the organization shall conduct internal audits at planned intervals (may be quarterly, semiannually, or annually…etc.)

The internal audit must evaluate the processes, procedures, and implementation of EnMS, in order to determine if they are appropriate to organization and to the implementation status, and to ensure conforming to requirements of ISO50001 standard and energy objectives and targets.[19]

The organization shall identify the actual non-conformities and potential cases like this, by making corrections, and by taking corrective actions and preventive actions.[19]

2.3.7. Management review

Top management shall make review for the EnMS, at planned intervals, to ensure that it continuing suitable, adequate, and effective.

The outputs from top management review of EnMS include any actions or decisions related to changes in the energy performance of the organization, and related to changes in energy policy or EnPI.

The output shall also include any actions or decisions related to changes to objectives and targets, or any other elements of EnMS, and changes to allocations of resources. [19]

2.4. Standard ISO50006:2014

The standard ISO50006 is international standard, which provides a general principles and guidance to organization on measuring energy performance using energy baselines (EnB) and energy performance indicator (EnPI), and how to establish, use and maintain them as part of this process – measuring energy performance.

Energy baseline (EnB) is defined as a quantitative reference providing a basic for comparison of energy performance and it reflects a specified period of time.

Energy performance indicator (EnPI) is defined as a quantitative value or measure of energy of energy performance as the organization define it, it may be a simple metric, ratio, or complex model.

Figure (2.1) shows relation between energy performance, EnPIs, EnBs and energy targets.[22]

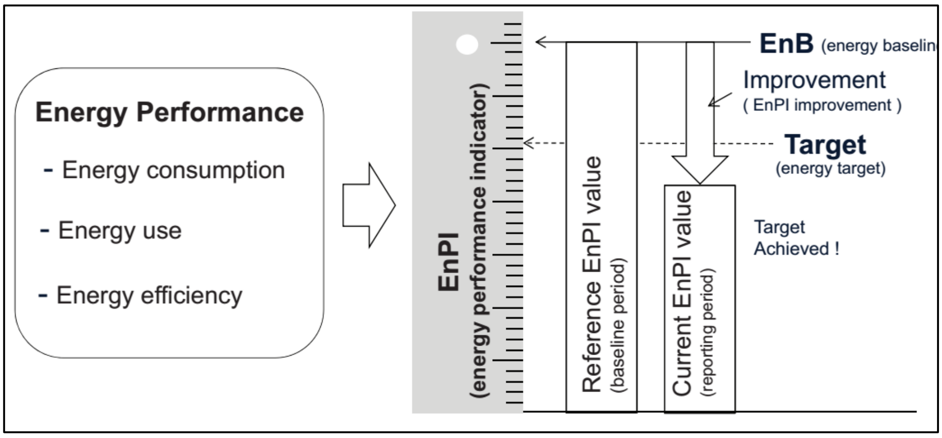

Figure (2.1): Relation between energy performance, EnPIs, EnBs and energy targets

2.4.1. Obtaining relevant energy performance information from the energy review

Energy review provides useful energy performance information for developing energy baselines and energy performance indicators.

The establishment of these baselines and indicators in appropriate way requires access to the available organizational energy data, analysis of the data, and processing of energy information. [22]

The following information must be defined in order to establish the EnPIs and EnBs:

- Defining the EnPI boundaries.

- Defining and quantifying energy flow.
- Defining and quantifying relevant variables.
- Defining and quantifying static factors.
- Gathering data

2.4.2. Identifying EnPIs

When identifying an EnPI, the organization should understand the characteristics of its energy consumption, such as base load, variable loads due to production, occupancy, weather, or other factors. The main types of energy EnPIs are:

- Measured energy value: the energy consumption of an entire site or one or more energy users.
- Ratio of measured value: such as specific energy consumption.
- Statistical model: relation between energy consumption and relevant variables using linear or non-linear regression.
- Engineering based model: relation between energy consumption and relevant variables using engineering simulation.

It is very important to identifying users of EnPIs; external and internal users, these indicators must be easily understood by them. Type and complexity of these indicators must be adapted to the different end users' needs. [19]

2.4.3. Establishing EnBs

The EnBs is characterized by the value of EnPI during the baseline period.

The following steps should be taken to establish an EnB:

- Determine the specific purpose of which the EnB will be used.
- Determine a suitable data period.
- Data collection.
- Determine and test energy baseline.[19]

Chapter (3) Industrial sector situation in Palestine regarding to applying requirement of EnMS – case studies

3.1. Overview of ISO50001 EnMS requirements

ISO50001 standard includes requirements that must be met in order to get benefit of adopting such EnMS. These requirements will be explained briefly in this section, and then, many case studies will be analyzed in order to see how far is the industrial sector in Palestine from starting ISO50001 certification schemes .

First step before thinking of applying EnMSs and energy efficiency projects in Palestine is to find the potential of energy savings in all sectors of energy consumers.

As mentioned before, industrial sector represents about 5% from total energy consumption in Palestine, despite that this percentage is somewhat little, potential of energy saving is very high. [3]

Palestinian Energy and Natural Resources Authority (PENRA) had carried out energy audits for many energy-consuming facilities and found energy saving potential for every facility.

In 2012, a study was carried out to find the potential of energy saving in many different industrial sectors; foods, pharmaceuticals, plastic industry, newspapers and press company, this study had shown a high energy saving potential in industrial sector. [3]

The requirements of ISO50001, which will be analyzed in this chapter, are the following:

1. Defining scope and boundaries of EnMS.
2. Management responsibilities of demonstration commitment and support. The top management must appoint management representative to oversee the implementation of the EnMS, and must appoint energy team to carry out all tasks related to EnMS.
3. Energy policy.
4. Energy planning, this requirement includes many elements:
   - Energy review, EnBs and EnPIs.
   - Energy objectives, targets, and action plans.
   - Energy profile.
   - Energy consumption (from bills, sub-meters, or estimation).
5. Implementation and operation; this requirement includes:
   - Competence, awareness, and training.
   - Communication.
   - Documentation.
   - Operational controls.
   - Design.
   - Procurement of energy services, products, and energy.
6. Checking, to achieve this requirements, some procedures must be taken:
   - Monitoring, measurement, and analysis.
   - Internal audits.

- Corrective and preventive actions for non-conformities.

7. Management review.

In this thesis, three industrial companies was chosen as case studies in Palestine. In this chapter applied requirements of EnMS in these companies will be determined and in the next chapter I will specify the shortages and make suggestions of how to fill the gap.

If the company had certified with any management systems, such as ISO14001 and/or ISO9001, the implementation of ISO50001 standard will be easier, because it only needs to be integrated in one integration system, with the same administrative procedures. [23]

3.2. Evaluation of Royal Industrial Trading Company situation regarding of EnMS requirements

Royal Industrial Trading Company was established in Hebron city on 1993. It is specialized in sanitary and water distribution insulations; it produces U-PVC pipes, PE water tanks and manholes, PP fittings, flushing cisterns, and many other products in the same field.

Royal company had certified quality management system ISO9001:2008, and environmental management system ISO14001:2004. In addition, it has a Palestinian Standard certificates for many of its products.

3.2.1 Scope and boundaries

This company has about 600 employees within a land area of more than 24000m^2 and building area of more than 40000m^2. The proposed EnMS will cover all employees and all the area of the company.

3.2.2 Management commitment

This requirement is an essential requirement for all management system standards. Therefore, because the Royal Company is certified with other management systems, it is easy to get the commitment from top management to implement EnMS.

3.2.3 Energy Policy

Again, the existence of other management system will facilitate the drafting of energy policy in Royal Company. The issuing of energy policy will not cost the company anything.

3.2.4 Energy Planning

3.2.4.1 Energy profile

The Royal company uses three types of energy; electricity, LPG, and diesel to operate the energy systems. Diesel is used in standby generators and for transportation, LPG is used for tank sections (ovens), the electricity is the energy source for chiller, cooling towers, compressors, pumps, production lines, lighting, split units, and elevators.

Electrical energy forms about 75% from total energy cost in the company and it is supplied by two transformers, each one 1000A rated.

The average power consumption in working days for transformer 1 and transformer 2 were 339kW and 348kW, respectively and in Friday were 100kW and 200kW, respectively. The average power factors were nearly 0.88 and 0.92, respectively.

Figure (3.1) shows electrical balance for the whole company. The percentage of each electrical consumer is calculated using energy analyzer and sometimes depending on nameplate. The detailed information about electrical consumption data will be shown in the next section.

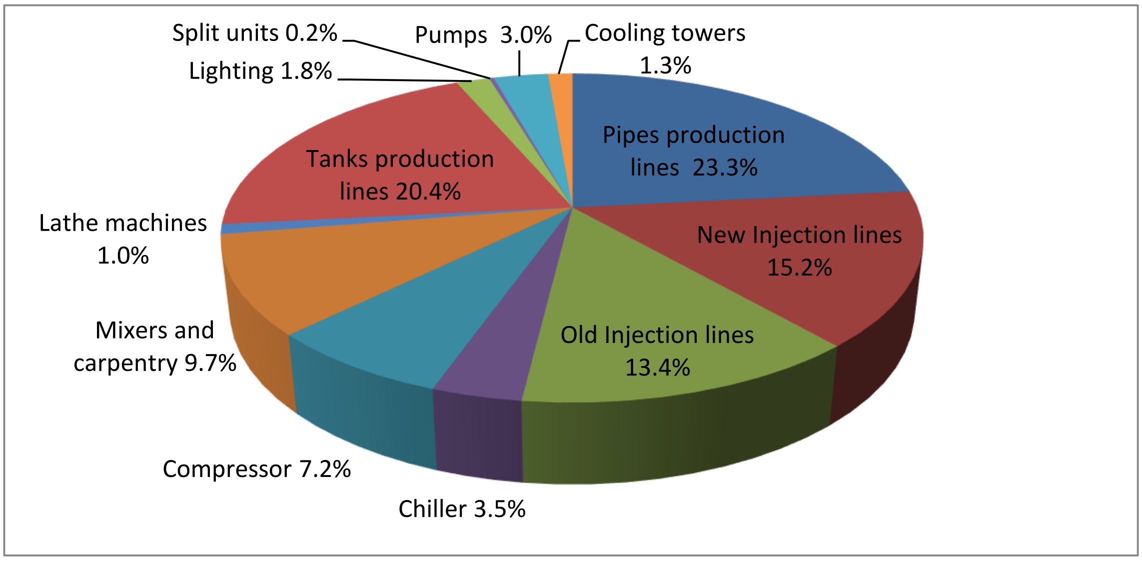

Figure (3.1): Electrical energy consumption distribution for Royal Company

3.2.4.2 Energy Consumption

Injection lines

There are 22-injection machines consumed power for motors and heaters and other mechanical parts (see appendix A-1). The injection lines are divided into two parts (old and new), by using energy analyzer, we had found the following consumption data illustrated in table (3.1).

Table (3.1): Energy consumption for injection lines in Royal

	Average Power (kW)	Average PF	Operation Time		Energy Consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
New Injection lines	122	0.95	20	6240	761280	15.2
Old Injection lines	107	0.97	20	6240	667680	13.4
Total	**229**	**-**	**20**	**6240**	**1428960**	**28.6**

Piping lines

There are four production lines for pipes, energy consumed by these lines refers to motors, electric heaters, extruders, pumps, withdrawers and cutters. The average power and the power factor are shown in table (3.2).

Table (3.2): Energy consumption for piping lines in Royal

	Average power (kW)	Average PF	Operation time		Energy consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
pipes production lines	187	0.9	20	6240	1166880	23.3

Mixing area for pipe lines and carpentry

Table (3.3) shows the electrical energy consumption data of the mixing area and carpentry.

Table (3.3): Energy consumption for Mixing and carpentry in Royal

Production Line	Average Power (kW)	Average PF	Operation time		Energy consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
Mixers and carpentry	78	0.99	20	6240	486720	9.7

Tank production lines

The consumption data of tank production lines is shown in table (3.4).

Table (3.4): Energy consumption for tank production lines in Royal

	Average power (kW)	Average PF	Operation time		Energy consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
Tanks production lines	162	0.97	20	6240	1010880	20.4

Lathe machines

Average power consumption during the work and power factor are shown in table (3.5).

Table (3.5): Energy consumption for lathe machines in Royal

	Average power (kW)	Average PF	Operation time		Energy consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
Lathe machines	7.8	0.44	20	6240	48672	1

Chillers

The company has four chillers, but only one is operated for cooling in injection lines, and some of them are disconnected and replaced by cooling towers, because they are more efficient in some machines. The data of the working chiller is illustrated in table (3.6), it was taken from nameplate and from measurements carried out.

Table (3.6): Chiller data in Royal

Parameter	Unit	Value
Water entering temperature	ºC	45-50
Water leaving temperature	ºC	10
Outdoor ambient temperature	ºC	25
Set water outlet temperature	ºC	5-6
Evaporating temperature	ºC	9
Condensing temperature	ºC	41

Average power consumption of the chiller and average value of power factor are shown in table (3.7).

Table (3.7): Energy consumption for chiller in Royal

	Average power (kW)	Average PF	Operation time		Energy Consumption (kWh/yr.)	Percentage %
			h/day	h/yr.		
Chiller	28	0.72	20	6240	174720	3.5

Cooling towers

Cooling towers are used for cooling in tanks production line that is responsible for preparing raw materials. The company has six cooling towers as shown in table (3.8). It shows also the total energy consumption and percentage from total electrical consumption.

Table (3.8): Energy consumption for cooling towers in Royal

Parameter	Unit	Value	
No. of cooling towers	-	3	3
Rated power	kW	2	4
Actual consumption	kW	1.2	2.4
Operation time	h/yr.	6240	
Energy consumption	kWh/yr.	22464	44928
Total	kWh/yr.	67392	
Percentage	%	1.3	

Compressors

The company has a centralized compressed air system for all machines in production lines, consists of three screw type compressors, the main one is

110hp and the standby two compressors are 60hp and 50hp. (see appendix A-2)

Table (3.9) shows power consumption and power factor for main compressor.

Table (3.9): Energy consumption for compressor in Royal

TYPE	Rated Power (kW)	measured Power (kW)	Power factor	operation time (h/day)	Average Consumption (kWh/yr.)	Percentage %
Air compressor1	75	58	0.82	20	361920	7.2

Lighting system

Electricity used to operate lighting systems represents less than 2% from total electricity consumed in the company.

Fluorescent lamps, CFL, and MH are typically used for lighting. It also noticed that day light is well exploited in stores and production area by using sky light, windows and doors.

Estimated value for electrical energy consumption for lighting loads is about 91713kWh/yr. (see appendix A-3)

Split units air conditions

There are 12 split units in the company used for cooling in offices, table (3.10) shows split units data and consumptions, which represents only about 0.2% from total consumption.

Table (3.10): Energy consumption for split units in Royal

Parameter	Unit	Value
No. of split units	-	12
Rated power	TR	2.5
	kW	3.5
Actual consumption	kW	2.5
Operation time	h/yr.	416
Energy consumption	kWh/yr.	**12480**
Percentage	%	0.2

Water pumps

There are many water pumps as shown in table (3.11), they consume about 3.0% from total company consumption.

Table (3.11): Energy consumption for water pumps in Royal

Type	quantity	Rated input power/each (kW)	Total actual input power (kW)	Consumption (kWh/yr.)
Water pumps, injection lines	2	7.5 kW	9	56160
Water pumps, Pipes lines	3	5kW	12 kW	74880
Water pump, Chiller	1	5.5 kW	3 kW	18720
Total				149760

Electricity balance

Electricity balance is used to know where electricity is being used. Table (3.12) shows all systems and production lines which consumed electricity and their percentages from total electrical energy consumption.

Table (3.12): Electrical energy balance for all consumers in Royal

Area	Average power (kW)	Operation time		Energy consumption (kWh/yr.)	Percentage %
		h/day	h/yr.		
Pipes production lines	187	20	6240	1166880	23.3
New Injection lines	122	20	6240	761280	15.2
Old Injection lines	107	20	6240	667680	13.4
Chiller	28	20	6240	174720	3.5
Compressor	58	20	6240	361920	7.2
Mixers and carpentry	78	20	6240	486720	9.7
Lathe machines	7.8	20	6240	48672	1.0
Tanks production lines	162	20	6240	1010880	20.4
Lighting	-	-	-	91317	1.8
Split units	-	-	-	12480	0.2
Pumps	-	-	-	149760	3.0
Cooling towers	-	-	-	67392	1.3
Total	**4999701 kWh/yr.**				**100%**

3.2.4.3 Energy review, EnBs, and EnPIs

These elements are specified after reviewing energy profile and consumption data. These data is considered the reference for comparison because it had been taken before the implementation actions of EnMS. Therefore, the energy base line is the consumption before applying EnMS and conservation measures.

We can consider annual energy consumption as energy performance indicator to see the impact of applying EnMS.

3.2.4.4 Energy objectives, targets and action plans

The objective can be easily stated, saving energy, reducing the energy consumption and GHGs emissions.

Target is more specific, the top management must specify target of energy saving according to energy profile and consumption and the opportunities of improvement.

Action plan can be established in order to start applying the elements of EnMS.

3.2.5 Implementation and operation

3.2.5.1 Competence, awareness and training

During the energy audit, it was noticed that every person inside Royal Company has competent in his domain.

The awareness side is not covered totally regarding to energy efficient use, there must be more awareness campaigns.

The maintenance team is not totally specialist in the energy efficient operation and maintenance; despite of some had trained in some subjects.

3.2.5.2 Documentation

The Royal Company has a good system of documentation since they are other management systems, so, the energy data must be documented in the same manner of environment and quality elements.

