منظمة الخليج للاستشارات الصناعية
Gulf Organization For Industrial Consulting

ENERGY EFFICIENCY GUIDEBOOK

A GOIC Publication for GCC Industries

2013

ENERGY EFFICIENCY GUIDEBOOK

A GOIC publicatin for GCC industries

The Energy Efficiency Guidebook for industries is a comprehensive resource to help industries adopt, develop and implement energy efficiency programs.

Published in 2013

GULF ORGANIZATION FOR INDUSTRIAL CONSULTING
INDUSTRIAL SUPPORT DEPARTMENT
DOHA – QATAR

Published by

Gulf Organization for Industrial consulting, Doha Qatar

Prepared by
Suleiman Al Balushi, Director of Industrial Support,
Shylesh Kumar Vakundakar, Head of Subcontracting Program in GCC

Layout
Hassan Ahmed Hassan

Editor
K. Krishna Kumar, Communications Consultant

Expert Team

Qatar University
Dr. Mariam AlAli AlMaadeed, Director, Center for Advanced Materials

Texas A&M University at Qatar
Dr. Mark Wichold , CEO and Dean

Qatar Environment and Energy Research Institute
Dr. Rabi Mohtar, Executive and Founding Director

Kuwait Institute for Scientific Research
Dr. Osamah Alsayegh, Research Scientist, Department of Advanced Systems, Division of Environment & Urban Development

Salman Bin Abdul Aziz University
Dr. Nasser Hammad Aljaeidi, President of Prince Abdul Rahmman Bin Nasser Institute of Research and Consultancy Services

Kingdom University, Bahrain
Prof. Yousef Abdul Ghaffar, President

Sultan Qaboos University
Dr. Ali Bin Soud Al-Bemani, Vice Chancellor

United Arab Emirates University
Dr. Abdalla Mohamed Alamiri, Associate Professor, Department of Mechanical Engineering

GOIC CODE: E/ISD/540/2012/02

FOREWORD

The energy issue is at the center of the global sustainability discourse. It is true that the abundance of hydrocarbon resources in the Arabian Gulf region have helped Gulf Cooperation Council (GCC) countries to achieve rapid economic and industrial development over the last four decades or so. However, this growth has also resulted in dramatic growth in the region’s population and resource consumption. Over the coming decades, as the population keeps growing and industrial expansion continues, the GCC region is bound to experience significant shortage of energy and equally significant increases in the price of energy.

While the anticipated energy crunch and cost is one issue, the need to address the environmental impact of industrialization and consumption on the region is also becoming more apparent. All these trends underline the need for energy efficiency and energy conservation in the GCC region. The Governments in GCC countries are already playing a significant role in trying to improve energy efficiency and reduce greenhouse gas emissions and the impact of climate change. They are adopting new policies to increase energy efficiency, introducing legislation to promote renewable energy use, and encouraging energy efficient technologies.

GOIC believes that industries in the GCC countries have vast untapped potential to improve energy efficiency. The sustainability of the region’s growth and industrial development hinges on our ability to ensure that the region’s industries operate at the highest possible levels of energy efficiency. The energy thus saved will go some way in meeting the future increases in demand as well as in minimizing the environmental impact of industrial growth.

According to the 2012 IEA report, in year 2010 the GCC countries consumed 407 Terra Watt hours of electricity, with an average of 11,345 KWh per capita. The industrial sector used 58 million tons of oil equivalents which is about 20 percent of total primary energy supply in the GCC and 33 percent of total final consumption by end user sectors.

Residential and Industry account for most of the energy consumption in the GCC. The current focus on achieving highest possible levels of efficiency should help and encourage the region's industries to wake up to the urgent need to save and conserve energy. GOIC is aware that industries in the region, especially the SME sector, are not very well-informed and updated about modern efficiency approaches and technologies – partly because energy is subsidized in the region.

This Energy Guidebook is designed to enable companies in the GCC to adopt workable and effective energy efficiency approaches and programs. It includes alternatives, procedures, tools and techniques to improve energy efficiency; it also includes case studies from more than 30 companies across the GCC in various industrial sectors.

The Guidebook is a result of the need anticipated by GOIC to disseminate energy efficiency awareness among industries and SMEs in the GCC countries to enable them to become more cost-effective and competitive. The Center for Industrial Technical Assessment (ITA) at GOIC is specialized in conceiving and implementing energy efficiency programs in the Gulf region. The objective of the center is to identify, evaluate and recommend energy conservation opportunities.

We encourage industries, financiers and decision-makers involved in the GCC industrial sector to use this Guide to advance energy efficiency programs, improve environmental performance and reduce greenhouse gas emissions that have been widely blamed for climate change.

Abdul Aziz Bin Hamad Al-Ageel
Secretary General
Gulf Organization for Industrial Consulting

ACKNOWLEDGMENTS

This Guidebook owes its existence to the industrial plants in the GCC region that participated in the Industrial Technical Assistance (ITA) program and to the engineers and experts who meticulously worked with these companies to piece together energy efficiency programs.

We would like to thank Dr. Mariam A Al Maadeed, Director, Center for Advanced Materials at Qatar University, Dr. Nabil Madi and Dalia ElSayed, also from Qatar University, for providing the research and analysis on various case studies; we are grateful for Dr. Rabi Mohtar, Executive and Founding Director of Qatar Environment and Energy Research Institute, for his valuable inputs.

We would also like to thank Dr. Mark H. Wichold, CEO and Dean of Texas A&M University Qatar, Dr. Osamah Alsayegh, Research Scientist, Department of Advanced Systems, Kuwait Institute for Scientific Research, Prof. Yousef Abdul Ghaffar, President of Kingdom University, Bahrain, Dr. Ali Bin Soud Al-Bemani, Vice Chancellor, Sultan Qaboos University, Dr. Abdalla Mohamed Alamiri, Associate Professor, Department of Mechanical Engineering, United Arab Emirates University, Dr. Nasser Hammad Aljaeidi, President of Prince Abdul Rahmman Bin Nasser Institute of Research and Consultancy Services, Salman Bin Abdul Aziz University, Dr. Osama S. Al-Gahtani, Dean of the College of Engineering, Salman Bin Abdulaziz University and Dr. Mujahed Al- Dhaifallah, Dean of the College of Engineering in Wadi Addawaser, Salman Bin Abdulaziz university, for their valuable comments and assistance in defining and pursuing this project.

We would like to express our gratitude to several individuals who supported or participated in the industrial technical assistance program in various capacities, including the staff of GOIC.

The authors profoundly thank and acknowledge the support of the Board of Directors and management of GOIC, and the technical experts' team for extending their support for the Guidebook.

Suleiman Al Balushi
Director of Industrial Support
Gulf Organization for Industrial Consulting

TABLE OF CONTENTS

List of Figures :

WHO SHOULD USE THIS GUIDE?

This Energy Guidebook is designed for industrial supervisors and managers in GCC region who would like to improve the efficiency of their plants.

A successful and effective energy efficiency program will involve staff with many different roles and levels of expertise. This guidebook endeavors to find a common language for personnel in companies to work together on energy efficiency.

For example, an Energy Manager might be quite familiar with the potential technical solutions, but would like to learn more about how to finance these solutions. Likewise, a financial director may want to learn more about technical measures in order to convince the management about launch an efficiency program. This guide also attempts to provide corporate with the tools they need to guide and encourage a plant's energy efficiency activities.

This guide is not written to provide detailed energy efficiency or engineering advice; nor are they intended as instructions on preparing a business plan. Rather, it points the reader toward key concepts and elements essential for implementing an energy efficiency program.

EXECUTIVE SUMMARY

Energy Efficiency and energy saving are major requirements for industry to be competitive at regional and global levels. GOIC is pleased to present this guidebook which is designed to enable industries in the GCC countries achieve higher levels of energy efficiency and savings. The Energy Guidebook has been developed on the basis of experience gained through the implementation of energy audits in various companies across the GCC by GOIC's Center for Industrial Technical Assessment (ITA). The case studies in this guidebook are based on actual data gathered from the audits conducted by GOIC during site visits and is therefore restricted in detail.

The center is specialized in addressing the needs of energy efficiency programs in the GCC region. The ITA is a ten-year old program that has been managed by a pool of energy experts, either in-house or external consultants. The objective of the center is to identify, evaluate and recommend energy conservation opportunities. The ITA Center has been active in assessing, managing and continuously improving and reporting on energy efficiency in GCC countries.

Energy is the major component of the economies in the GCC region. The abundance of energy at low cost in the past decades has led to inadequate attention been given to efficiency by the industries at the micro industrial level. A systematic approach and structured analysis of an organization's energy system provides various opportunities for improvements and cost savings. The aim of this Guidebook is to provide a step-by-step process on how to analyze an energy system in an organization. It will help Small and Medium Enterprises (SMEs) and major industries which are consuming most of the energy in the GCC to identify their energy consumption in different areas within the company, set a baseline for continuous monitoring, identify areas of improvement, save cost and provide guidance on how to eliminate typical weaknesses.

The Guidebook gives valuable information for companies to improve energy efficiency. In the majority of SMEs in the GCC region, principal technical areas and hardware are common. They include chiller units, heating, lighting, ventilation and electric motors. The Guidebook has briefly covered the main aspects for these areas. Typical weak points are explained and activities presented, aiming at eliminating the weak points and improving the system with ‘no cost’ and low cost investments.