3.2.5.3 Maintenance and operational controls

Maintenance and operational controls is done perfectly in the company, but after walking through the audit, it was find that are two opportunities of energy saving by maintenance and operational control.

Prevention air leaks from the compressor, and adjusting indoor temperature for split units. Their calculations will be explained later.

3.2.5.4 Procurements

It was found that total power factor of transformer 1 is 0.88 which is less than 0.92, so the company must install power factor correction panel.
The company use procurement procedure to choose the suitable equipment and products for power factor correction panel in order to be installed at main feeder of transformer 1 inside the company.

3.2.5.5 Design

Royal Company usually takes measures to ensure that design stage is done with the most efficient criteria, but this must be documented.

3.2.6 Checking

3.2.6.1 Internal audits

The company according to ISO50001 standard must carry out internal audit in specified periods. The Royal Company did it annually.

3.2.6.2 Corrective and preventive actions for non-conformities

The maintenance team deals with any problem related to energy consumption.

3.2.7 Management review

This requirement can be easily done by top management or management representative; if the EnMS is integrated with other management systems.

3.3. Evaluation of Siniora Food Industries Company situation regarding of EnMS requirement

Siniora Food Industries Company was established in 1920, located in Al-Azariya in Jerusalem. The company produces more than 60 items in many sizes distributed among three production lines.

Siniora Company has a quality control department; it has the following management systems certificates:

- ISO9001:2008
- ISO22000:2005
- HACCP
- OHSAS – ISO18001:2007
- ISO14001:2004

3.3.1. Scope and boundaries

The number of employees is about 80 persons and the company consists of six buildings with total area about 5200m^2, the proposed EnMS must cover all buildings and all persons there.

3.3.2. Management commitment

This requirement is an essential requirement for all management system standards. Therefore, because the Siniora Company is certified with other management systems, it is easy to get the commitment from top management to implement EnMS.

3.3.3. Energy Policy

Again, the existence of other management system will facilitate the drafting of energy policy in Siniora Company. The issuing of energy policy will not cost the company anything.

3.3.4. Energy planning

3.3.4.1. Energy profile

The company uses three types of energy; electricity, heavy oil, and diesel.
Heavy oil is used for steam boiler, the water is used for production lines and ordinary usage, and diesel is the energy source for standby generator, forklifts and other means of transportation.

Electrical energy is supplied from the electrical distribution company through three transformers; 630A each one. Electrical energy is the source for lighting, split units, compressors, chillers, production lines, fans, refrigerators and freezers, cooling towers, washing machines, and the elevators.

The company is supplied with electricity by three 630A transformers. Transformer 3 supply a small load temporarily, so it will be neglected through this audit. The other two transformers feed the main load in the company.

Figure (3.2) shows the energy cost percentages for different energy sources.

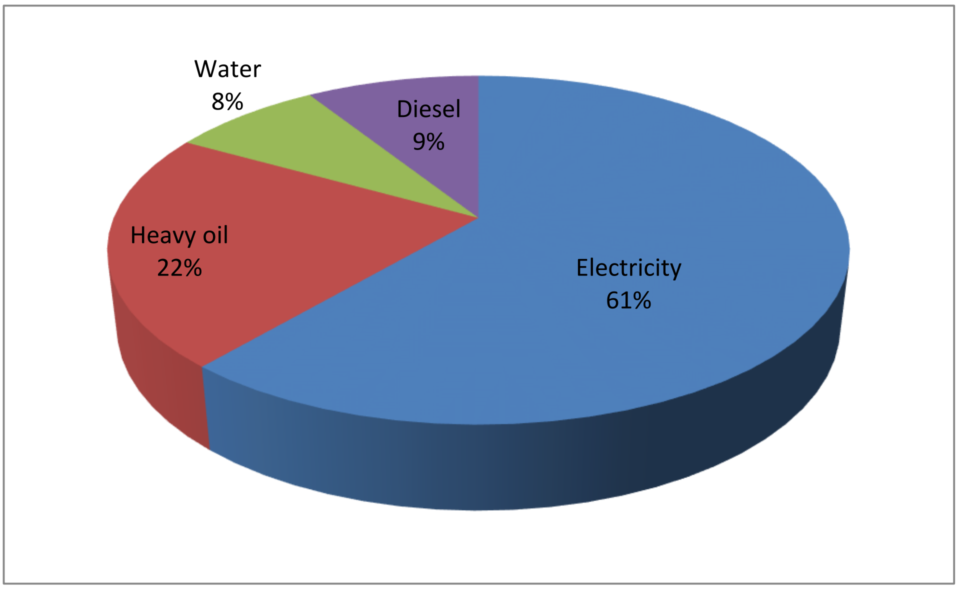

Figure (3.2): Energy sources cost percentages in Siniora Company

Transformer 1 supply electricity for many loads such as chillers and refrigerators. Average power consumption of it is about 171.36kW and energy consumption was 4113kWh/day. Power factor was 0.99 which is perfect value.

Transformer 2 supply electricity for many loads such are menshar (saw) and cutter. Average power consumption is about 49kW which means energy consumption was 1176kWh/day. Average power factor value was 0.80, which must be at least 0.92 to be acceptable.

Total energy consumption was about 1860659kWh/yr. Figure (3.3) shows electrical balance for the whole company.

Consumption of heavy oil was about 156600L/yr. Figure (3.4) shows heavy oil balance in the company.

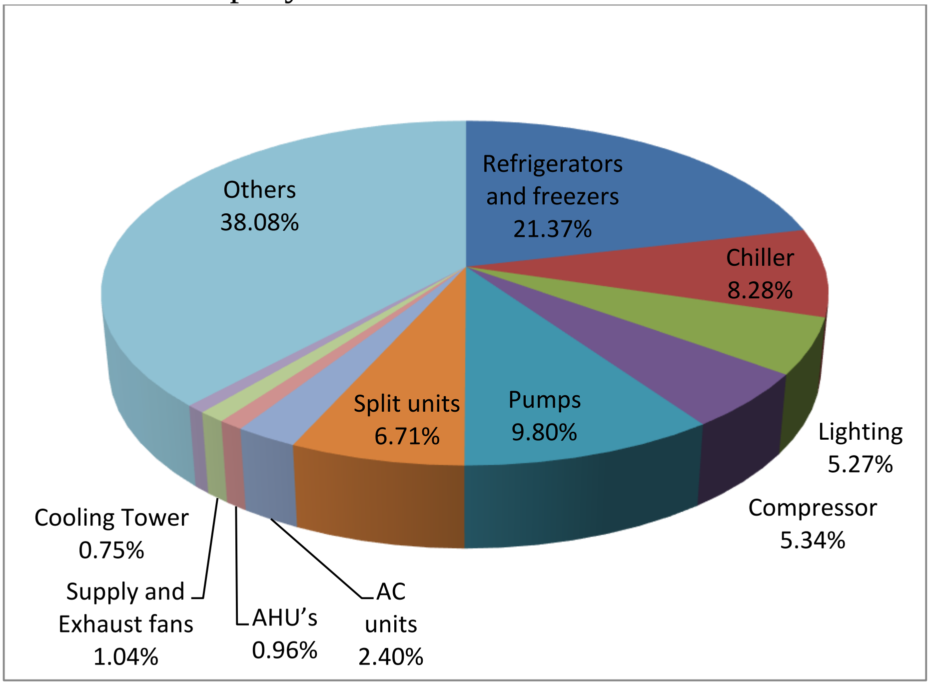

Figure (3.3): Electrical energy balance for all loads in Siniora Company

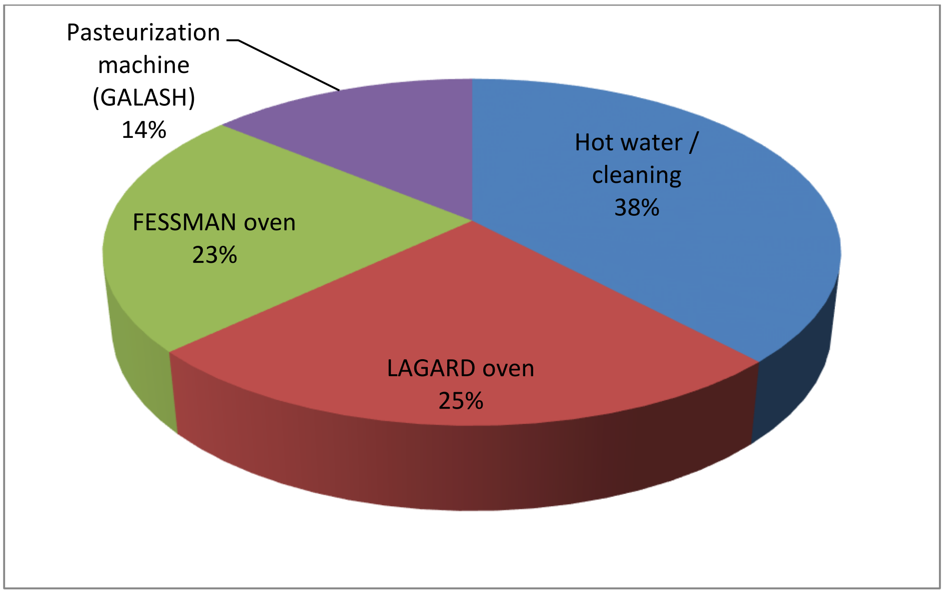

Figure (3.4): Heavy oil balance for loads in Siniora Company

3.3.4.2. Energy consumption

Steam Boiler

Steam boiler is considered one of most important systems to save energy because it consumes large amount of fuel. The company has one steam boiler which its data are shown in table (3.13).

Table (3.13): Nameplate data for boiler in Siniora

Parameter	Units	Boiler
Type of boiler	---	Steam
Capacity of boiler	kW	1500
Operation time	h/day day/yr. h/yr.	24 300 7200
Max. pressure	bar	10
Steam pressure	bar	5
Fuel used	---	Heavy oil
Average quantity of fuel consumed	L/month	11922
	L/h	20
GCV of fuel	kWh/L	9.95
Blow down (times/day)	times/day	48

Blow down defined as how many times that water is intentionally wasted from a boiler to avoid concentration of impurities during continuing evaporation of steam.

Combustion analyzer was used to measure the combustion efficiency, percent of excess air and exhaust gas temperature. Table (3.14) shows the combustion analyzer measured data when boiler reaches steady state during work.

Table (3.14): Measured data from combustion analyzer in Siniora

Parameter	Unit	Value
Combustion efficiency	%	81.4
Ambient Temperature	ºC	21
Stack temperature	ºC	229
O_2	%	9.6
CO	PPM	35
CO_2	%	8.8
Excess Air	%	80
NO	PPM	171
NO_2	PPM	0
NO_x	PPM	171
SO_2	PPM	208

There are two methods for evaluating the boiler efficiency; first one is to calculate (output/input), second method is evaluation of the different losses in the boiler: [24]

Boiler efficiency = $1-P_g-P_w-P_b$ (3.1)

P_g: Losses in combustion gases

P_w: Losses through the walls

P_b: Losses in blow down

Boiler capacity (full capacity) = 1500 kW

Average diesel consumption (q) = 20 L/h

Actual capacity (Q) = q × CV = 20 × 9.95 = 199 kW (3.2)

$$\text{Wall losses Pw} = \frac{1.5\% \times Full\ capacity}{Actual\ capacity} = \frac{1.5\%\ \times 1500}{199} = 11.3\% \qquad (3.3)$$

Combustion gas losses P_g =100% - combustion efficiency = 100% - 81.4% = 18.6%

$$Q_{\text{Blow down}} = \frac{m}{operation\ hour \times 3600} \times (h_{g\ @5bar} - h_{f\ @20ºC}) \qquad (3.4)$$

$$= \frac{48}{24*3600} \times (2{,}749 - 84) = 1.5 \text{ kW}$$

Blow down losses $P_b = \frac{\text{Q Blow down}}{\textit{Actual capacity}} = \frac{1.5}{199} = 0.75\%$ (3.5)

So, by using equation (3.1), boiler efficiency = 1-(0.113+0.186+0.0075) =69.35%. [24]

Table (3.15): Energy efficiency calculations for the boiler in Siniora

Parameter	Units	Value
Boiler capacity	kW	1500
Actual capacity	kW	199
Max. capacity	kW	995
Shell heat loss [1.5% * full capacity/actual capacity]	%	11.3
Combustion heat loss	%	18.6
Blow down losses	%	0.75
Boiler efficiency	%	69.35

Compressors

Air compressors are used to supply process requirements; to operate pneumatic tools and equipment, and to meet instrumentation needs. Energy power analyzer was installed on the electric board for the compressor for one day. It was found that the power consumption in average is about 13.8 kW and the energy consumption over a year is about 99360 kWh/yr. this value represents 5.4% of total company consumption.

Chiller

There is one chiller in the company used for air conditioning units and AHU's in production area. It was found that energy consumption of the chiller is about 154066 kWh/yr., which represents about 8.3% of the company total consumption. The information of this chiller is listed in table (3.16), taken from nameplate.

Table (3.16): Nameplate and measured data for chiller in Siniora

Parameter	Unit	Main Chiller
Manufacture	-	TRANE
Compressor	-	2 screw compressors
Condenser	-	Air Cooled
Rated Cooling Capacity	TR	150
Compressors Input Power A/B	kW	132/132
Compressor cooling capacity A/B	TR	85/85
Condensing temperature	ºC	Compressor B (33)
Evaporating temperature	ºC	Compressor B (-2.5)
Ambient temperature	ºC	15
Set water temperature	ºC	2.5
Inlet water temperature	ºC	3.5
Outlet water temperature	ºC	1.8
Condenser fans	fans	10
One fan power	kW	1.25

Refrigeration and ice machines

Energy analyzer was installed for one day to measure energy consumption for main refrigerators, freezers, and production main hall units in the company. The total energy consumption was calculated to be about 397610 kWh/yr., which represents 21.37% from total consumption. (see appendix B-1)

Lighting

Annual consumption for lighting system was evaluated by calculating the number of lamps in the company and estimating the operation time for each lamp. The consumption for one shift is estimated to be about 81654 kWh/yr. multiplied with safety factor of 20%, this means this means

(81654×1.2 = 97985 kWh/yr.). This value represents 5.3% from total electricity consumption of the company. (see appendix B-2)

Pumps

Clamp meter was used to calculate the energy consumption for existing pumps. The electricity consumption for the pumps section in the company is 182392 kWh/yr., which represents about 9.8% from total consumption in the company. (see appendix B-3)

Split unit

There are many areas in the company are air conditioned by split units, which represents 6.7% from total electricity consumption. Assuming that the operation time of the split units in the office is 60%, annual energy consumption for the split units will be about 124927kWh/yr. (see appendix B-4)

AC units fans and AHU's in the production zones

There are many zones in production area cooled by chiller, the cooling capacity for each unit is between 25-35 kW.

The energy consumption for AC unit fans was 44647 kWh/yr., which represents 2.4% of total company consumption. The energy consumption for AHU's was 17776 kWh/yr., which represents 1% of total energy consumption. (see appendix B-5 and B-6)

Supply and exahust fans

The power of all supply and exhaust fans was measured using a clamp meter, then the energy consumption was calculated and was about

19374kWh/yr. which is about 1% of total electrical energy consumption of the company. (see appendix B-7)

Cooling tower

Cooling towers are used for cooling in laggard ovens and cooling vacuum pumps. By using clamp meter, the power of cooling tower was measured and the energy consumption was calculated, it was about 13986 kWh/yr., which represents about 0.75% of total energy consumption.

Energy Balance

Electrical balance for all equipment and energy systems existed in the company are listed in table (3.17).

Table (3.17): Electrical energy balance for all loads in Siniora

No.	Equipment	Energy consumption (kWh)	Energy consumption percentages
1	Refrigerators and freezers	397610	21.37%
2	Chiller	154066	8.28%
3	Lighting	97985	5.27%
4	Compressor	99360	5.34%
5	Pumps	182392	9.80%
6	Split units	124927	6.71%
7	AC units	44647	2.40%
8	AHU’s	17776	0.96%
9	Supply and Exhaust fans	19374	1.04%
10	Cooling Tower	13986	0.75%
11	Others (Production lines, elevators, office equipment, etc.)	708536	38.08%
	Total	**1860659**	**100%**

3.3.4.3. Energy review, EnBs, and EnPIs

These elements are specified after reviewing energy profile and consumption data. These data is considered the reference for comparison because it had been taken before the implementation actions of EnMS. So, the energy base line is the consumption before applying EnMS and conservation measures.

We can consider annual energy consumption as energy performance indicator to see the impact of applying EnMS.

3.3.4.4. Energy objectives, targets and action plans

The objective can be easily stated, saving energy, reducing the energy consumption and GHGs emissions.

Target is more specific, the top management must specify target of energy saving according to energy profile and consumption and the opportunities of improvement. Action plan can be established in order to start applying the elements of EnMS.

3.3.5. Implementation and operation

3.3.5.1. Competence, awareness and training

During the energy audit, it was noticed that every person inside Saniora Company has competent in his domain.

The awareness side is not covered totally regarding to energy efficient use, there must be more awareness campaigns.

3.3.5.2. Documentation

The Siniora Company has a good system of documentation since they are other management systems, so, the energy data must be documented in the same manner of environment and quality elements.

3.3.5.3. Maintenance and operational controls

Maintenance and operational controls is done perfectly in the company, but after walking through the audit, it was find that are many opportunities of energy saving by maintenance and operational control.

3.3.5.4. Procurements

During search for energy saving opportunities, there found some actions might need to apply procurement method in order to purchase the efficient equipment, such as SWH system, steam/water mixers, and replacement of boiler.