In the process of developing this Guidebook, GOIC consulted a number of energy experts in the GCC to evaluate and validate its contents.

GOIC is pleased to dedicate this Guidebook to industrial plants in the GCC region.

1. ENERGY OUTLOOK IN GCC

Although the GCC countries are blessed with abundant hydrocarbon resources, experts project that the region will begin facing energy shortages in the not-too-distant future. The Gulf region has experienced rapid growth in population coupled with strong economic, industrial and infra-structure development in a short span of time, boosting energy consumption and carbon emission levels. Over the years, natural gas emerged as the fuel of choice to support industrial growth and urbanization because of the region's hydrocarbon resources.

Relatively cost-effective access to natural gas has enabled the Gulf countries to diversify their economies and develop world-scale petrochemicals, heavy metal, aluminum and plastics industries. Natural gas also enabled Gulf countries to undertake massive power generation and water desalination projects to meet the increasing needs of the people and industries.

With the newly industrializing and modernizing GCC countries achieving economic prosperity, successive governments in the region provided consumers with natural gas and electricity at prices far below those in the global market. In some countries and communities, the resources were even distributed to people free of cost. It is also true that SMEs in the GCC enjoy high levels of energy subsidies that are offered by governments as incentives. As a result, gas consumption in Saudi Arabia, Qatar, Kuwait and the UAE rose by nearly 50 percent from 2004 to 2011 (or 7.9 percent per annum), while electricity generation grew at nearly the same rate. GCC generation capacity reached 75,000 megawatts (MW) during 2007, but it is estimated that by 2015, GCC countries could need 60,000 MW in new generation, nearly 80 percent of the current installed capacity. Given that the majority of that capacity is expected to be powered by gas, the gas supply deficit could reach 7 billion cubic feet per day by 2015.

All GCC countries except Qatar are already dependent on imports. Kuwait is importing natural gas from Russia; UAE and Oman are importing from Qatar; Dubai is building a terminal to receive natural gas imports; and Saudi Arabia and Kuwait are using very expensive oil to supplement natural gas in operating their power plants.

Industries, homes, enterprises, schools and governments in the GCC, consume more than 90 percent of the natural gas and electricity. Obviously, the region needs to focus on energy efficiency more than ever before to address the challenges of energy security, air pollution, and climate change. There is tremendous potential to save energy just by ensuring that efficiency programs are implemented widely. It is high time for the region to adopt further energy conservation and demand side management programs to improve energy efficiency and capture the resulting savings.

Effective implementation of such programs is the real challenge. Inadequate laws and regulations to enforce energy efficiency is one of the most important reasons for inaction on this front. Nevertheless, both large-scale industries and SMEs stand to benefit significantly from integrating energy efficiency into resource planning.

This guide offers valuable information about methods that can be integrated into the day-to-day operation of industrial plants to achieve improvements in energy efficiency.

2. NEED FOR ENERGY EFFICIENCY IN GCC

6 Essential Reasons

1. Resource conservation

The six GCC states may be described as the world's energy hub, holding 57 percent of the proven crude oil reserves and 28 percent of natural gas. However, fast-rising demand for energy, mainly natural gas feedstock for power generation, is a major challenge for these states. Qatar, given its large natural gas reserves, is in a strong position to meet the supply of gas for electricity generation for the foreseeable future. Saudi Arabia, the United Arab Emirates, Oman, Kuwait and Bahrain do not have that luxury and are facing shortage of natural gas for power generation.

2. Reduce operating cost

Energy efficiency will improve an industrial plant's operations and products in several ways. First, it will decrease energy costs. GCC manufacturing and processing plants typically consume a high amount of energy compared with foreign competitors because the subsidized per unit cost of energy is much less than what their competitors pay. Reduced energy expenses will enable companies to invest in other avenues of business while the energy thus saved would be available for distribution.

3. Sustain fuel supply

Energy efficiency will help in ensuring supply consistency. Implementing an energy efficiency program will benefit a plant-wide energy strategy and demand management. For example, energy efficiency will lead to optimization of demand which in turn will reduce demand pressure and help stabilize supplies.

4. Improve product quality

Energy efficiency will improve the quality of a process or product, for example, commonly addressing both energy use and product characteristics and flows. Efficient energy management also ensures a more reliable supply of energy which is critical for many production processes. Metallurgical plants, for example, one can lose millions of dollars if energy is shut off abruptly. Both energy efficiency and product quality are closely related to effective maintenance and attention to operational detail.

5. Protect the environment

Energy efficiency will help reduce pollution, which can reduce environmental damage and drain financial resources. Reduction in the amount of fuel used as energy in manufacturing will lead in aggregate in lower emissions.