3.3.5.5. Design

Siniora Company usually takes measures to ensure that design stage is done with the most efficient criteria, but this must be documented.

3.3.6. Checking

3.3.6.1. Corrective and preventive actions for non-conformities

The maintenance team deals with any problem related to energy consumption.

3.3.7. Management review

This requirement can be easily done by top management or management representative; if the EnMS is integrated with other management systems.

3.4. Evaluation of Jerusalem Pharmaceutical Company situation regarding of EnMS requirements

Jerusalem Pharmaceutical Company (JPC) was established in 1969, it is located in AL-Bireh. The company produces more than 350 items and its market is not limited to the Palestinian territory, it is spread to Jordan, Algeria, and European markets.

JPC company was certified with GMP standard, ISO14001 standard, ISO9001 quality management standard.

3.4.1. Scope and boundaries

The numbers of employees is about 350 persons. Total area of the building is about 10000m^2 with a small building for the department of penicillin.

3.4.2. Management commitment

This requirement is an essential requirement for all management system standards. Because that JPC is certified with other management systems, it is easy to get the commitment from top management to implement EnMS.

3.4.3. Energy policy

The drafting of energy policy in JPC Company can be done easily because the existence of other management systems.

3.4.4. Energy planning

3.4.4.1. Energy profile

The company uses three types of energy; electricity, diesel, and LPG. LPG is used for kitchen and cafeteria, filling machine, and laboratories. Diesel is used in steam boiler, hot water boiler, and standby generator. Electrical energy is comes from JDECO company and supply chillers, AHU's, fans, dust collectors, split air conditions, air compressors, pumps, lighting, elevators, and office equipment. Table (3.18) shows distribution of electrical energy during months of 2016. [25]

Table (3.18): Electrical energy consumption and cost in 2016 in JPC

Month	kWh	NIS	NIS/kWh
January	101865	67794	0.67
February	79385	52996	0.67
March	101595	66347	0.65
April	93141	57540	0.62
May	99819	61619	0.62
June	109937	75967	0.69
July	154797	93524	0.6
August	161871	96691	0.6
September	157967	97415	0.62
October	120145	66667	0.55
November	103202	60038	0.58
December	82245	50992	0.62
Total	**1365969 kWh**	**847590 NIS**	**Average 0.62NIS/kWh**

Diesel consumption was about 84677 liters, which cost 541933NIS, and the main consumer for diesel was the steam boiler while only 5000 liter was used for hot water boilers. [25]

Third source of energy is LPG and the company had consumed about 3000L/yr. and cost about 40000NIS with price of about 13NIS/L. [25]

Figures (3.5) and (3.6) show the cost percentage and energy consumption percentage of different sources of energy.

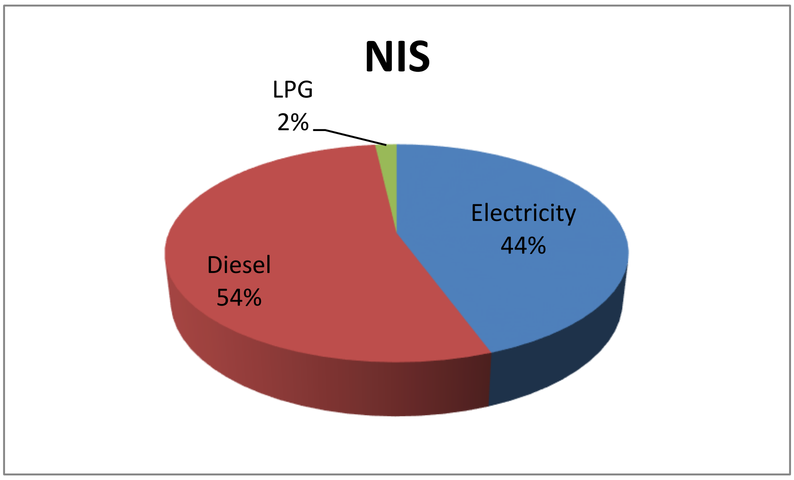

Figure (3.5): Energy cost percentage in JPC

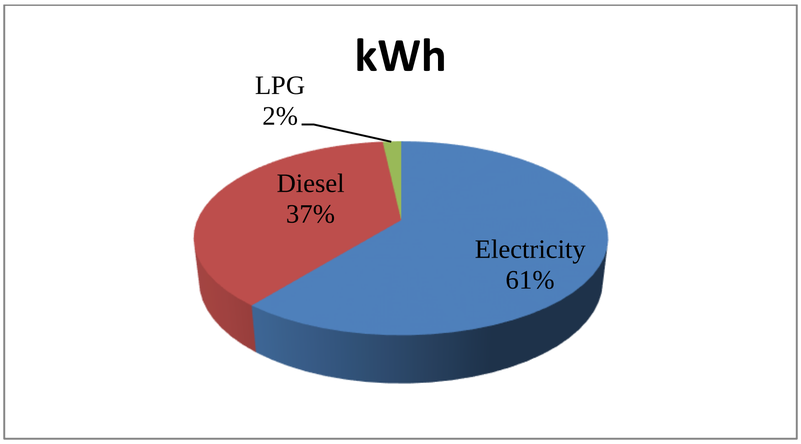

Figure (3.6): Energy consumption percentage in JPC

Figure (3.7) shows electrical energy percentages balance in JPC. Then Figure (3.8) shows diesel balance in JPC.

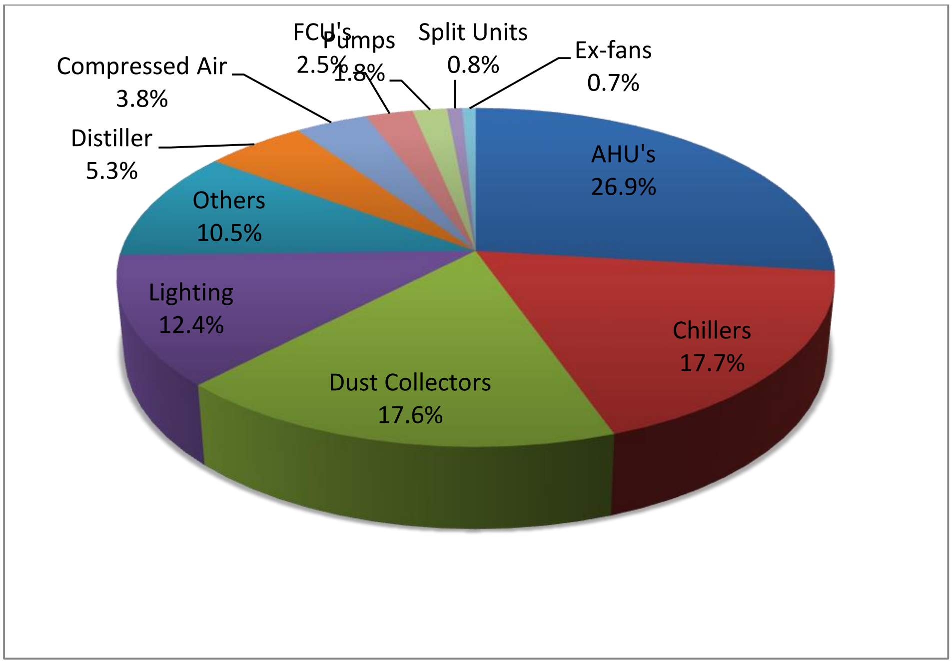

Figure (3.7): Electrical energy balance for all users in JPC

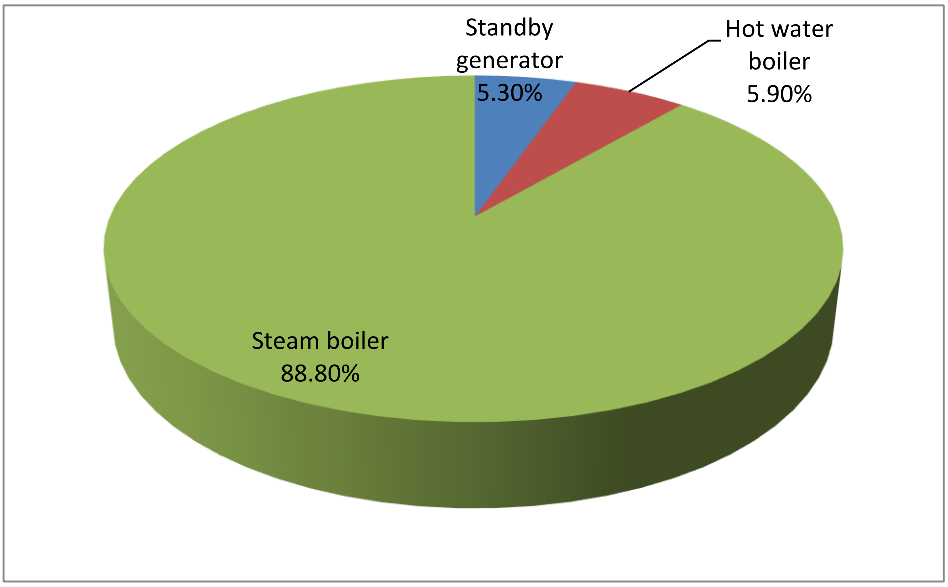

Figure (3.8): Diesel consumption balance in JPC

3.4.4.2. Energy consumption

Air conditioning Chillers

There are four chillers in JPC company at work, two of them deliver cold water to the AHU's in the main building, and one delivers cold water to AHU in the penicillin building, the last one is used for offices air conditioning through fan coil units. Table (3.19) shows the nameplate data for all chillers in the company.

Table (3.19): Air-Conditioning Chillers Data for JPC

Parameter	Unit	Chiller 1	Chiller 2	Penicillin Chiller	AC Chiller
Manufacture	--	Carrier	Carrier	AQUA-CIAT	AQUA-CIAT
Model No.	--	30RB402	30RB402	LD600Z	LD600Z
Zones	--	Main Building AHU's	Standby or Backup for Chiller 1	Penicillin Building	Offices AC
Operation time	h/day	8.5	8.5	8.5	--
	h/yr.	1,480	--	1,480	--
Compressor	--	3 Scroll compressors	3 Scroll compressors	4 Scroll compressors	4 Scroll compressors
Condenser	--	Air cooled	Air cooled	Air cooled	Air cooled
Nominal Cooling Capacity	kW	391	391	123	123
Nominal Input Power	kW	147	147	59.6	59.6
Condenser fans	unit	6	6	3	3
One fan power	kW	1	1	1	1

It is very difficult to measure the actual consumption of the chillers, the most appropriate method is to estimate the consumption from the difference in average electrical consumption between warm months (April to October) and cold months (November to March). It was calculated and it was 242068kWh/yr., which represents about 17.7% of total electrical energy consumption.

Air handling units (AHU's)

The air handling system consists from four different equipment parts; air-handling units, dust collectors, exhaust fans, and fan coil units.

The energy consumption for every section in air handling system is estimated by reading the rated power for every equipment and multiplied with the working hours during a year, which is about 2500 hours. The energy of every section was as the following: (see appendix C-1)

- Air handling units consume about 367750kWh/yr.
- Dust collectors consume about 240750kWh/yr.
- Exhaust fans consume about 9363kWh/yr.
- Fan coil units consume about 34100kWh/yr.

The overall system power factor was measured and it was about 0.9 in average which need some modification.

Pumps

There are many sets of pumps used in different locations for the heating and cooling systems, in chillers and boilers, and for supplying the water tanks on the roof of the building. The total energy consumptions of the pumps are estimated in the 24469kWh/yr. (see appendix C-2)

Split air conditioning units

There are number of split air conditioning units with screw type compressors, these units are used for offices, laboratories, etc. Electrical energy consumption was about 10308kWh/yr.

Air compressor

The company has one air compressor used to supply processes equipment and to operate pneumatic system for all production lines. Measured data from energy analyzer show that average power of the compressor is 20.2kW and average power factor is 0.83. The total energy consumption as about 51510 kWh/yr.

Water treatment system (Distiller)

The company has water treatment system which consists from several stages; filtration, reverses osmosis, and then sterilized water. For such process, the system uses circulation pumps, electric water heaters, and then using distiller. By installing energy analyzer for the supply of this system, we had found that average power was 8.2kW and average power factor of 0.75, and the total energy consumption will be 71864kWh/yr.

Lighting system

For the lighting system, the number of lighting fixtures was counted and the energy consumption was calculated. The ballast factor is assumed to be 15% for all lamps because it is magnetic type. The types of lams are; fluorescent lamps 18W, 36W, and 110W, CFL lamps 18W, 24W, 26W, 40W, and 55W, halogen lamps and spots are used for internal lighting.

The energy consumption was calculated for all buildings and found that 168948kWh/yr. which represents about 12.4% of total electrical energy consumption. (see appendix C-3)

Other equipment

There are some miscellaneous equipment in the company such as elevators, refrigerators, water coolers, electric water heaters, computers, and others. Their consumption was estimated from the electrical bills after discount all mentioned systems, and we found that it represents about 10.5% from total electrical consumption which is about 144839kWh/yr.

Standby diesel generator

In JPC, there is one standby generator with capacity of 640KVA and efficiency of 40%, the diesel consumption is the 90L/h. Data of this generator is illustrated in table (3.20).

Table (3.20): Diesel consumption for standby generator in JPC

Parameter	Unit	Amount
Capacity	KVA	640
PF	%	80
efficiency	%	40
GCV	kWh/L	9.95
Loading	%	70
Consumption	L/h.	90
Operation	h/yr.	50
Annual Consumption	**L/yr.**	**4,503**

Boilers

There are three boilers in the company; one steam boiler used for dehumidifier, coat machine, double jacket, fluid bed drier and some AHU's, and two hot water boilers for space heating by FCU's, one boiler provide offices and the other provides sterilized section. Specifications of these boilers are illustrated in table (3.21).

Table (3.21): Specifications of steam and hot water boilers in JPC

Parameter	Unit	Steam Boiler	Offices HW boiler	Sterile section HW boiler
Model Type	--	baltur burner	RIELLO burners	--
Model year	--	8-2012	New	old
Usage	--	Steam production	Space heating	Space heating
Nominal Consumption	kg/h	16.9 – 71.6	8 - 18	--
Boiler Capacity	kW	200 - 850	95 - 213	
Fuel	--	Diesel	Diesel	Diesel
Pressure/Temperature Set	--	4.5 – 6 bar	60ºC	60ºC
Operating time	h/day	8.5	8.5	8.5
	h/yr.	2,550	800	800

As mentioned before, the total consumption of diesel from the bills was 84677L/yr. and the consumption for the hot water boilers was estimated only 5000L/yr., so that the steam boiler consumed the remaining quantity after subtract the standby generator consumption (4503L), which is 75174L/yr.

Electric energy balance

Energy balance for electrical sectors in JPC company was illustrated in table (3.22).

Table (3.22): Total electrical energy balance in JPC

System	Consumption	
	(kWh/yr.)	%
Chillers	242068	17.7
AHU's	367750	26.9
Dust Collectors	240750	17.6
FCU's	34100	2.5
Ex-fans	9363	0.7
Split Units	10308	0.8
Compressed Air	51510	3.8
Pumps	24469	1.8
Lighting	168948	12.4
Distiller	71864	5.3
Others	144839	10.5
Total	**1365969**	**100.0**

Total diesel balance

Table (3.23) shows amount and percentage of diesel consumption in JPC Company.

Table (3.23): Total diesel balance in JPC

System	Consumption	
	L/yr.	%
Standby generator	4503	5.3
Hot water boiler	5000	5.9
Steam boiler	75174	88.8
Total	84677	**100.0**

3.4.4.3. Energy review, EnBs, and EnPIs

These elements are specified after reviewing energy profile and consumption data. These data is considered the reference for comparison because it had been taken before the implementation actions of EnMS. So, the energy base line is the consumption before applying EnMS and conservation measures.

We can consider annual energy consumption as energy performance indicator to see the impact of applying EnMS.

3.4.4.4. Energy objectives, targets and action plans

The objective can be easily stated, saving energy, reducing the energy consumption and GHGs emissions.

Target is more specific, the top management must specify target of energy saving according to energy profile and consumption and the opportunities of improvement. Action plan can be established in order to start applying the elements of EnMS.

3.4.5. Implementation and operation

3.4.5.1. Competence, awareness and training

During the energy audit, it was noticed that every person inside JPC has competent in his domain.

The awareness side is not covered totally regarding to energy efficient use, there must be more awareness campaigns.

3.4.5.2. Documentation

JPC Company has a good system of documentation since they are other management systems, so, energy data must be documented in the same manner of environment and quality elements.

3.4.5.3. Maintenance and operational controls

Maintenance and operational controls is done perfectly in the company, but after walking through the audit, it was find that are many opportunities of energy saving by maintenance and operational control.

3.4.5.4. Procurements

During search for energy saving opportunities, there found some actions might need to apply procurement method in order to purchase the efficient equipment, such as SWH system, LPG dual burner for steam boiler, modulating valves for AHUs, and lighting replacement.

3.4.5.5. Design

JPC Company usually takes measures to ensure that design stage is done with the most efficient criteria, but this must be documented.

3.4.6. Checking

3.4.6.1. Corrective and preventive actions for non-conformities

The maintenance team deals with any problem related to energy consumption.

3.4.7. Management review

This requirement can be easily done by top management or management representative; if the EnMS is integrated with other management systems.

Chapter (4) Gap analysis for implementing ISO50001 EnMS in industrial sector in Palestine – case studies

4.1 Gap analysis for implementing EnMS in Royal Company

In order to fill the gap between ISO50001 EnMS and the current situation, the requirements which are not applied to Royal Company must be specified.

4.1.1 Management representative

Top management must designate a management representative to oversee the operation and development of EnMS.

In this case, annual cost for this management representative is about 84000NIS, considering their full time is dedicated to EnMS, so 2000$/monthly (~7000NIS/monthly) will be his salary.

4.1.2 Energy team

Energy team must be established within following areas; management, procurement, production, human resources, and maintenance.

There will be no additional cost for the energy team since they will integrate EnMS responsibilities with their original work.

4.1.3 Communication

The internal communication is a very important requirement in the facility. It may include how are the employees are made aware of energy issues, how decisions are made and information is reached to them.

There should be a communication system for suggestions and complaints regarding energy management activities.

The communication procedures will not cost the company any additional cost since it is already have other management systems.

4.1.4 Monitoring, measurements and analysis

This requirement can be met by installing sub-monitoring system with analysis software, or mini-SCADA system can be installed to the energy consumers inside the company.

The proposed monitoring system consists of products from Schneider electric to implement monitoring system in the case studies, and then I will calculate the cost of implement such system in the basis of number and types of energy consuming sectors in facility.

In order to build the system, the following components are to be installed and connected together:

- Power meter reads power and energy – PM8240 (see appendix D-1).
- Ethernet gateway – EGX300 (see appendix D-2)
- Power management software – Power Logic ION enterprise V5.6.
- Digital input/output modules – PM89M2600 (see appendix D-3).
- Current transformers (CTs) and Voltage transformers (VTs).
- Temperature sensors, pressure sensors, gas flow meters, water flow meters.
- Connection cables

Monitoring system for each case study is different from other ones because everyone had different energy consuming loads. The general connection of monitoring system is illustrated in figure (4.1).

Figure (4.1): Monitoring system components

Energy consuming sections in Royal Company are illustrated in table (4.1) with quantity of points that must be monitored.

Table (4.1): Quantity of points that must be monitored in Royal

Sector	Quantity of points
Pipes production lines	4
New and old Injection lines	22
Chiller	4
Compressor	3
Mixers and carpentry	2
Lathe machines	1
Tanks production lines	2
Lighting	1
Split units	0
Pumps	6
Cooling towers	6
Total inputs to energy meter	**51 points**

Monitoring system inside Royal Company will consists of components detailed in table (4.2) to cover the whole electrical system (51 points), according to characteristic of every component.

Table (4.2): Total cost of implementing monitoring system in Royal

Component	Quantity	Unit price (NIS)	Total price (NIS)
Power meter - PM8240	2	6500	13000
Ethernet gateway EGX300	1	4000	4000
Power Logic ION enterprise V5.6.	1	18000	18000
Digital I/O modules – PM89M2600	10	800	8000
Current Transformer (CT)	51	100	5100
Voltage Transformer (VT)	51	100	5100
Cables and installation and panels	1	10000	10000
Total			**63200**

In order to assess the cost of implementing monitoring system in Royal Company, the annual value of system must be calculated.

By assuming that lifetime of monitoring system will be 10 years and the interest rate will be 10%, then, the annual value of the system can be calculated according to the following equation:

Annual value = Present value × (A/P, 10%, 10yrs.) (4.1)

A/P is called capital recovery factor, which is a factor to find annual value if present value is given, taking into account the rate of interest and the lifetime of the system, which is can be obtained from tables (see appendix E). [26]

Annual value = 63200×(0.1627) = 10283NIS/yr.

4.2 Gap analysis for implementing EnMS in Siniora Company

4.2.1 Management representative

Top management must designate a management representative to oversee the operation and development of EnMS.

In this case, annual cost for this management representative is about 84000NIS, considering their full time is dedicated to EnMS, so 2000$/monthly (~7000NIS/monthly) will be his salary.

4.2.2 Energy team

Energy team must be established within following areas; management, procurement, production, human resources, and maintenance.

There will be no additional cost for the energy team since they will integrate EnMS responsibilities with their original work.

4.2.3 Communication

The internal communication is a very important requirement in the facility. It may include how are the employees are made aware of energy issues, how decisions are made and information is reached to them.

There should be a communication system for suggestions and complaints regarding energy management activities. The communication procedures will not cost the company any additional cost since it is already have other management systems.

4.2.4 Monitoring, measurements and analysis

Energy consuming sectors in Siniora Company are illustrated in table (4.3) with quantity of points that must be monitored.

Table (4.3): Quantity of points must be monitored in Siniora

Sector	Quantity of points
Refrigerators and freezers	17
Chiller	1
Lighting	1
Compressor	2
Pumps	9
Split units	5
AC units	6
AHU's	0
Supply and Exhaust fans	1
Cooling Tower	0
Others (Production lines, elevators, office equipment, etc.)	8
Total inputs to energy meter	**50 points**

Monitoring system inside Siniora Company will consists of the following components to cover the whole electrical system (50 points), according to the characteristic of every component.

Table (4.4): Total cost of implementing monitoring system in Siniora

Component	Quantity	Unit price (NIS)	Total price (NIS)
Power meter - PM8240	2	6500	13000
Ethernet gateway EGX300	1	4000	4000
Power Logic ION enterprise V5.6.	1	18000	18000
Digital I/O modules – PM89M2600	10	800	8000
Current Transformer (CT)	50	100	5000
Voltage Transformer (VT)	50	100	5000
Cables and installation and panels	1	10000	10000
Total			**63000**

In order to assess the cost of implementing monitoring system in Siniora Company, the annual value of system must be calculated as I did with Royal Company.

Annual value = Present value × (A/P, 10%, 10yrs.)

Annual value = 63000×(0.1627) = 10250 NIS/yr.

4.2.5 Internal audits

Internal audit of EnMS is different from usual energy audit or assessment. Internal audit must be carried out periodically to evaluate the processes, procedures, and implementation of EnMS to decide if they are conform the requirements of ISO50001 EnMS. It helps to identify opportunities for improvement within the EnMS.

If it has carried out by internal energy management team, it will not cost a lot of money. In Siniora Company, it is estimated to cost only 2000NIS/yr.

4.3 Gap analysis for implementing EnMS in JPC

4.3.1 Management representative

Top management must designate a management representative to oversee the operation and development of EnMS.

In this case, annual cost for this management representative is about 84000NIS, considering their full time is dedicated to EnMS, so 2000$/monthly (~7000NIS/monthly) will be his salary.

4.3.2 Energy team

Energy team must be established within following areas; management, procurement, production, human resources, and maintenance.

There will be no additional cost for the energy team since they will integrate EnMS responsibilities with their original work.

4.3.3 Communication

The internal communication is a very important requirement in the facility. It may include how are the employees are made aware of energy issues, how decisions are made and information is reached to them.

There should be a communication system for suggestions and complaints regarding energy management activities.

The communication procedures will not cost the company any additional cost since it is already have other management systems.

4.3.4 Monitoring, measurements and analysis

Energy consuming sectors in JPC are illustrated in table (4.5) with quantity of points must be monitored.

Table (4.5): Quantity of points must be monitored in JPC

Sector	Quantity of points
Chillers	4
AHU's	18
Dust Collectors	6
FCU's	0
Ex-fans	0
Split Units	0
Compressed Air	2
Pumps	10
Lighting	1
Distiller	1
Others	4
Total inputs to energy meter	**48 points**

Monitoring system inside JPC will consists of the following components to cover the whole electrical system (48 points), according to the characteristic of every component.

Table (4.6): Total cost of implementing monitoring system in JPC

Component	Quantity	Unit price (NIS)	Total price (NIS)
Power meter - PM8240	2	6500	13000
Ethernet gateway EGX300	1	4000	4000
Power Logic ION enterprise V5.6.	1	18000	18000
Digital I/O modules – PM89M2600	10	800	8000
Current Transformer (CT)	48	100	4800
Voltage Transformer (VT)	48	100	4800
Cables and installation and panels	1	10000	10000
Total			**62600**

In order to assess the cost of implementing monitoring system in JPC Company, the annual value of system must be calculated as I did with previous case studies.

Annual value = Present value × (A/P, 10%, 10yrs.)

Annual value = 62600×(0.1627) = 10158 NIS/yr.

4.3.5 Internal audits

The internal audit of EnMS is different from usual energy audit or assessment. Internal audit must be carried out periodically to evaluate the processes, procedures, and implementation of EnMS to decide if they are conform the requirements of ISO50001 EnMS. It helps to identify opportunities for improvement within the EnMS.

If it has carried out by internal energy management team, it will not cost a lot of money. In JPC Company, it is estimated to cost only 3000NIS/yr.

Chapter (5) Economical evaluation for applying EnMS and saving measures

5.1. Introduction to energy Economy

After covering administrative and technical sides of EnMS, it is important to find economic feasibility of applying such system according to implementation of ISO50001 standard series.

Energy management takes many different forms; it may vary from installation of new, more efficient technology to simple maintenance and operational activities that ensure equipment and systems will use energy efficiently and effectively.

Economic analysis is very important part in EnMS in order to evaluate it and to reach to the right decisions from top management with regard to energy related activities to reach finally to optimum alternatives.

There are many economic methods to evaluate the energy projects; but the most familiar one is simple payback period (S.P.B.P). [26]

5.2. Energy conservation opportunities in Royal Industrial Trading Company

In Royal Company, it was found that the opportunities to save energy are available in the compressed air system, air conditioning system, and in power factor correction activities.

5.2.1 Air compressor system

Leakage test was carried out on the main air compressor, by turning the compressors on while turning off all equipment that use compressed air.

This test is usually used to detect the percentage of leakage and to calculate the additional energy need to compensate this leakage, and then to calculate the saving potential. These calculations are illustrated in the following equations and the results are summarized in table (5.1). [27]

$$\text{Leakage (\%)} = T/(T+t) \times 100\% \qquad (5.1)$$

$$P_{additional}\,(kW) = \%leakage \times (W_{loaded} - W_{unloaded}) \qquad (5.2)$$

$$\text{Losses (kWh/yr.)} = P_{additional} \times \text{Operation time} \qquad (5.3)$$

$$\text{Saving (kWh/yr.)} = 0.5 \times \text{Losses} \qquad (5.4)$$

Where:

$P_{additional}$: additional power needed to compensate the leakage

W_{loaded} : compressor power at full load.

$W_{unloaded}$: compressor power at no load.

T : time on load in minutes.

t : time on unload in minutes.

Table (5.1): leakage calculations in compressor in Royal

Parameter	Unit	Value
T	minutes	1.065
t	minutes	2.545
Leakage	%	30%
W_{loaded}	kW	68
$W_{unloaded}$	kW	39
$P_{additional}$	kW	8.7
Operation time	hours	6240
Energy losses	kWh/yr.	54288
Money losses	NIS/yr.	32573
Energy saving	kWh/yr.	27144
Money saving	NIS/yr.	16286

5.2.2 Air conditioning system

Energy saving can be achieved by adjusting the set temperature either in summer or winter, it is recommended to set the temperature of split units to 23ºC in summer, they do not use split units in winter. The saving can be calculated according to the following equations and the results are summarized in table (5.2): [28]

Energy Saving (%) = $([T_{existing}-T_{out}]-[T_{suggested}-T_{out}])/[T_{existing}-T_{out}]$ (5.5)

Where:

$T_{existing}$: temperature inside the room.

T_{out} : temperature before heating the space.

$T_{suggested}$: suggested room temperature.

Table (5.2): Saving calculations of split units in Royal

Unit	Temperature before heating ºC	Set temperature in summer ºC	Energy consumption kWh/yr.	Suggested temperature ºC	Saving %
Director offices	30	21	12480	23	22.2%
Total Saving			kWh/yr.	2773	
			NIS/yr.	1663	

5.2.3 Power factor improvement

It was found from the audit carried out in Royal Company that the low power factor comes from mainly three energy consumer, chiller, compressor, and lathe machine. This had affected the overall power factor in Transformer 1 feeder which was about 0.88 and this will cause penalties on the company.

So, it is recommended to improve power factor either for the loads or in the main supply.

Let take the improvement take place in the main supply feeder of transformer, the maximum power can be reached according to the energy analyzer data is about 450kW, with average power factor about 0.88, to avoid penalties we need a capacitor bank with controller for about 65KVAR according to the following equation:

$$Q\ (KVAR) = P \times (\tan(\cos^{-1}(P.F._{old}))-\tan(\cos^{-1}(P.F._{new}))) \quad (5.6)$$

$$Q\ (KVAR) = 450kW \times (\tan(\cos^{-1}(0.88))-\tan(\cos^{-1}(0.93)))$$

$$Q\ (KVAR) = 65KVAR.$$

The cost of such reactive power compensation will be about 7500NIS, and will save about 70000 NIS as penalties, which represent 1% for each percent less than 0.92 from total energy consumption in transformer 1 bills. [29]

5.2.4 Cost of implementing ISO50001 requirements

In this section, cost of the elements and requirements of the EnMS will be identifies according to ISO standard ISO50001.

The cost of certification scheme will be excluded because it varies from one certification body to another. Until now, there is no facilities has certified with ISO50001 certification in Palestine.

Table (5.3) illustrates the approximate annual cost for different elements of EnMS.

Table (5.3): Requirements of EnMS and their costs in Royal

Stage	Requirement	Elements	Annual cost
Plan	Outline management responsibilities	Commitment	No cost
	Defining the scope	Scope and boundaries	No cost
	Establish team	Energy maintenance team Management representative Members from different sections	84000NIS/yr.
	Set energy policy	Energy policy	No cost
	Identifying SEUs	Energy Manual	No cost
	Determine EnPIs		No cost
	Set energy objectives and targets		No cost
	Preparing action plan		No cost
Do	Manage and control documentation	Documents Records	No cost
	Internal communication		No cost
	Confirm competency, training, and awareness	Certificates Awareness programs Trainings	10000NIS/yr.
	Define energy procurement specifications		No cost
Checks	Verify legal and other requirements		No cost
	Implement monitoring, measurements, and analysis plan	Sub-monitoring system Measuring devices Analysis software OR mini-SCADA system	10283
	Conducting internal audits		No cost
Act	Perform management review		No cost
TOTAL			**104283 NIS/yr.**

5.2.5 Summary

Table (5.4) summarizes energy saving opportunities in Royal Company. It was found that the percentage of saving in energy consumption is less than 1% and the saving in energy cost is about 2.7% only which means that the company applying a good energy management and it is very easy to get the ISO50001 certificate.

Table (5.4): List of actions and savings in energy with SPBP in Royal

Energy saving action	Cost (NIS)	Saving (kWh/yr.)	Saving (NIS/yr.)	SPBP
Prevent air leaks from compressors	No cost	27144	16286	immediate
Adjusting indoor temperature for split units	No cost	2773	1663	immediate
Power factor improvement	7500	-	70000	~ 40 days
Energy management system cost	**Cost (NIS/yr.)**			
Total	104283			

5.3. Energy conservation opportunities of Siniora Food Industrial Company

Energy saving opportunities in Siniora Company is mainly existed in heating systems. In this section, steam boiler, heat recovery and SWH system, will be explained.

5.3.1 Steam boiler system

There are many opportunities related to the steam boiler system; such as improving combustion efficiency, using SWH, and other opportunities which will be explained in the following parts.

5.3.1.1 Improving combustion efficiency

Increasing the energy efficiency of the boiler system can be done by adjusting excess air system. This adjustment improving the combustion efficiency of the boiler, so, the fuel consumption can be achieved.

From the table (3.14) in chapter (3), it was found that combustion efficiency of steam boiler was 81.4% at excess air of 80%. At 229 ºC, which equal about 450F.

Figure (5.1) shows relation between boiler efficiency, O_2, CO_2, with excess air percentage. It is obvious that when making excess air percent 18%, the efficiency will be improved to 85%. O_2 percentage is 3.5% and CO_2 percent is 14%. [30]

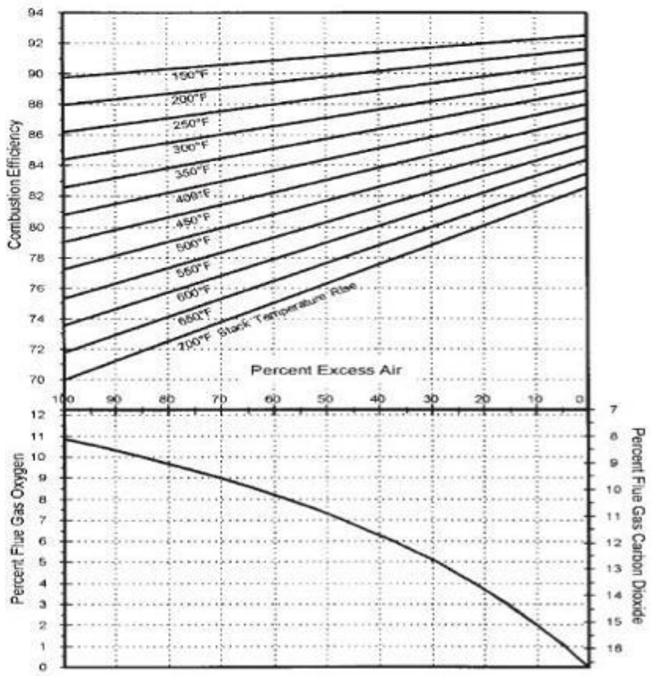

Figure (5.1): Relation between boiler efficiency, O_2, CO_2, with excess air

Heavy oil consumption for steam boiler before adjusting the excess air percentage was 156000L/yr. Fuel saving calculations was made according to the following equations.

Fuel saving = $U \times (1-(\eta_1 / \eta_2))$ …….. [30] (5.7)

Where:

U: fuel consumption in L/yr.

η_1: combustion efficiency before improvement.

η_2: combustion efficiency after improvement.