6. Improve safety & productivity

Energy efficiency will result in reduced maintenance costs and improved worker safety. Energy-efficient technologies are more reliable. For example, fluorescent lighting requires less maintenance and fewer replacements than incandescent lighting. Likewise, repairing gas leaks and insulating gas lines can make gas pipeline systems safer. This in turn will improve labor morale and productivity.

3. ROADMAP TO AN EFFECTIVE ENERGY EFFICIENCY PROGRAM

A successful and effective energy efficiency program will accomplish sustainable real savings and benefits for an industrial plant. Energy Efficiency is defined in terms of use of engineering and economic principles to control the direct and indirect cost of energy without any compromise to the function. For example, a one-time investment in a modern energy management project can reduce plant-wide electricity use immediately by up to 10-15 percent. More importantly, this benefit will be sustained way beyond the duration of the energy management project. Follow-up projects year after year, even at a small scale, may be combined to create sustained growth in savings. In the long run, such a program will have a major impact on a company's profits and product quality.

Industries, regardless of their size and complexity, can draw up effective energy efficiency programs by following a well-defined and scientific approach as presented below.

1. Identify opportunities

For industrial plants that are already in operation, assessment of current consumption and identification of opportunities and areas of improvement are good starting points to drawing up an effective efficiency program.

2. Set specific and time-bound goals

Specific and time-bound goals for the program will enable the plant to meet its targets. Specific goals allow to measure performance and will provide an added incentive for exceeding the target savings. Goals will also serve as a useful tool to guide planning efforts. It is easier to plan in order to meet a goal than to plan without clear goals. For example, a plant may set a specific goal to reduce energy costs by 3 percent per year for the next ten years. Such a goal would be challenging, but it is achievable and measurable.

3. Measure and analyze

Measuring and analyzing data is the most important step after identifying the opportunities to strengthen energy efficiency.

3.1 Ensure data accuracy

Industrial plants need to ensure that they have accurate data on energy use. Accurate data will enable operations to identify focus areas and pinpoint saving opportunities. Availability of data also allows reasonable quantification of savings.

3.2 Conduct economic and technical analysis

Economic and technical analysis will allow comparison of different types of measures on a level playing basis, which will lead to selection of the best measures for implementation.

3.3 Life-cycle analysis

Life-cycle analysis (including complete cost estimates and incorporation of the time value of money in calculations), common assumptions for all measures, sensitivity analyses and full reporting of risks are all components of objective analysis. Life-cycle analysis is a technique used to compare investments with different costs, cash flows and economic lives. It involves accounting for all costs throughout the life of an investment. The life cycle calculations for industrial plants taking into consideration of energy efficiency projects will improve the analysis.

4. Provide training and focus on internal communications

Training and internal communications are extremely important for any new plant-level initiative to succeed by winning support for the program throughout the organization. Training courses must be designed to meet the needs of different groups of staff. For example, training for the energy team will probably be more technical than training for operators or managers.

5. Assign program ownership

It is also important to assign program ownership at the floor level. Assigning ownership will encourage employees to show a higher level of commitment to the program. Establishing a monitoring and verification plan will also help staff to be more persistent about energy efficiency.

6. Ensure commitment and team effort

No plant-level efficiency program can succeed without the wholehearted support of the management and the total commitment of operators and other technical staff. The management team must conceive effective ways of reaching out to staff at all levels to elicit contributions and suggestions on making the program successful.

4. ESSENTIAL FIRST STEPS

There are three essential first steps that any plant must take while embarking on an energy efficiency program.

Step 1 : Dedicated managerial resource

Step 2 : Assess and review current efforts

Step 3 : Leverage the knowledge

STEP 1 • Energy Manager

It is necessary to **appoint an Energy Manager/Coordinator**, who will be responsible for the program and act as the focal point. Depending on the size of the plant, its operations and staff strength, the position may be offered as an added assignment to an eligible plant manager, but this could also be a full-time position. The Energy Manager will be responsible for all activities undertaken within the initial energy efficiency review.

Engineers/Managers often have multiple tasks and it will be a challenge to develop and manage new initiatives while keeping up with existing responsibilities. Ideally, the Energy Manager should be possess multi-disciplinary skills covering finance, engineering, technical assistance and general administration.

It is also ideal to assign primary responsibility for the program to a single individual. This will enable efficient streamlining of administrative/management functions as well as smooth planning and implementation.

The first step for the **Energy Manager** is to get an overview of the information and data available in the organization. Apart from the availability of written documents, significant additional knowledge may be obtained from the workforce. The Energy Manager will obviously need to focus on typical energy intensive areas of the plant as shown in Fig 1.

Fig 1 : Typical Energy Intensive Areas

The **energy efficiency team** must comprise staff with sound technical knowledge of processes and technologies. They will have the ability to influence energy consumption in the departments they are based, and would be in a better position to contribute to the development and support of a company-wide strategy. Secluded production processes and a cost accounting system following profit centers act as a barrier to a common strategy to increase the overall efficiency of the energy system. In smaller organizations the energy manager is familiar and can co-operate informally with the organizational layers.

The plant must assess and review existing machinery and other resources as well as ongoing efforts to reduce energy consumption. A comprehensive review will help identify the plant's equipment, devices and other resources that can contribute to an efficiency plan.

STEP 3 • Leverage the knowledge

Baseline research helps informed decisions about energy end-uses and equipment that will be most readily and cost-effectively targeted with energy efficiency programs. As a first step to **establish an energy efficiency baseline,** gather relevant information about various equipment that have energy efficiency components. Users of such equipment would be able to provide valid information on energy consumption and efficiency.

The next step would be to identify key information gaps. **Baseline research** in these areas would help to reduce the uncertainty level and improve the chances of the program's success.

For example, typically the majority of program savings come from electrical motor measures. A large industrial plant could undertake baseline research to determine key lighting features within the plant, such as the average number of light sockets, and the bulbs and incandescent bulbs installed in a given area.

5. STEPS TO ASSESS ENERGY EFFICIENCY POTENTIAL

To enhance energy efficiency in a plant, the first step would be to identify the potential. Any study to determine the potential is primarily a data collection and analysis exercise. The key steps to conducting a top-down assessment of energy efficiency potential are summarized below.

STEP 1

- Compile and analyze data

A high-level assessment relies primarily on secondary data from the plant. Whether using real time data or theoretical data, it will be necessary to normalize the data to ensure that the assumptions for the study are reasonable under the localized conditions. The potential study data requirements are shown in Fig 2 :

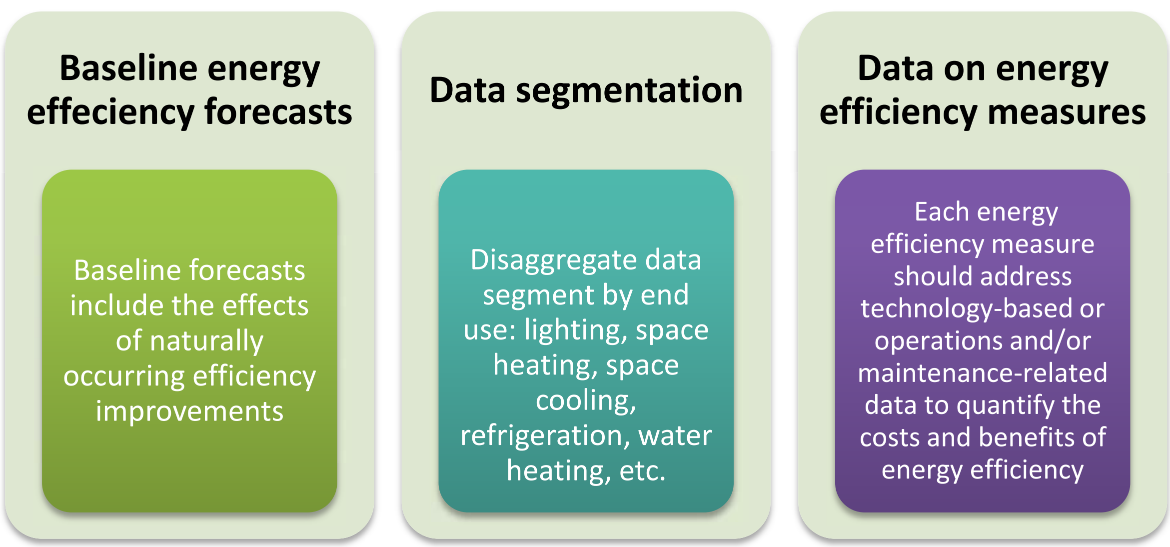


Fig 2 : Fundamental Data Structuring

Structured data collection is fundamental to the energy review. As a first step, use existing data sources. Potential sources of data are shown in Fig 3 :

Fig 3 : Potential Sources of Data

Compile an inventory based on a physical inspection of the major electrical and mechanical systems at the facility:

- Description of mechanical and electrical installations
- Interior lighting systems
- Exterior lighting systems
- Ventilation systems

- Motors
- Pumping equipment
- Heating systems and equipment
- Cooling and refrigeration systems and equipment
- Domestic cold/hot water systems
- Steam systems and furnaces
- All related processes equipment
- Other equipment and loads

Considerable amount of energy data and information are usually available within the plant, but in most cases they need interpreting and collating. A clear picture of energy use and costs should emerge from this exercise.