Fuel saving = 156000 × (1-(81.4 / 85))

Fuel saving = 6607 L/yr. = 6607 L/yr. × 2.75 NIS/L = 18170 NIS/yr.

Fuel cost saving = 6607 L/yr. × 2.75 NIS/L = 18170 NIS/yr.

5.3.1.2 Using SWH for hot water production

Table (5.5) summarizes all calculations related to installing compound parabolic collectors (CPC) evacuated system in order to cover hot water demand and saving fuel need for that purpose. The following equations used to design SWH in right way. [31]

$$Q = m * C_w * \Delta T \quad (5.8)$$

$$A_{SWH} = Q / \eta * E_{sd} \quad (5.9)$$

Where:

Q: Thermal Energy required for heating (W_s)

m: mass of water to be heated (Kg).

C_w: specific heat of water = 4186 W_s/kg- ºC

ΔT: temperature difference. (ºC)

η: efficiency of solar collector = 70% .

E_{sd}: Daily average of solar radiation intensity = 5.4kWh / m^2 – day.

Usually the system consists of three parallel connected collectors and each collector area is 1.7 m^2 and the storage tank of hot water is 200 liters.

Table (5.5): SWH system saving calculations for Siniora

Parameter	Unit	Value
Hot water demand	m^3/day	31
Inlet water temperature	ºC	20
required water temperature	ºC	45
Operation days	day	300
Energy demand	kWh/day	901
	kWh/yr.	270410
Energy production	kWh/day-coll.	11
No. of collectors	collector	82
System Efficiency	%	70
Energy production	kWh/yr.	189287
Boiler efficiency	%	69.4
Saving	L/yr.	27412
	NIS/yr.	75383
Investment		
Cost of collectors	NIS	311600
Pipes, fittings and insulations	NIS	50000
Heat exchangers and pumps	NIS	30000
Storage tanks 10,000L	NIS	100000
Controller	NIS	10000
Total	**NIS**	**501600**
SPBP	**years**	**6.65**

5.3.1.3 Using steam/water mixers

Direct mixing of steam into water has been a process used in multiple industries in order to heat water to temperatures higher than normally seen using other typical heat exchanger processes.

This method can be used from GALASH pasteurization machine, because the amount of heat loss from condensate water can be saved by using steam/water mixture to the boiler. Energy savings is illustrated in table (5.6). The investment of one steam/water mixer includes mixer, reducing valve, pumps and pipes is about 5500 NIS.

Table (5.6): Saving calculations using steam water mixers in Siniora

Parameter	Unit	Value
Heavy oil consumption (q)	L/yr.	21611
Heavy oil price	NIS/L	2.75
GCV diesel	kWh/L	9.95
Boiler efficiency	%	69.4
Fresh water temperature /boiler	ºC	20
Condensate water temperature	ºC	96
h_g steam at 5 bar	kJ/kg	2749
h_f water at 50ºC	kJ/kg	209
Quantity of condensates water	ton/yr.	211.5
Energy saving in condensate $m \times C_p \times (T_c - T_w)/3600$	kWh/yr.	18695
	L/yr.	2707
Energy saving in condensate (10% of total heavy oil consumption)	L/yr.	2161
Total saving	L/yr.	4868
	NIS/yr.	13387

5.3.1.4 Boiler replacement

Existing boiler which has low efficiency (69.35%), should be replaced by another one with higher efficiency (85%) to get the following savings which calculations are shown in table (5.7).

Table (5.7): Fuel saving when uses a new boiler in Siniora

Parameter	Unit	Existed boiler	New boiler
Capacity	KW/h	1500	1500
Shell losses	%	11.3	5
Combustion efficiency		18.6	13
Blow down losses		0.75	0.75
Efficiency (at full load)		-	85
Efficiency		69.35	81
Fuel consumption	L/yr.	156600	
Saving	%	14.3	
	L/yr.	22394	
	NIS/yr.	61583	
If SWH system is implemented with new boiler			
Fuel consumption	L/yr.	129188	
Saving	%	14.3	
	L/yr.	18501	
	NIS/yr.	50875	
Investment	NIS	300000	
SPBP	year	5.9	

5.3.2 Cost of implementing ISO50001 requirements

Table (5.8) includes the items which will cost the company additional money, as I made when talking about Royal company. The no cost requirements will be the same.

Table (5.8): Requirements of EnMS and their costs in Siniora

Requirement	Elements	Annual cost
Establish team	Energy maintenance team Management representative Members from different sections	84000NIS/yr.
Confirm competency, training, and awareness	Certificates Awareness programs Trainings	5000NIS/yr.
Implement monitoring, measurements, and analysis plan	Sub-monitoring system Measuring devices Analysis software OR mini-SCADA system	10250NIS/yr.
Conducting internal audits		2000NIS/yr.
TOTAL		101250 NIS/yr.

5.3.3 Summary

Table (5.9) summarizes energy saving opportunities in Siniora Company. It was found that the percentage of saving in energy consumption is about 11.2% and the saving in energy cost is about 7%.

Table (5.9): List of actions and savings in energy with SPBP in Siniora

System	Action	Investment (NIS)	Saving (L/yr.)	Saving (NIS/yr.)	SPBP years
Steam boiler	Improving combustion efficiency	No cost	6607	18170	immediate
	Using SWH	501600	27412	75383	6.65
	Using steam/water mixers	5500	4868	13387	0.41
	Boiler replacement	300000	22394	61583	4.87

Energy management system cost	Cost (NIS/yr.)
Total	101250

5.4. Energy conservation opportunities for JPC Company

Energy saving opportunities in JPC Company are divided in two main sections; steam boiler system, AHU's, and lighting system. It very critical to try saving in production lines because the processes of medicine production are very sensitive.

5.4.1 Steam network heat losses

5.4.1.1 Pipe surface heat losses

There is conduction heat loss due to non-insulated pipes, where there is about 2.5m length of 1" pipes and 8.5m length of 2" pipes in the steam network near the boiler. Figure (5.2) shows the temperature of non-insulated steam pipe using thermal camera.

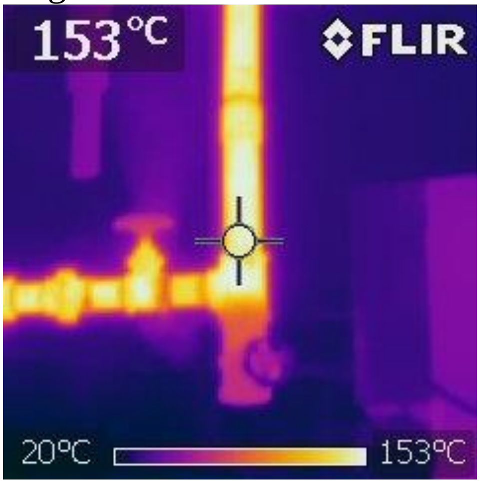

Figure (5.2): Temperature of non-insulated steam pipes in JPC

Heat losses from pipe surface, and the fuel losses can be calculated using the following equations in both cases, with and without insulation material:

$$\text{Heat loss} = S \times A \quad (5.10)$$

$$S = 4.187 \times (10 + (T_s - T_a)/20) \times (T_s - T_a) \quad (5.11)$$

$$A = \pi \times \text{diameter} \times \text{length} \quad (5.12)$$

$$\text{Fuel loss} = \text{kWh} / (\text{GCV} \times \eta_{boiler}) \quad (5.13)$$

Where:

S: surface heat loss in [kJ/h.m^2]

A: pipe surface area in [m^2]

T_s: hot surface temperature [°C]

T_a: ambient temperature [°C]

If the we cover non-insulated pipes with insulation material of 40mm thickness for 2" pipe and 30mm thickness for 1" pipe, the new fuel loss can be calculated with assumption of new T_s = 30°C. Table (5.10) summarizes all calculations, the difference between two fuel losses will be the saving due insulation process.

Table (5.10): Heat and fuel losses from insulated and non-insulated pipes in JPC

Parameter	Unit	Value for non-insulated pipes	Value for insulated pipes
Ambient temp	°C	25	25
Steam pipe temp	°C	153	30
Surface Heat Loss	$kJ/h.m^2$	8789	214.6
Heat Loss	kJ/h	13711	893
	kW	3.81	0.25
Operation Hours	h/yr.	2550	2550
Energy Consumption	kWh/yr.	9716	637.5
Boiler Efficiency	%	75.4	75.4
Fuel Loss	L/yr.	1295	85

From table (5.10), saving in fuel will be 1210L/yr., and the investment in insulating these pipes with fiberglass will be about 2000NIS. In this case, saving will be about 7744NIS and SPBP of about 3 months only.

5.4.1.2 Leakage heat loss

Steam leakage was observed from steam pipes and was estimated to be 200L/day. (63700L/yr.). the amount of heat loss due to leakage can be calculated from the following equation:

$$\text{Leakage heat loss} = m_L \times (h_{g@5.5bar} - h_{f\,@25^oC})\ /3600 \qquad (5.14)$$

Where:

m_L: amount of water leakage [kg/yr.]

$h_{g@5.5bar}$: specific enthalpy of saturated vapor at pressure of 5.5bar [kJ/kg]

$h_{f\,@25^oC}$: specific enthalpy of saturated liquid at temperature 25°C [kJ/kg]

Leakage heat loss = 63700×(2753.33-105.34)/3600 = 46855kWh/yr.

Fuel loss = 46855/(9.95×75.4%) = 6245L/yr. this will cost 39968NIS/yr.

This value can be saved by some maintenance to the steam network to prevent such leakages, let this maintenance cost about 5000NIS only, the SPBP will be only 1.5 month only.

5.4.2 Using SWH system

Evacuated solar system can be used for hot water production to about 70ºC. SWH system can be implemented for the company steam boiler inlet hot water. Table (5.11) shows SWH system calculations and the saving.

Table (5.11): SWH system saving calculation for JPC

Parameter	Unit	Amount
Hot water demand	m^3/day	1.5
Inlet water temperature	ºC	20
Required water temperature	ºC	70
Operation days	day	300
Solar System Efficiency	%	70
C_p	kJ/kg.ºC	4.19
Energy demand	kWh/day	87.3
	kWh/yr.	26188
Energy production	kWh/day-coll.	11
No. of collectors needed	collector	8
Boiler efficiency	%	75.4
GCV diesel	kWh/L	9.95
Diesel Price	NIS/L	6.4
Saving by using SWH	L/yr.	2443
Saving	NIS/yr.	15635
Investment		
Cost of collectors	NIS	30400
Pipes, fittings and insulations	NIS	10000
Heat exchangers and pumps	NIS	5000
Storage tanks 1,000L	NIS	10000
Controller	NIS	10000
Total	NIS	65400
SPBP	years	4.2

5.4.3 Using dual burner for steam boiler

Dual burner using both LPG and diesel to be used in steam production, the cost of one kWh produced by LPG is less than cost of one produced by diesel, so, the total expenses will be eliminated. The diesel consumption after applying energy saving measures discussed in this section, the new consumption will be:

New fuel consumption = 75174 - 1210 - 6245 - 2443 = 65276 L/yr.

Saving calculations by using LPG instead of diesel are illustrated in table (5.12). The investment of dual burner with the cost of installation is estimated to be 60000NIS taking into the account the existence of LPG tank in the company with SPBP of about 5.8 months.

Table (5.12): Saving calculation for using LPG dual burner

Parameter	Unit	Diesel	Unit	LPG
Steam boiler consumption	L/yr.	65276	--	--
	NIS/yr.	417766	--	--
Price	NIS/L	6.4	NIS/kg	5.8
GCV	kWh/L	9.95	kWh/kg	12.9
Boiler efficiency	%	75.4	%	75.4
Energy Unit cost	NIS/kWh	0.64	NIS/kWh	0.45
Saving	%	30%		
	NIS/yr.	125330		

5.4.4 Control AHUs using modulating valves

The control of AHU's is done by 3 way valves manually, but from the temperature data of production zones in the company, the mean temperature was about 18ºC. The reduction of 1ºC temperature will increase the energy consumption of the chiller from 3-5%, so it is recommended to control all AHUs by using motorized modulating valve with duct temperature sensors.

Energy saving by increasing the room temperature 4ºC using 3 way modulating valve estimated to be 16%, and by assuming that 90% of chiller consumption used for AHUs, the electrical energy saving will be as following.

Electrical saving = 16% × 90% × 242068 = 34858 kWh/yr.

Money saving = 34858 kWh/yr. × 0.6 NIS/kWh = 20915 NIS/yr.

Investment =~ 70000 NIS.

SPBP = 3.35 years.

5.4.5 Lighting units replacement

Lighting system in this company forms a large portion of electrical energy consumption (12.4%), and there is a great potential to saving in electricity. Fluorescent and CFL lamps are typically used for task lighting in the building.

It is suggested to replace the 2×110W fluorescent lamps units (29units) with 1×50W LED lamps. The total annual consumption of these units is about 16333kWh/yr. the cost of every 50W LED unit including installation is 850NIS. The cost of all LED units is 24650NIS.

Saving percentage = ((2×110)-50)/(2×110) = 77.3%

Energy saving = 16333 × 77.3% = 12625 kWh/yr.

Energy cost saving = 7575 NIS/yr.

SPBP = 3.25 years.

5.4.6 Cost of implementing ISO50001 requirements

Table (5.13) illustrates the cost of implementing EnMS requirements in JPC Company.

Table (5.13): Requirements of EnMS and their costs in JPC

Requirement	Elements	Annual cost
Establish team	Energy maintenance team Management representative Members from different sections	84000NIS/yr.
Confirm competency, training, and awareness	Certificates Awareness programs Trainings	5000NIS/yr.
Implement monitoring, measurements, and analysis plan	Sub-monitoring system Measuring devices Analysis software OR mini-SCADA system	10185NIS/yr.
Conducting internal audits		3000NIS/yr.
TOTAL		102185NIS/yr.

5.4.7 Summary

Table (5.14) is the summary of all saving opportunities in JPC Company. The saving in energy cost from all sources was about 13.4% with implementation of EnMS requirements.

Table (5.14): List of actions and savings in energy with SPBP in JPC.

Action	Investment (NIS)	Saving (L/yr.)	Saving (NIS/yr.)	SPBP years
Pipe surface insulation	2000	1210	7744	0.26
Leakage maintenance	5000	6245	39968	0.13
Using SWH for steam boiler inlet	65400	2443	15635	4.2
Using dual burner for steam boiler	60000	-	125330	0.48
Action	**Investment (NIS)**	**Saving (kWh/yr.)**	**Saving (NIS/yr.)**	**SPBP years**
Control AHUs using modulating valves	70000	34858	20915	3.35
Lighting units replacement	24650	12625	7575	3.25

Energy management system cost	Cost (NIS/yr.)
Total	102185

5.5. Generalization of economical evaluation

Table (5.15) shows the cost of implementing monitoring system in 12 industrial companies according to quantities of points for each one.

Table (5.15): Total and annual cost of implementing monitoring system in 12 industrial companies

#	Facility	Quantity of points to be monitored	Total cost of implementing monitoring system (NIS)	Annual value (NIS/yr.)
1	Arab Industrial Co.	15	42900	6980
2	Sinokrot Food Co.	30	55800	9079
3	Al-Ayyam Co.	20	46700	7598
4	Birzeit Pharm. Co.	40	61400	9990
5	Palestinian Plastic Co.	15	42900	6980
6	Pharmacare Co.	35	58800	9567
7	Royal Industrial Co.	51	63200	10283
8	Al-Juneidi Co.	57	74900	12186
9	Siniora Food Co.	50	63000	10250
10	Al-Pinar Diary Co.	40	61400	9990
11	Jerusalem Pharm. Co.	48	62600	10185
12	Biet Jala Pharm. Co.	48	62600	10185

Table (5.16) shows the total annual cost of implementing the requirements of EnMS for all companies.

Table (5.16): Annual cost of implementing EnMS requirements in 12 industrial companies

#	Facility	Cost of Energy team (NIS/yr.)	Cost of Training and competency (NIS/yr.)	Cost of Monitoring system (NIS/yr.)	Cost of internal audit (NIS/yr.)	Total Cost (NIS/yr.)
1	Arab Industrial Co.	84000	5000	6980	2000	97980
2	Sinokrot Food Co.	84000	10000	9079	0	103079
3	Al-Ayyam Co.	84000	5000	7598	2000	98598
4	Birzeit Pharm. Co.	84000	10000	9990	0	103990
5	Palestinian Plastic Co.	84000	5000	6980	2000	97980
6	Pharmacare Co.	84000	5000	9567	3000	101567
7	Royal Industrial Co.	84000	10000	10283	0	104283
8	Al-Juneidi Co.	84000	14000	12186	0	110186
9	Siniora Food Co.	84000	5000	10250	2000	101250
10	Al-Pinar Diary Co.	84000	10000	9990	3000	106990
11	Jerusalem Pharm. Co.	84000	5000	10185	3000	102185
12	Biet Jala Pharm. Co.	84000	5000	10185	2000	101185
	Total					**1229273**

Results of that audits are shown in table (5.17), it contains energy consumptions, percentages of saving if applying EnMS for each facility, and the energy saving by applying EnMS.

It is clear from table (5.17) that applying ECM will lead to great savings reach to about 14.8% from total energy consumption of all 12 industrial facilities. The additional cost for implementation of EnMS requirements will guarantee the commitment from top management in each facility to apply the output results and recommendations of the conducted audits.

Table (5.17) : Energy Saving information for many industrial facilities in Palestine

#	Facility	Diesel consumption (L/yr.)	LPG consumption (L/yr.)	Electrical consumption (kWh/yr.)	Total energy consumption (kWh/yr.)	Percentage of energy saving	Amount of energy saved (kWh/yr.)	cost of implementing EnMS (NIS/yr.)
1	Arab Industrial Co.	59512	60398	92197	1121025	8%	89682	97980
2	Sinokrot Food Co.	166307	274819	782118	4423814	15.18%	671535	103079
3	Al-Ayyam Co.	5509	-	932300	987113	16.8%	165835	98598
4	Birzeit Pharm. Co.	134785	-	1625155	2966265	16.2%	480535	103990
5	Palestinian Plastic Co.	3030	-	1359200	1389344	9%	125041	97980
6	Pharmacare Co.	38200	-	979450	1359538	18.2%	247436	101567
7	Royal Industrial Co.	-	212000	4999701	6532500	1%	65325	104283
8	Al-Juneidi Co.	660000	-	3493200	10060201	24.4%	2454689	110186
9	Siniora Food Co.	29397	(Heavy oil) 156600	1860658	3938402	11.2%	441101	101250
10	Al-Pinar Diary Co.	96438	-	541458	1501018	16.6%	249169	106990
11	Jerusalem Pharm. Co.	84677	3000	1365969	2230193	14%	312227	102185
12	Biet Jala Pharm. Co.	37000	-	1674319	2042470	20%	408494	101185
	Total energy consumption and saving				**38551842**		**5711069**	**1229273**

In order to find the feasibility of implementing EnMS and energy conservation measures in these 12 industrial facilities, we can use annual worth (AW) method to evaluate this feasibility, for all costs and benefits during 10 years and with interest rate of 10%. If AW>0, the EnMS and conservation measures will be feasible, otherwise, the system will be not economic feasible.

Table (5.18) shows initial investment for energy conservation measures, annual cost of EnMS and the annual saving due to applying these measures and systems.

Table (5.18): Investments, costs of EnMS, and savings in 12 industrial facilities

#	Facility	Investment (NIS)	Saving (NIS/yr.)	Cost of EnMS (NIS/yr.)
1	Arab Industrial Co.	8775	26834	97980
2	Sinokrot Food Co.	270025	329834	103079
3	Al-Ayyam Co.	17680	105470	98598
4	Birzeit Pharm. Co.	101200	305726	103990
5	Palestinian Plastic Co.	72000	66967	97980
6	Pharmacare Co.	183500	158528	101567
7	Royal Industrial Co.	7500	87949	104283
8	Al-Juneidi Co.	1359000	2100153	110186
9	Siniora Food Co.	807100	168523	101250
10	Al-Pinar Diary Co.	478300	155297	106990
11	Jerusalem Pharm. Co.	227050	217167	102185
12	Biet Jala Pharm. Co.	397680	245757	101185
	Total	**3929810**	**3968205**	**1229273**

Figure (5.3) shows cash flow for all incomes and outcomes of the system in 12 industrial facilities.

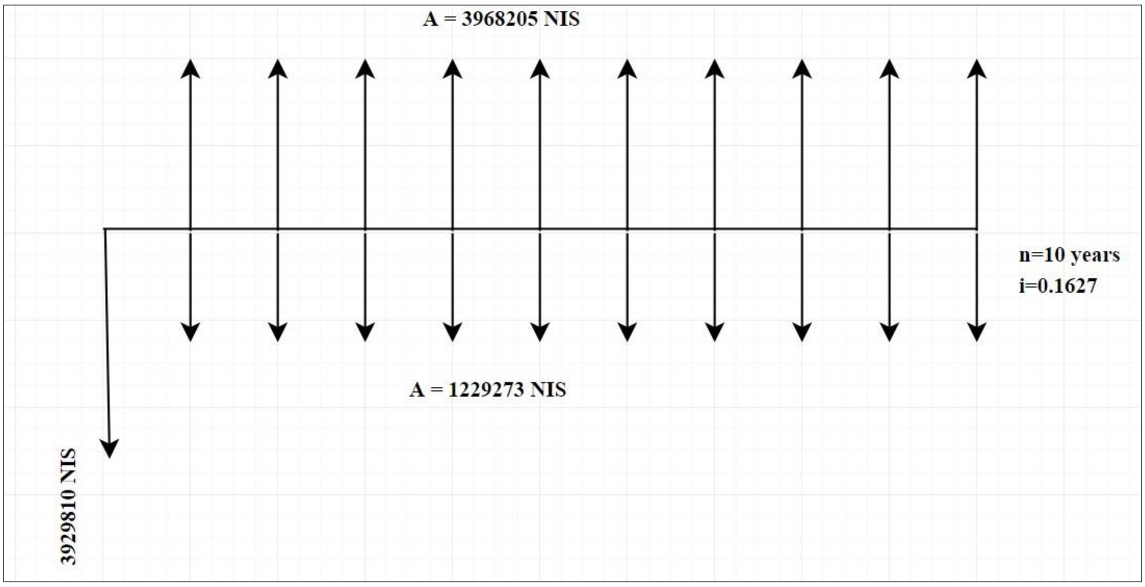

Figure (5.3): cash flow for EnMS and conservation measures for 12 facilities

AW evaluation for implementation of EnMS and conservation measures is according with the following equation:

AW = Annual saving - Present value × (A/P, 10%, 10yrs.) - Annual expenses (5.15)

AW = 3968205 - 3929810×(0.1627) – 1229273 = **2099552 NIS/yr.**

The AW value is positive and very high value, which means that implementing EnMS in industrial sector in Palestine has a great potential and will save a lot of money for the companies.

Chapter (6) The environmental impact of energy saving and EnMS implementation

6.1. Introduction

The first goal of implementing EnMS is to save money, which means reducing energy cost.

The next importance of applying such energy management is to reduce the pollution released to air and cause many environmental problems.

The problems associated with GHGs are not restricted in the global warming, but there are many climate phenomena expected due to increasing of GHGs will be mentioned briefly as following:

- Global warming which causes desertification, increasing of melted snow and ice which leading to raise sea level, and stronger storms and extreme climate events.
- Ocean acidification due to increase of CO_2 levels which have made world ocean 30% more acidic since the industrial revolution.
- Changes to the growth of plants and the levels of nutrition.
- Smog and ozone pollution.
- Depletion of ozone layer.

6.2. Energy and environment

As mentioned before, there is a strong relation between CO_2 emissions that produced from energy production and consumption, and the climate change through greenhouse effect.

The main source of production CO_2 emission pollutants is combustion of fossil fuels. The share of energy production and consumption in CO_2 emissions was about 81.6% in 2010 according to International Energy Agency (IEA), this means that the energy production and consumption is the main source of climate change. [33]

It is obvious from these figures that renewable energy use and energy saving projects will lead to reduce dependent on the fossil fuels sources for produce energy, which means a less environmental impact results from emissions of CO_2 and other GHGs.

ISO has developed Environmental Management System (EMS) – ISO14001 standard, which is similar to (EnMS). This standard helps facilities to minimize how their operations and processes negatively affect the environment.

The facilities can merge two or more management systems. EnMS, EMS, and QMS can be merged in one integration system to guarantee that the energy efficiency will lead to improve environmental effect.

6.3. Emission Reduction due to energy saving

Relation between energy consumed and CO_2 and other gases emitted to the air comes from the process of combustion of fossil fuels in the electrical generation station, is expressed by electricity/heat specific emission factor.

Electricity/heat specific emission factor is expression of the amount of CO_2, CH_4, NO_x, and SO_2 released due to consumption of 1kWh electrical energy including the losses in transmission and distribution of energy.

The Electricity/heat specific emission factor depends on the region of power generation, and includes the electrical and heat generated from the process of combustion of fossil fuels. There are published tables for the emission factor for every country and expressed in kg(gas)/kWh.

The electricity/heat specific emission factors for different gases in Israel which can be used when calculate emissions reduction due to energy saving is illustrated below for 1kWh energy unit comes from both; direct electrical consumption and diesel used: [34]

- CO_2 – 0.695 kg/kWh for electricity consumption.
- SO_2 – 0.0017 kg/kWh for electricity consumption.
- NO_x – 0.0018 kg/kWh for electricity consumption.
- CO_2 – 0.267kg/kWh for diesel consumption.
- SO_2 – 0.095×10^{-3}kg/kWh for diesel consumption.
- NO_x – 0.29×10^{-3}kg/kWh for diesel consumption.
- CH_4 – is neglected because the emission factor is very small.

The energy saving calculated in table (5.19) in the past chapter can be used for calculations of gases reduction amount due to energy saving that industrial facilities.

6.4. Emissions amounts from industrial sector in Palestine

The total reduction of CO_2, SO_2, and NO_x due to energy saving for one year is calculated according to the following equations:

CO_2 reduced =electrical saving×0.695kg/kWh+diesel saving×0.267kg/kWh (6.1)

SO_2 reduced =electrical saving×0.0017kg/kWh+diesel saving×0.095×10^{-3}kg/kWh (6.2)

NO_x reduced =electrical saving×0.0018kg/kWh+diesel saving×0.29×10^{-3}kg/kWh (6.3)

Table (6.1) shows amount of reduction in the industrial facilities mentioned in the chapter (5).

It is clear from table (6.1) that total CO_2, SO_2, and NO_x reduction will be 2265344kg/yr., 3319.4kg/yr., and 4268.7kg/yr., respectively. These values are considered huge values which can be saved by applying energy saving measures, and the commitment can be achieved by trend to ISO50001 EnMS and ISO14001 EMS.

Table (6.1) : Emission reductions due to energy savings for many industrial facilities in Palestine

#	Facility	kWh saving from diesel (kWh/yr.)	kWh saving from electricity (kWh/yr.)	Total CO_2 reduction (kg/yr.)	Total SO_2 reduction (kg/yr.)	Total NO_x reduction (kg/yr.)
1	Arab Industrial Co.	43039	46643	43908.3	83.4	96.4
2	Sinokrot Food Co.	123082	548453	414037.7	944.1	1022.9
3	Al-Ayyam Co.	8418	157417	111652.4	268.4	285.8
4	Birzeit Pharm. Co.	326002	154533	194443.0	293.7	372.7
5	Palestinian Plastic Co.	0	125041	86903.5	212.6	225.1
6	Pharmacare Co.	192213	55223	89700.9	112.1	155.1
7	Royal Industrial Co.	0	65325	45400.9	111.1	117.6
8	Al-Juneidi Co.	2172109	282580	776346.2	686.7	1138.6
9	Siniora Food Co.	400163	40938	135295.4	107.6	189.7
10	Al-Pinar Diary Co.	240510	8659	70234.2	37.6	85.3
11	Jerusalem Pharm. Co.	265715	46512	103271.7	104.3	160.8
12	Biet Jala Pharm. Co.	209704	198790	194150.0	357.9	418.6
	Total emission reduction			**2265344.2**	**3319.4**	**4268.7**

Conclusions

The energy situation in Palestine is very critical due to lack of conventional energy generation resources such as coal and oil. Also, there is no independency in controlling the imported energy from neighbors (especially from Israel) due to political and economic situations. These factors create a fluctuation of reliability and the cost of energy.

The industrial sector consist an important portion of energy consumption in the world, it is about 31% of total world energy consumption, and the losses in the industrial sector forms about 21% from total energy losses in the world. These figures give a good indication to the importance of energy conservation projects in industrial sector.

Although the industrial sector consists only about 5% from total energy consumption in Palestine, the potential of energy conservation projects is feasible economically and environmentally.

In order to ensure that energy conservation measures found during energy audits are implemented and have a commitment from facilities managers, it must be put in a framework that impose the managers to plan, implement, check, maintain and review the results of applying ECM. This framework is EnMS based on international standards such as ISO50001 and its series, and getting its certification.

Applying ISO50001 standard and other related standards will lead to significant conservation opportunities as I show in the energy audits conducted to three industrial facilities. The applying of EnMS lead to energy conservations of 1%, 11.2%, and 14%. Then, I had generalized the idea of using EnMS to other 9 industrial companies in Palestine and I had found significant conservations in energy consumptions. 5711069 kWh/yr. (~14.8%) can be saved through applying EnMS on the 12 industrial facilities.

The applying of EnMS standards will lead positive environmental impact through reducing GHGs emissions in the atmosphere. The energy savings 12 companies mentioned in this thesis will lead to reduce 2265.33ton/yr. of CO_2, 3319.4kg/yr. of SO_2 and 4268.7kg/yr. of NO_x.

The cost of applying EnMS is somewhat high, but there are different ways to get funds to such projects beside the investment from companies itself.

Recommendations

According to my thesis and other studies and reports related to energy management, the following recommendations must be taken into account:

1. Draw attention of the competent authorities and decision makers in Palestinian Authority about the importance of implementing EnMSs and the importance of commitment to apply ECM in order to save money and reduce environmental pollution.
2. Awareness workshops and campaigns must be organized to the industrial sector managers and workers regarding the importance of energy management and applying the rational use of energy.
3. Introduce intensives from the government for the companies which have implemented certified EnMS standards, to encourage other companies to adopt EnMS, such like reducing taxes, give them lower energy prices, encourage their products, …etc.
4. Use intelligent EnMS in order to achieve optimum energy consumption through monitoring all energy consuming systems inside the facility.
5. For companies, applying the requirements of recognized EnMS, such as ISO50001, and take into account the use of other harmonized standards when design, purchase, and procurement stages, in order to get most efficient equipment that will help to save energy in facility.
6. Inside the facilities, get benefit of using daylight when design the building, and to have the heat from sun through transparent roofs and using solar water heaters.

7. Insure good insulation for the building in order to reduce the heat losses that transfer from building and then reduce the HVAC system consumption.
8. Take care of training the stuff of facility to the efficient use of energy, and take care to appoint energy management team from different departments.
9. Encourage to establish energy services companies (ESCOs) in Palestine which can introduce different services in the field of energy efficiency and management.

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Appendices

Appendix (A): Energy consumption data in Royal Industrial Trading Company

(A-1) Injection Lines

№	Machine's Name	Main Motor (kW)
1	MA, 200 ton	22
2	MA, 320 ton	37
3	MA, 320 ton	55
4	MA, 320 ton	55
5	MA, 470 ton	55
6	MA, 600 ton	55
7	MA, 600 ton	55
8	MA 700 ton	22+45
9	MA 800 ton	22+55
10	MA 1300	37+37+37
11	168 ton	18.5
12	280 ton	22
13	380 ton	37
14	380 ton	37
15	500 ton	55
16	380 ton	37
17	188 ton	15
18	120 ton	15
19	160 ton	18.5
20	160 ton	18.5
21	BL 780	30+30
22	New one MA, 1000 ton	37+55

(A-2) Compressors data

Type	Compressor	Motor
Air compressor1	9.5 m^3/min P_{max}=13 bar P_{min}=8.5 bar	110 hp, 75kW 380 V
Air compressor2	6.19 m^3/min P_{max}=10 bar P_{min}=8.5 bar	60 hp, 49.5kW 400 V
Air compressor3	5.15 m^3/min P_{max}=10 bar P_{min}=8.5 bar	50 hp, 37kW

(A-3) Lighting system

Floor	Place	Lampe type	No. of lamps			Rated power	Operation time	Energy consumption
			N	n	N*n			
Ground floor	Sewn	Fluorescent	8	1	8	36	8	718.8
	production area	Mercury	10	1	10	400	24	29952
		Fluorescent	20	2	40	36	8	3594.24
		Fluorescent	50	2	100	36	24	26956.8
First Floor	offices	PL	4	2	8	9	1	22.464
		PL	20	2	40	18	10	2246.4
		Fluorescent	7	4	28	18	10	1572.48
		Fluorescent	46	4	184	18	10	10333.44
		PL	17	2	34	18	10	1909.44
		Fluorescent	34	4	136	18	10	7637.76
		PL	8	2	16	18	10	898.56
Second Floor	Reception	PL	19	1	19	18	14	1493.85
		PL	1	1	1	9	14	39.3
		spots	4	1	4	20	14	349.44
		T5	2	1	2	18	14	157.2
		spots	8	1	8	20	14	698.88
		Fluorescent	1	1	1	18	14	78.6
	Warehouse	Fluorescent	40	4	160	18	1	898.6
		PL	11	2	22	18	1	123.6
		PL	18	1	18	18	1	101.1
Third floor	Theater	spots	13	1	13	50	0.25	50.7
		Fluorescent	27	4	108	18	0.25	151.6
		spots	24	1	24	20	0.25	37.4
		PL	9	2	18	18	0.25	25.3
		diming	6	1	6	300	0.25	140.4
		Fluorescent	4	1	4	18	0.25	5.6
out door		HPS	6	1	6	50	12	1123.2
Total								**91,317**