Invoices provide the primary source of energy information. Data sources are located in different departments of the business, which if appropriate, should also be integrated.

Data quality : The analysis of the system is only as good as the quality of the data used, poor data will lead to poor analysis. The accuracy of data is of considerable importance as is the consistency of data collection methods. Make sure that checking devices are calibrated and are 100 percent accurate.

It is essential that follow-up calculations and the development of indicators are based on real data rather than on estimates.

STEP 2

• Conduct cost-effectiveness screening

Cost-effectiveness screening compares the net present value of benefits produced over the lifetime of the energy efficiency measure with the cost of the measure. Measures that do not pass the cost-effective screen with a benefit/cost ratio of 1.0 or above are excluded from savings potential estimates.

Having collected invoice data, the energy manager will need to fill gaps in required data. This step will help to get a better overview of all areas involved. Calculations can be undertaken for areas where the power requirement and the operating hours are known. The following options may be considered:

♥ A rough estimate for Generator, Engines and Chilling unit can be obtained by multiplying the power rating by operating hours.

♥ To obtain an estimate for light consumption, count light bulbs and multiply the number by operating hours and wattage.

♥ The Energy Manager should identify areas for which little or no information is available about energy consumption.

- *Measure the energy consumption of individual processes, plant or devices by prioritizing the devices which have high energy costs; it would be ideal to install automated systems to monitor data continuously or regularly (example: heating and air-conditioning systems).*

STEP 3

- Estimate energy savings potential

For each energy efficiency measure, project the energy saving over a specified time horizon, and aggregate the results.

STEP 4

- Assess uncertainty

Assessment of potential involves data availability challenges, and there is always a degree of uncertainty around potential study results. It is useful to assess the sensitivity of overall results to changes in key assumptions made in the analysis.

STEP 5

- Present results

Analysts typically produce a final report to present potential study results. For goal-setting and program planning purposes, the most important information to be communicated in the report is the projected energy savings and peak demand reduction, the expected cost of achieving these energy savings results, and the estimated net economic benefits produced. Estimating other benefits associated with energy efficiency investments, such as job creation and emissions reductions, may also be useful for as an effective and convincing point

Design an Energy distribution chart: Design a distribution chart with the help of available data; the energy system should be envisaged with an energy distribution chart. This is a graphical representation of all relevant energy changes in the company.

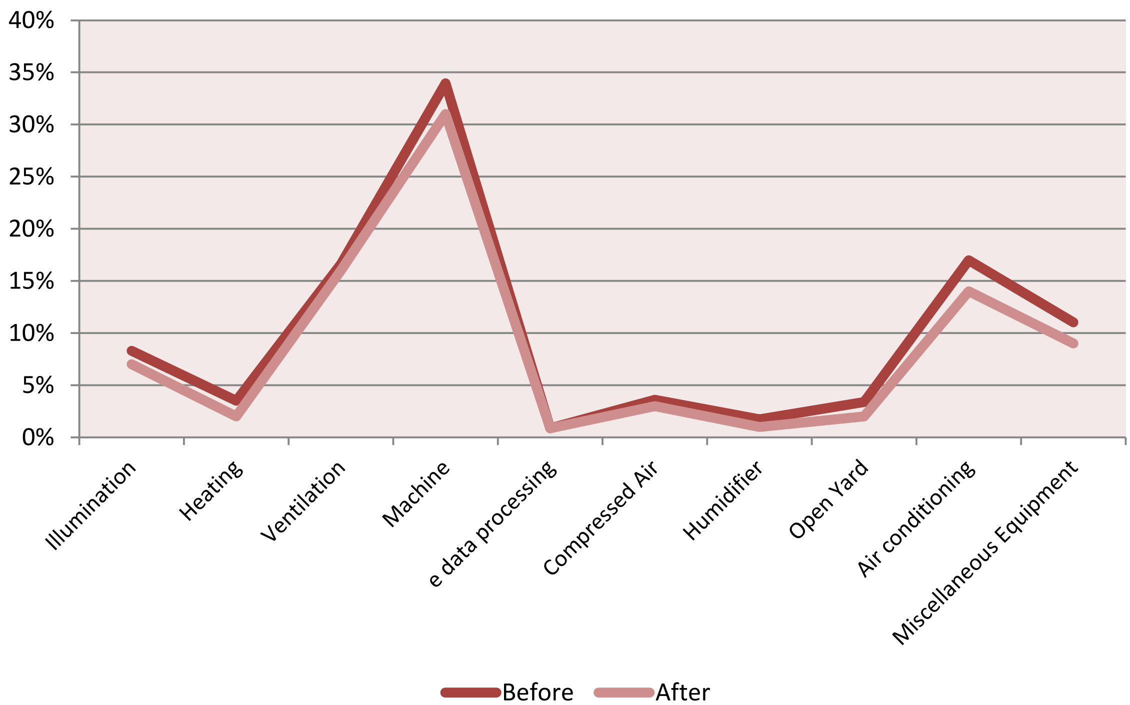


Fig 4 : Energy Distribution Chart

A simple distribution chart can be designed as shown in Fig 4 - to illustrate energy fluctuations and identify the organization's energy flow and associated quantities. The flowchart must include all the physical units that are part of the plant. The variation of the flow depends on the energy consumption of the system or machine. The annual input figures can be collected from collated documents, such as the invoices.

The above example only considers the electricity flow. If other energy sources are used, it is useful to prepare a distribution chart for the consuming elements. After the preparation of the simple energy flow chart, the following aspects must be considered:

- ♥ Compare before and after projections for the energy efficiency
- ♥ Which areas need more analysis as there was not enough data during

this phase

- ♥ Which machines and processes are responsible for most of the energy consumption and need to be analyzed further.

From the data, the Energy Manager will compile indicators for:

- ♥ The entire company/operation
- ♥ Departments of the company
- ♥ Individual processes

These indicators will help the management and staff in different ways to keep a tab on consumption. Indicators for the entire company would be essential for senior management as they show the company's overall energy performance. Indicators for departments and processes should be developed as a tool for staff to monitor the efficiency of machines and processes. They will help staff to identify opportunities that hold the potential to improve energy efficiency.

Indicators may also be used to compare:

- Machines of different capacities
- Processes which use different technologies
- Machines which produce similar products
- Compare the efficiency of similar machines

It is important to note that these indicators should only be built with real data. Indicators using estimated figures should be avoided as they cannot be related to actual performance.

5.1 Setting Goals and Budgets: Establishing clear goals for energy efficiency initiatives serves an important accountability function, making it possible to conduct an unbiased assessment of performance. An energy efficiency program must set goals at multiple levels: for the entire company, the plant and every equipment, product and process.

There are diverse approaches to goal-setting, including differences in the types of goals that are adopted. Key criteria to be followed in goal-setting are:

- Ensure that goals are internally consistent, actionable and measurable.
- Ensure that experts are involved in defining goals that are aligned with available resources, business and management.
- Develop tools to track performance against goals and institute reporting mechanisms that monitor performance on a regular basis.

Establishing long-term goals (three- to five-year targets rather than annual goals) helps to ensure consistency in funding commitments and program resources. Consistency in goals avoids disruptions in expenditure cycles and program offerings, and allows sufficient time for new programs to become established.

Determining a savings goal based on a percentage of annual energy saving is a straightforward approach. In addition to setting quantitative savings goals, a plant may choose to adopt qualitative objectives, such as customer satisfaction targets, aligning goal-setting with integrated resource planning processes.

6. ENERGY AUDIT GUIDELINES

Various studies in GCC countries have shown that **significant energy-efficiency improvement opportunities exist in the industrial sector**, many of which are visible and cost-effective. These energy-efficiency options include both cost-cutting as well as measures that are specific to products and/or processes. However, industrial plants are not always aware of the potential for energy-efficiency improvement. Conducting an energy audit is one of the first steps in identifying the potential. Even so, many plants do not have the capacity to conduct an effective energy audit.

This **chapter provides guidelines for energy auditors** regarding the key elements for preparing for an energy audit, conducting an inventory and measuring energy use, analyzing energy bills, benchmarking, analyzing energy use patterns, identifying energy-efficiency opportunities, conducting cost-benefit analysis, preparing energy audit reports, and undertaking post-audit activities.