Appendix (B): Energy consumption data in Siniora Food Industries Company

(B-1) Refrigeration and ice machines

<table>
<tr><th>No.</th><th>Ref./Freezer</th><th>Room Temp Range</th><th>No. of comp.</th><th>Rated capacity of comp.</th><th>No. of cond. Units</th><th>Operation/cond. fans</th><th>Cond. Fans Power</th><th>No. of evap. Units</th><th>Operation /evap. fans</th><th>Evap. Fans Power</th><th>Operation Time</th></tr>
<tr><td>1</td><td>Main freezer</td><td>-12 to -18</td><td>2</td><td>2×30 hp</td><td>2 units</td><td>20%</td><td>5×0.66
4×0.47</td><td>4 units</td><td>95%</td><td>6×0.6
4×0.47</td><td>24×365</td></tr>
<tr><td>2</td><td>Main Refrigerator</td><td>0 to 4</td><td>3</td><td>3×30 hp</td><td>3units</td><td>50%</td><td>9×0.66</td><td>3 units</td><td>95%</td><td>18×0.415</td><td>24×365</td></tr>
<tr><td>3</td><td>Containers (Refrigerator) (Freezer)</td><td>0 to -18</td><td>6</td><td>4×5.5 hp
1×4.5 hp
1×2 hp</td><td>2 units</td><td>50%
With comp.</td><td>12×0.55</td><td>6 units</td><td>95%</td><td>6×0.415</td><td>24×150</td></tr>
<tr><td>4</td><td>Elev. Freezer</td><td>-15 to -18</td><td>1</td><td>7.5 hp</td><td>1 unit</td><td>50% one fan</td><td>2×0.55</td><td>1 unit</td><td>95%</td><td>3×0.275</td><td>24×335</td></tr>
<tr><td>5</td><td>Epic meat Freezer</td><td>-15 to -18</td><td>1</td><td>7.5 hp</td><td>1 unit</td><td>50% one fan</td><td>2×0.55</td><td>1 unit</td><td>95%</td><td>2×0.25</td><td>24×365</td></tr>
<tr><td rowspan="6">6</td><td>Defrost</td><td>0 to 4</td><td rowspan="6">3</td><td rowspan="6">3×10hp</td><td rowspan="6">1 unit</td><td rowspan="6">50% one fan one comp.</td><td rowspan="6">6×0.66</td><td rowspan="6">6 units</td><td>95%</td><td>2×0.415</td><td>24×150</td></tr>
<tr><td>Templar</td><td>0 to 4</td><td>95%</td><td>2×0.56</td><td>24×160</td></tr>
<tr><td>Productions</td><td>0 to 4</td><td>95%</td><td>2×0.40</td><td>24×365</td></tr>
<tr><td>Ovens</td><td>0 to 4</td><td>95%</td><td>2×0.39</td><td>24×365</td></tr>
<tr><td>Receptions</td><td>0 to 4</td><td>95%</td><td>3×0.38</td><td>24×365</td></tr>
<tr><td>Cure meat</td><td>0 to 4</td><td>0%</td><td>2×0.40</td><td>24×365</td></tr>
<tr><td>7</td><td>Ice machine</td><td>ice</td><td>1</td><td>3 TR</td><td>1 unit</td><td>--</td><td>--</td><td>1 unit</td><td>--</td><td>--</td><td>20%
24×365</td></tr>
</table>

No.	Ref./Freezer	Room Temp. Meas. ºC	Low Temp. ºC	High Temp. ºC	Ambient Temp. ºC	Energy Cons. comp. & cond. kWh/yr.	Total Energy Cons. kWh/yr.
1	Main Refrigerator	2	-20	35	15	33851	48358
2	Main freezer	-13	-28	40	15	69251	101174
3	Containers (Refrigerator) (Freezer)	1 -13	-40	25	15	4×3585 2×7170	28680
4	Elev. Freezer	-17	-25	60	22	19216	26170
5	Epic meat Freezer	-17	-25	54	22	31040	35584
6	Prod. Hall Refrigerator	2	-5	45	22	113313	152388
7	Ice machine	ice	--	--	20	5256	5256
Total							**397610**

(B-2) Lighting System

Place	Type	No.	Rated (w)	Operation time (hour/day)	Consumption (kWh/yr.)
Housing	36w ceiling mount fluorescent lighting fixture	22	792	8	1900.8
Sales	36w ceiling mount fluorescent+ 2*36w ceiling	6+4	504	8	1209.6
Protection	2*36w ceiling mount W.P fluorescent lighting fixture	5	360	24	2592
External lighting		33	2376	12	8553.6
Finance	4" SPOT LINE+4*18w ceiling	23+29	2364	8	5673.6
Administration		36+16	1584	8	3801.6
Service room	2*36w ceiling mount W.P fluorescent lighting fixture	23	1656	6	2980.8
Cow store		9	648	5	972
changing clothes and cafeteria area	4" SPOT LINE12w+4*18w ceiling	66+16	1944	8	4665.6
Biology lab.	2*36w ceiling mount W.P fluorescent lighting fixture	2	144	8	345.6
Chemical lab.	4*18w ceiling mount PARABOLIC LOUVER lighting fixture	4	288	8	691.2
low voltage room		2	144	1	43.2
Stores office	80 w lamp	2	160	8	384
Maintenance offices	2*36w ceiling mount W.P fluorescent lighting fixture	5	360	8	864
Maintenance room		10	720	8	1728
Elevator freezer		2	144	4	172.8
Epic meat freezer		2	144	2	86.4
Production refrigerator		3	216	5	324
Templer refrigerator		2	144	5	216
Defrost refrigerator		1	72	6	129.6
Reception refrigerator		3	216	3	194.4
Oven		4	288	3	259.2

Place	Type	No.	Rated (w)	Operation time (hour/day)	Consumption (kWh/yr.)
refrigerator					
Cure meat room		2	144	8	345.6
Ovens		25	1800	12	6480
Poly clips area		9	648	10	1944
Production corridor		9	648	12	2332.8
Hema area		12	864	8	2073.6
Laundry		2	144	8	345.6
Mensar and cutter area		17	1224	8	2937.6
Canned food packing		17	1224	10	3672
Entrance and reception area		10	720	10	2160
Peeling and multi area		11	792	8	1900.8
Grilling area		2	144	8	345.6
GALNESH area		6	432	8	1036.8
Multi path		5	360	8	864
Main store		24	1728	4	2073.6
South store		18	1296	6	2332.8
High panel		57	4104	3	3693.6
Stair and spice path		9	648	10	1944
Spice preparing room		4	288	8	691.2
Male bath	4*18w ceiling mount PARABOLIC LOUVER lighting fixture	4	288	4	345.6
Changing clothes room(men)	4" SPOT LINE	15	195	4	234
Hall stairs	2*36w ceiling mount W.P fluorescent lighting fixture	3	216	8	518.4
Cafeteria corridor	4*18w ceiling mount PARABOLIC LOUVER lighting fixture	10	720	10	2160
Washing clothes room	2*36 w.p + 4" SPOT LINE	1+11	215	8	516
Research and development	4" SPOT LINE	4	52	6	93.6

Place	Type	No.	Rated (w)	Operation time (hour/day)	Consumption (kWh/yr.)
office					
Female path		11	143	4	171.6
Cafeteria		36	468	8	1123.2
Changing clothes(women)		10	130	8	312
Low panel	2*36w ceiling mount W.P fluorescent lighting fixture	57	4104	0.2	246.24
Spice store		9	648	5	972
Total consumption for one shift					**81,654**

(B-3) Pumps

Component	Location	Rated power (kW)	Measured power (kW)	Operation time (h/yr.)	Consumption (kWh/yr.)
Tower pump	near tower	1.1	0.74	1800	1332
water from cooling tower to laggard Oven pump	near tower	11	7.46	1350	10071
Main circulation pump	Water treatment	5.5	3.69	8760	32324
HW return pump	Water treatment	1.5	1	6000	6000
Boiler pump	Boiler room	4	2.68	8760	23477
Laggard circulation Pump (2 pumps)	near oven	11	7.37	1800	26532
vacuum pump	near tower	3.7	2.48	2700	6696
Chiller circulation pump	near chiller	15	10.55	7200	75960
Total					182392

(B-4) Split units

Location	No	Type	No. of phases	Rated input power (kW)	Actual input power (kW)	operation time (h/yr.)	Energy consumption (kWh/yr.)
House	1	Tadiran	1ph	3.7	2.22	1500	3330
The old sales	1	Electra	3ph	8	4.8	1200	5760
The new sales	1	Electra	3ph	7.4	4.44	1200	5328
Protection	1	Electra	1ph	3.55	2.13	1200	2556
The old administration	1	Electra	3ph	14.04	8.424	1500	12636
The new administration	1	Electra	3ph	7.4	4.44	1200	5328
IT room	2	Tadiran	3ph	5.3	3.18	1800	11448
Director of Finance office	1	Tadiran	1ph	3.7	2.22	1500	3330
Research and Development office	1	Tadiran	1ph	5.2	3.12	1500	4680
The old Cafeteria	1	Electra	3ph	10.2	6.12	600	3672
The new Cafeteria	1	Electra	3ph	4.7	2.82	600	1692
Biological laboratory	1	carrier	1ph	5.2	3.12	1200	3744
Chemical laboratory	1	Electra	1ph	5.2	3.12	1500	4680
Low voltage room	1	Electra	3ph	10.4	6.24	5400	33696
Warehouse office	1	Elco	1ph	3.4	2.04	600	1224
Accounting offices	1	Tadiran	3ph	14.04	8.424	1800	15163
Maintenance offices	1	carrier	1ph	8.8	5.28	900	4752
Maintenance room	1	Elco	1ph	5.3	3.18	600	1908
Total	**19**						**124927**

(B-5) AC units in production zones

Zone	Op. Time	No.	Rated power (kW)	Operation time (h/yr.)	Actual power (kW)	Energy (kW/yr.)
Receptions	90%	3	0.36	8760	0.252	5960.3
filling zone	95%	4	0.36	8760	0.252	8388.6
cutting zone	40%	8	0.645	8760	0.452	12656.4
Multi-vac zone	35%	2	0.6	8760	0.420	2575.4
Gal-ash zone	35%	2	0.6	8760	0.420	2575.4
Poly-cleb zone	35%	4	0.6	8760	0.7	5150.9
Hema zone	35%	4	0.6	8760	0.7	5150.9
corrd. VC-999	35%	2	0.17	8760	0.7	729.7
Peeling zone	70%	2	0.17	8760	0.7	1459.4
Total						**44647**

(B-6) AHU's in production zones

Component	Location	Rated power (kW)	Measured power (kW)	Operation time (h/yr.)	Consumption (kWh/yr.)
A.H.U.1	Air cooled unit	3kW	2.22	4380	9724
A.H.U.2 (2)	Spices area	-	3.05	600	3660
A.H.U.3	Ovens area	-	1.83	2400	4392
Total					**17776**

(B-7) supply and exhaust fans

Component	No.	Location	Measured power(kW)	Operation time (h/yr.)	Consumption (kWh/yr.)
EX. fan1	1	-	0.78	3600	2808
EX. fan2	1	-	0.33	3600	1188
EX. fan3	1	Barbecuing area	0.23	3000	690
EX. fan4	1	Cleaning area	0.5	3000	1500
EX. fan5	1	Cleaning area	0.5	3000	1500
EX. fan6	1	Galash machine	0.5	3000	1500
EX. fan7	3	Spices stores	0.78	3000	7020
EX. fan8	2	Ovens area	0.33	4800	3168
Total					**19374**

Appendix (C): Energy consumption data in Jerusalem Pharmaceutical Company

(C-1) Air handling units (AHU's)

Air Handling Unit

No.	Location	Power (kW)	Supply air (L/s)	Operation Time (h/yr.)	Electric Consumption (kWh/yr.)
1	Micro Lab	4.8	1,319	2,500	12,000
2	Tablet 1	6.8	1,890	2,500	17,000
3	Tablet 2	8	1,282	2,500	20,000
4	Ampoule	11.4	4,000	2,500	28,500
5	Suppositories	11.4	2,500	2,500	28,500
6	Syrup	9.1	3,100	2,500	22,750
7	Cream	9.1	2,500	2,500	22,750
8	Weighing	6.8	1,700	2,500	17,000
9	Powder	5.7	3,000	2,500	14,250
10	Cephalosporin S	8.6	3,000	2,500	21,500
11	Cephalosporin P	8.6	1,765	2,500	21,500
12	Cephalosporin D	8	2,034	2,500	20,000
13	Cephalosporin V	15.4	1,852	2,500	38,500
14	R&D	5.7	2,750	2,500	14,250
15	Penicillin	13.4	4,000	2,500	33,500
16	Blister and Packaging	14.3	5,500	2,500	35,750
17	Ampoule Packaging	4.1	1,037	0	0
18	1st FL Gowning	6.6	1,781	0	0
Total	--	45,010	--	**367,750**	

Dust Collectors

No.	Location	Power (kW)	Operation Time (h/yr.)	Consumption (kWh/yr.)
1	Tablet DCE 1	16	2,500	40,000
2	Tablet DCE 2	16	2,500	40,000
3	Cephalosporin D	20.6	2,500	51,500
4	Cephalosporin P & S	20.6	2,500	51,500
5	Powder	10.4	2,500	26,000
6	Penicillin	12.7	2,500	31,750
Total	**240,750**			

Ex-Fans

No.	Ex-Fan	Power (kW)	Operation time (h/yr.)	Consumption (kWh/yr.)
1	Warehouse sampling area	0.095	2,500	238
2	1st floor WC	0.255	2,500	638
3	2nd floor blistering area	1.5	2,500	3,750
4	2nd floor Quarantine & IPC Lab area	0.72	2,500	1,800
5	3rd floor vials washing area	0.665	2,500	1,663
6	3rd floor main corridor area	0.37	2,500	925
7	3rd floor WC male	0.07	2,500	175
8	3rd floor WC female	0.07	2,500	175
Total	**9,363**			

Fan Coil Units

No.	FCU	Power (kW)	Operation Time (h/yr.)	Consumption (kWh/yr.)
1	Meeting Room6	1.1	2,500	2,750
2	Ch. of Bd office	1.1	2,500	2,750
3	GM office	1.1	2,500	2,750
4	TM office	1.1	2,500	2,750
5	QA office	1.1	2,500	2,750
6	R&D office	1.1	2,500	2,750
7	Registration office	1.1	2,500	2,750
8	Financial Manager office	0.39	2,500	975
9	Accountants office 1	0.39	2,500	975
10	Accountants office 2	0.39	2,500	975
11	Cashier office	0.39	2,500	975
12	IT Manager office	0.39	2,500	975
13	IT Personal office	0.39	2,500	975
14	Purchasing Director office 1	0.39	2,500	975
15	Purchasing Director office 2	0.39	2,500	975
16	Purchasing Director Assistants office	0.39	2,500	975
17	Facility Manager office	0.39	2,500	975
18	HR Manager office	0.39	2,500	975
19	HR Manager Assistant office	0.48	2,500	1,200
20	Reception	0.39	2,500	975
21	Meeting Room1	0.39	2,500	975
22	Meeting Room2	0.39	2,500	975
Total	**34,100**			

(C-2) Pumps

Pump	No.	Operated	Rated Power (kW)	Estimated Power (kW)	Operation time (h/yr.)	Consumption (kWh/yr.)
Main two Chillers Circulation	4	3	7.5	5.25	1400	22050
Offices AC Chiller	2	1	1.1	0.77	850	655
Penicillin Chiller	2	1	1.1	0.77	1400	1078
Office boiler circulation	1	1	0.7	0.49	700	343
Sterile Section boiler circulation	1	1	0.7	0.49	700	343
Total						**24469**

Split air conditioning units

Location	Capacity (TR)	Power (kW)	Operation Time (h/yr.)	Operation (%)	Consumption (kWh/yr.)
QC1 (QC Lab1)	3	3.3	300	60	594
QC2 (QC corridor)	3	3.3	300	60	594
QC3 (QC instruments Lab)	3	3.3	300	60	594
Cafeteria	4	4.2	300	60	756
Maintenance Workshop	3	3.3	900	60	1,782
Engineers office	3	3.3	900	60	1,782
Control room	1	1	4,000	60	2,400
Server room	1	1	4,000	60	2,400
Total					**10308**

(C-3) Lighting system

Floor	Place	Lamps type	Lamps N	Lamps n	Lamps N*n	Rated power (W)	Total Rated Power(W)	operation Time (h/yr.)	Ballast Factor %	Energy Consumption (kWh/yr.)
reception	Meeting Room 1	T5	5	2	10	36	360	2550	15	1056
reception	Meeting Room 1	T5	2	2	4	14	56	2550	15	164
reception	Meeting Room 1	T5	2	2	4	8	32	2550	15	94
reception	Entrance	T5	11	2	22	36	792	2550	15	2323
reception	Entrance	T5	7	2	14	14	196	2550	15	575
reception	Entrance	T5	6	2	12	8	96	2550	15	282
reception	Meeting Room 2	T5	3	2	6	36	216	2550	15	633
reception	Meeting Room 2	T5	1	2	2	14	28	2550	15	82
reception	Meeting Room 2	T5	1	2	2	8	16	2550	15	47
reception	Corridor	T5	4	2	8	25	200	2550	15	587
reception	Corridor	T5	13	1	13	36	468	3000	15	1615
reception	Corridor	T5	3	2	6	13	78	2550	15	229
reception	Office 1	FL	3	4	12	18	216	2550	15	633
reception	Office 2	FL	3	4	12	18	216	2550	15	633
reception	Office 3	FL	3	4	12	18	216	2550	15	633
reception	Locker Room	FL	5	1	5	36	180	600	15	124
Ground Floor (Warehouse)	Ground B1	FL	5	2	10	110	1100	1200	15	1518
Ground Floor (Warehouse)	Ground B1	FL	5	2	10	36	360	1200	15	497
Ground Floor (Warehouse)	Ground B1	FL	4	1	4	36	144	1200	15	199
Ground Floor (Warehouse)	Corridor	FL	4	2	8	36	288	2550	15	845
Ground Floor (Warehouse)	B2	FL	14	1	14	36	504	1200	15	696
Ground Floor (Warehouse)	B3	FL	7	2	14	110	1540	1200	15	2125
Ground Floor (Warehouse)	B3	FL	2	2	4	36	144	1200	15	199
Ground Floor (Warehouse)	B3	FL	5	1	5	36	180	1200	15	248
Ground Floor (Warehouse)	Office	FL	3	4	12	18	216	2550	15	633
Ground Floor (Warehouse)	B4	FL	3	2	6	110	660	2550	15	1935
Ground Floor (Warehouse)	Office	FL	1	2	2	110	220	2550	15	645
Ground Floor (Warehouse)	B5	FL	1	2	2	36	72	1200	15	99
Ground Floor (Warehouse)	B5	FL	7	2	14	110	1540	1200	15	2125
Ground Floor (Warehouse)	B5	FL	2	1	2	110	220	1200	15	304
Ground Floor (Warehouse)	B5	FL	2	1	2	36	72	1200	15	99
Ground Floor (Warehouse)	B6	FL	4	2	8	110	880	1200	15	1214
Ground Floor (Warehouse)	B7	FL	3	4	12	18	216	30	15	7
Ground Floor (Warehouse)	B8	PL	4	2	8	26	208	2550	15	610
Ground Floor (Warehouse)	B9	PL	2	2	4	26	104	2550	15	305
Ground Floor (Warehouse)	B10	PL	13	2	26	55	1430	2550	15	4193
Ground Floor (Warehouse)	offices	FL	41	4	164	18	2952	2550	15	8657

Floor	Place	Lamps type	Lamps N	Lamps n	Lamps N*n	Rated power (W)	Total Rated Power(W)	operation Time (h/yr.)	Ballast Factor %	Energy Consumption (kWh/yr.)
	B11	FL	3	1	3	36	108	2550	15	317
First Floor	Cafeteria	T5	34	1	34	36	1224	600	15	845
		PL	3	1	3	40	120	600	15	83
		PL	6	1	6	24	144	600	15	99
		PL	7	2	14	55	770	600	15	531
		FL	8	2	16	36	576	600	15	397
	maintenance	FL	4	2	8	36	288	2550	15	845
		FL	8	2	16	36	576	2550	15	1689
	maintenance Store	FL	7	2	14	36	504	1200	15	696
	R&D department	FL	18	2	36	36	1296	2550	15	3801
	corridor	FL	2	2	4	36	144	2550	15	422
		PL	1	2	2	18	36	2550	15	106
	Clothes change 1	PL	8	2	16	18	288	2550	15	845
		FL	4	2	8	36	288	2550	15	845
	Clothes change 2	FL	8	2	16	36	576	2550	15	1689
		PL	3	2	6	18	108	2550	15	317
	Stairs entrance	FL	2	1	2	36	72	2550	15	211
	Production corridor	FL	3	2	6	36	216	2550	15	633
		PL	1	1	1	18	18	2550	15	53
	GD11	FL	4	2	8	36	288	2550	15	845
	GD12	FL	3	2	6	36	216	2550	15	633
	GD13	T5	9	2	18	36	648	2550	15	1900
	GD14	FL	1	2	2	36	72	2550	15	211
	GD15	FL	5	2	10	36	360	2550	15	1056
		T5	16	2	32	54	1728	2550	15	5067
	GD16	T5	7	2	14	36	504	2550	15	1478
	GD17	T5	3	2	6	36	216	2550	15	633
	GD18	T5	3	2	6	54	324	2550	15	950
	GD19	T5	2	2	4	54	216	2550	15	633
	GD110	T5	4	2	8	36	288	2550	15	845
	GD111	T5	2	2	4	36	144	2550	15	422
	GD112	FL	4	2	8	36	288	2550	15	845
Second Floor	SF1	FL	6	4	24	18	432	2550	15	1267
		PL	9	2	18	18	324	2550	15	950
		FL	2	2	4	36	144	2550	15	422
	SF2	FL	11	4	44	18	792	2550	15	2323
		FL	3	2	6	36	216	2550	15	633

Floor	Place	Lamps type	Lamps			Rated power (W)	Total Rated Power(W)	operation Time (h/yr.)	Ballast Factor %	Energy Consumption (kWh/yr.)
			N	n	N*n					
		PL	1	2	2	18	36	2550	15	106
	SF3	FL	20	4	80	18	1440	2550	15	4223
		PL	2	2	4	18	72	2550	15	211
	SF4	FL	5	2	10	36	360	2550	15	1056
		FL	4	2	8	18	144	2550	15	422
	SF5	T5	12	2	24	36	864	2550	15	2534
	SF6	T5	20	2	40	36	1440	2550	15	4223
		PL	2	2	4	18	72	2550	15	211
	corridor	FL	14	4	56	18	1008	2550	15	2956
		PL	11	2	22	36	792	2550	15	2323
	SF7	PL	54	2	108	36	3888	2550	15	11402
	SF8	FL	36	4	144	18	2592	2550	15	7601
		FL	4	2	8	36	288	2550	15	845
	SF9	FL	20	4	80	18	1440	2550	15	4223
	SF10	FL	24	4	96	18	1728	2550	15	5067
Third Floor	TF1	FL	47	4	188	18	3384	2550	15	9924
		PL	8	2	16	18	288	2550	15	845
	TF2	FL	89	2	178	36	6408	2550	15	18791
		FL	6	4	24	18	432	2550	15	1267
		PL	9	2	18	18	324	2550	15	950
	TF3	FL	40	2	80	36	2880	600	15	1987
		PL	1	2	2	18	36	600	15	25
Main building Consumption										**153,592**
Total Company Consumption(Main building + Penicillin)										**168,948**

Appendix (D): Datasheets for components of monitoring system

(D-1) PM8240 datasheet

Product data sheet
Characteristics

METSEPM8240
PowerLogic PM8000 - PM8240 Panel mount meter - intermediate metering

Main

Range	PowerLogic
Product name	PowerLogic PM8000
Device short name	PM8240
Product or component type	Power meter

Complementary

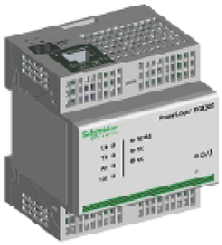
Power quality analysis	Waveform capture Harmonic distortion Programmablity (logic and math functions) Voltage sag and swell detection Up to the 63rd harmonic Compliance report EN 50160 Power quality monitoring IEC 62586 Power quality measurement IEC 61000-4-30 : class S
Device application	WAGES metering Power monitoring
Type of measurement	Power factor (total) Apparent power (total) Active and reactive power (total) Active and reactive power (per phase, rms) Apparent power (per phase, rms) Power factor (per phase, rms) Voltage Current Frequency
[Us] rated supply voltage	90...415 V AC +/- 10 % (45...65 Hz) 110...415 V DC +/- 10 %
Network frequency	50 Hz 60 Hz
[In] rated current	1 A 10 A 5 A
Poles description	1P + N 3P

(D-2) EGX300 datasheet

Product data sheet
Characteristics

EGX300
SEMS - Ethernet gateway with embeded server for configuration

Green Premium



Main

Device short name	EGX300
Product or component type	Gateway module
Device application	Server Gateway
Range compatibility	Compact Masterpact PowerPact

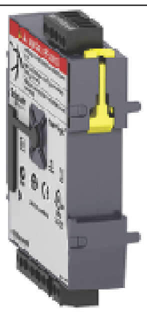
Complementary

Communication network type	RS232/485, Modbus RTU and ASCII even/odd or none parity, at 38400/57600 bauds on SUB-D 9 RS232/485, PowerLogic (SY/MAX) even/odd or none parity, at 38400/57600 bauds on SUB-D 9 RS232/485, JBUS even/odd or none parity, at 38400/57600 bauds on SUB-D 9 Ethernet, HTTP on RJ45 Ethernet, Modbus TCP/IP on RJ45 Ethernet, FTP on RJ45 Ethernet, SNMP on RJ45 Ethernet, BOOTP (Bootstrap Protocol) on RJ45
Communication gateway	Ethernet/Fieldbus
Web server	Embedded
Mounting mode	By clips
Mounting support	35 mm DIN rail
Control type	By software
[Us] rated supply voltage	24 V DC
Power consumption in W	4 W
Product certifications	CUL UL 508 FCC Class A
Standards	EN 55011 EN 55022 EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5

(D-3) PM89M2600 datasheet

Product data sheet
Characteristics

METSEPM89M2600
PowerLogic PM8000 - I/O Module - Digital - 6 Inputs + 2 relays outputs



Main

Range	PowerLogic
Product or component type	I/O module
Device application	Optional expansion module
Range compatibility	Powerlogic PowerLogic PM8000 Powerlogic PowerLogic ION7400

Complementary

Number of outputs	2 form C relay output
Number of inputs	6 digital
Width	22 mm
Depth	90.5 mm
Height	90.5 mm
Product weight	140 g

Environment

Ambient air temperature for operation	-25...70 °C
Ambient air temperature for storage	-40...85 °C
IP degree of protection	IP30 IEC 60529

Offer Sustainability

RoHS (date code: YYWW)	Compliant - since 1611 - Schneider Electric declaration of conformity Schneider Electric declaration of conformity

Appendix (E): Compound interest table for 10% interest

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
n	Compound Amount Factor Find F Given P F/P	Present Worth Factor Find P Given F P/F	Sinking Fund Factor Find A Given F A/F	Capital Recovery Factor Find A Given P A/P	Compound Amount Factor Find F Given A F/A	Present Worth Factor Find P Given A P/A	Gradient Uniform Series Find A Given G A/G	Gradient Present Worth Find P Given G P/G	n
1	1.100	.9091	1.0000	1.1000	1.000	0.909	0	0	1
2	1.210	.8264	.4762	.5762	2.100	1.736	0.476	0.826	2
3	1.331	.7513	.3021	.4021	3.310	2.487	0.937	2.329	3
4	1.464	.6830	.2155	.3155	4.641	3.170	1.381	4.378	4
5	1.611	.6209	.1638	.2638	6.105	3.791	1.810	6.862	5
6	1.772	.5645	.1296	.2296	7.716	4.355	2.224	9.684	6
7	1.949	.5132	.1054	.2054	9.487	4.868	2.622	12.763	7
8	2.144	.4665	.0874	.1874	11.436	5.335	3.004	16.029	8
9	2.358	.4241	.0736	.1736	13.579	5.759	3.372	19.421	9
10	2.594	.3855	.0627	.1627	15.937	6.145	3.725	22.891	10
11	2.853	.3505	.0540	.1540	18.531	6.495	4.064	26.396	11
12	3.138	.3186	.0468	.1468	21.384	6.814	4.388	29.901	12
13	3.452	.2897	.0408	.1408	24.523	7.103	4.699	33.377	13
14	3.797	.2633	.0357	.1357	27.975	7.367	4.996	36.801	14
15	4.177	.2394	.0315	.1315	31.772	7.606	5.279	40.152	15
16	4.595	.2176	.0278	.1278	35.950	7.824	5.549	43.416	16
17	5.054	.1978	.0247	.1247	40.545	8.022	5.807	46.582	17
18	5.560	.1799	.0219	.1219	45.599	8.201	6.053	49.640	18
19	6.116	.1635	.0195	.1195	51.159	8.365	6.286	52.583	19
20	6.728	.1486	.0175	.1175	57.275	8.514	6.508	55.407	20
21	7.400	.1351	.0156	.1156	64.003	8.649	6.719	58.110	21
22	8.140	.1228	.0140	.1140	71.403	8.772	6.919	60.689	22
23	8.954	.1117	.0126	.1126	79.543	8.883	7.108	63.146	23
24	9.850	.1015	.0113	.1113	88.497	8.985	7.288	65.481	24
25	10.835	.0923	.0102	.1102	98.347	9.077	7.458	67.696	25
26	11.918	.0839	.00916	.1092	109.182	9.161	7.619	69.794	26
27	13.110	.0763	.00826	.1083	121.100	9.237	7.770	71.777	27
28	14.421	.0693	.00745	.1075	134.210	9.307	7.914	73.650	28
29	15.863	.0630	.00673	.1067	148.631	9.370	8.049	75.415	29
30	17.449	.0573	.00608	.1061	164.494	9.427	8.176	77.077	30
31	19.194	.0521	.00550	.1055	181.944	9.479	8.296	78.640	31
32	21.114	.0474	.00497	.1050	201.138	9.526	8.409	80.108	32
33	23.225	.0431	.00450	.1045	222.252	9.569	8.515	81.486	33
34	25.548	.0391	.00407	.1041	245.477	9.609	8.615	82.777	34
35	28.102	.0356	.00369	.1037	271.025	9.644	8.709	83.987	35
40	45.259	.0221	.00226	.1023	442.593	9.779	9.096	88.953	40
45	72.891	.0137	.00139	.1014	718.905	9.863	9.374	92.454	45
50	117.391	.00852	.00086	.1009	1163.9	9.915	9.570	94.889	50
55	189.059	.00529	.00053	.1005	1880.6	9.947	9.708	96.562	55
60	304.482	.00328	.00033	.1003	3034.8	9.967	9.802	97.701	60
65	490.371	.00204	.00020	.1002	4893.7	9.980	9.867	98.471	65
70	789.748	.00127	.00013	.1001	7887.5	9.987	9.911	98.987	70
75	1271.9	.00079	.00008	.1001	12709.0	9.992	9.941	99.332	75
80	2048.4	.00049	.00005	.1000	20474.0	9.995	9.961	99.561	80
85	3299.0	.00030	.00003	.1000	32979.7	9.997	9.974	99.712	85
90	5313.0	.00019	.00002	.1000	53120.3	9.998	9.983	99.812	90
95	8556.7	.00012	.00001	.1000	85556.9	9.999	9.989	99.877	95
100	13780.6	.00007	.00001	.1000	137796.3	9.999	9.993	99.920	100

جامعة النجاح الوطنية

كليةالدراسات العليا

التقييم الفني والاقتصادي لتطبيق متطلبات نظام إدارة الطاقة في القطاع الصناعي في فلسطين وفقاً للمواصفة ISO50001

إعداد

عبد الرحمن سليم عبد الرحمن عودة

إشراف

د. عماد بريك

قدمت هذه الاطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في هندسة الطاقة النظيفة وترشيد الاستهلاك من كلية الدراسات العليا في جامعة النجاح الوطنيـة، نابلس، فلسطين

2018م

التقييم الفني والاقتصادي لتطبيق متطلبات نظام إدارة الطاقة في القطاع الصناعي في فلسطين وفقاً للمواصفة ISO50001

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الملخص

تعتبر مصادر الطاقة وتوليدها واستخدامها من القضايا الهامة في الوقت الحاضر التي تسترعي انتباه جميع الجهات ذات الصلة والباحثين. ويرجع ذلك إلى زيادة التكاليف وانخفاض كمية مصادر الطاقة التقليدية، والأثر البيئي المقابل لاستخدام هذه المصادر.

تناقش هذه الأطروحة إدارة الطاقة في القطاع الصناعي بشقيه الإداري والفني، مع الأخذ بعين الاعتبار مواصفة إدارة الطاقة ISO50001.

تقدّم هذه الأطروحة دراسة لتأثير تطبيق متطلبات نظام إدارة الطاقة في ثلاث حالات دراسيّة من القطاع الصناعي في فلسطين، وسوف تُظهر هذ الدراسة إلى أي مدى تكون هذه المنشآت قريبة من الحصول على شهادة ISO50001. ثم سيتم تعميم نتائج هذه الحالات على تسع منشآت صناعية أخرى.

تنفيذ متطلبات نظام إدارة الطاقة سوف يؤدي إلى توفيرات سنوية في الطاقة كما يلي: 65.3 ميغاواط.ساعة و 441.1 ميغاواط.ساعة و 312.2 ميغاواط.ساعة، في كل من شركة رويال وشركة سنيورة وشركة القدس للمستحضرات الطبية على التوالي. وذلك يعادل توفيرات مالية سنوية تقدّر بالمبالغ التالية: 39195 شيكل و 264660 شيكل و 187336 شيكل على التوالي.

تكاليف تطبيق نظام إدارة الطاقة إعتماداً على مواصفة ISO50001 على الحالات الدراسية الثلاثة كانت 104283 شيكل\سنوياً و101250 شيكل\سنوياً و 102185 شيكل\سنوياً ، في كل من شركة رويال وشركة سنيورة وشركة القدس للمستحضرات الطبية على التوالي.

وبالإضافة إلى ذلك، تبين أن الوفورات السنوية من تطبيق متطلبات نظام إدارة الطاقة في المرافق الصناعية الإثني عشر كانت حوالي 5.711 غيغاواط. ساعة من جميع مصادر الطاقة. وكانت

تكاليف تطبيق نظام إدارة الطاقة إعتماداً على مواصفة ISO50001 على المرافق الصناعية الإثني عشر حوالي 1229273 شيكل\سنوياً.

وسوف يؤدي توفير الطاقة من تنفيذ نظام إدارة البيئة إلى خفض انبعاثات غازات الدفيئة في الغلاف الجوي. وبالنسبة لتخفيضات ثاني أكسيد الكربون هناك 45.4 طن/سنة و 135.3طن/سنة و 103.3طن/سنة في كل من شركة رويال وشركة سنيورة وشركة القدس للمستحضرات الطبية على التوالي.

وبالنسبة لتخفيضات ثاني أكسيد الكبريت، هناك 111.1كغم/سنة و 107.6كغم/سنة و 104.3كغم/سنة. في كل من شركة رويال وشركة سنيورة وشركة القدس للمستحضرات الطبية على التوالي.

وبالنسبة لتخفيضات أكاسيد النيتروجين، هناك 117.6كغم/سنة و 189.7كغم/سنة و 160.8 كغم/سنة في كل من شركة رويال وشركة سنيورة وشركة القدس للمستحضرات الطبية على التوالي.

وبالإضافة إلى ذلك، تبين أن التخفيضات السنوية في غازات الدفيئة من تطبيق متطلبات نظام إدارة الطاقة في المرافق الصناعية ال 12 بلغت نحو 2265.34طن/سنة من ثاني أكسيد الكربون و 3.319طن/سنة من ثاني أكسيد الكبريت و 4.269 طن/سنة من أكاسيد النيتروجين.