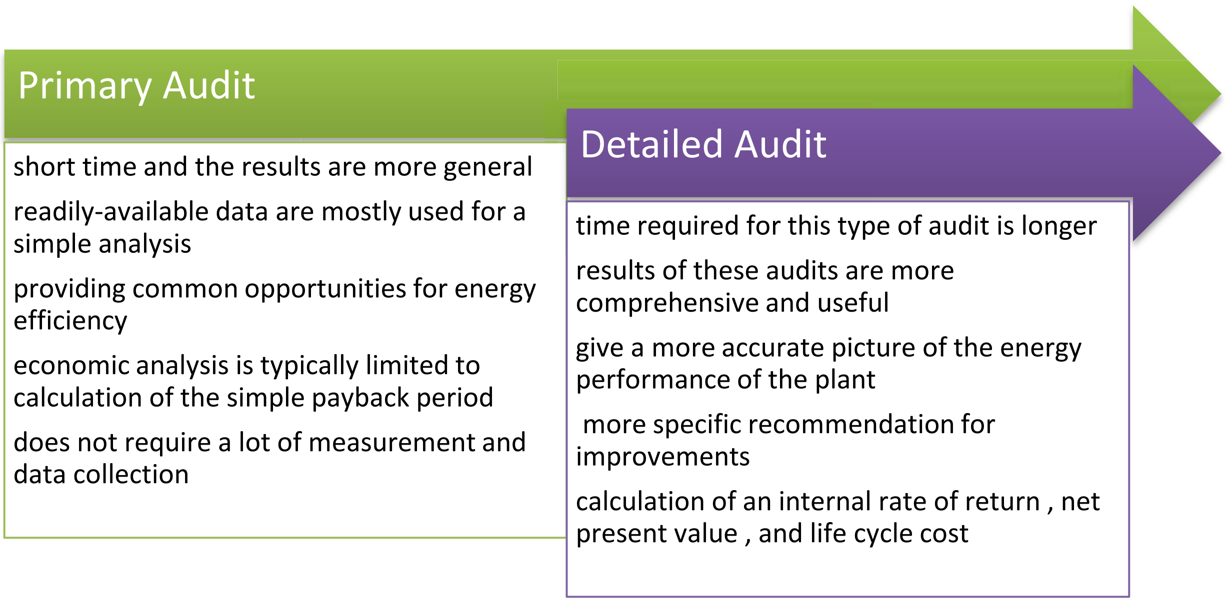
Energy audits assist companies in gaining a deeper understanding of how their operations use energy and help to identify the sources of waste opportunities for improvement The brief guidelines in this chapter are designed to enable easy execution even by those who have not previously conducted energy audits.

6.1 Objectives

The objectives of an energy audit can vary from one plant to another. However, an energy audit is usually conducted to understand how energy is used within the plant and to find opportunities for improvement and energy saving. Sometimes, energy audits are conducted to evaluate the effectiveness of an energy efficiency project or program.

7. TYPES OF ENERGY AUDITS

Typically an industrial energy audit can be classified into two types:



As shown in Fig 5, an industrial energy audit may be based on criteria such as function, size, type of the industry and the depth of the exercise.

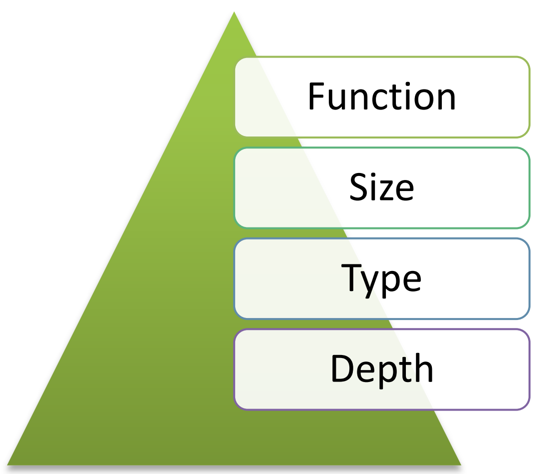


Fig 5 : Factors for industrial energy audit

8. PREPARATION FOR THE ENERGY AUDIT

Typical steps for preparation of an energy audit, which is broadly classified into four segments as shown in Fig 6:

Fig 6 : Steps for typical energy audit and preparation of action plan

Defining the audit criteria

The following criteria should be taken into consideration for an energy audit:

- Audit objective
- Audit type
- Audit methodology and standards
- Staff involvement
- Site or equipment boundary
- Timeline
- Reporting requirements

Defining the audit scope

The audit scope needs to consider the available resources such as staff, time, audit boundaries, level of analysis, expected results, the degree of detail, and the budget for conducting the energy audit. The audit scope will depend on the purpose of the specific audit and may be defined by company audit program. It should also define the share of processes included in the audit of a plant's total energy use as well as comprehensiveness and the level of detail for the final recommendations.

Selection of energy audit team

The selection of the energy auditing team and energy auditors is a key decision for industrial plant managers. The plant's top management, after consultation with the Unit managers of the plant, must decide whether the audit will be conducted by the plant's internal staff or by an outside consultant. If a company has several plants, the staff in one plant can provide support for conducting energy audits in the other plants.

Making an audit plan

An audit plan outlines the audit strategy and procedure. The plan helps the auditors to check the consistency and completeness of the audit process and make sure nothing important is neglected or overlooked. The typical audit plan should provide the following:

- Scope of the energy audit
- Time of the audit and its duration as well as the timeline for each step of the audit process
- Elements of the audit that have a high priority
- Responsibilities and tasks of each audit team member
- Format of the audit report and its outline

Preparing an audit checklist

The audit checklist helps the auditor to conduct the work in a systematic and consistent way. The checklist should include:

- Steps to be taken during the energy audit
- Data and information that should be collected
- Existing measurement instrument and the data recorded
- Required measurements during the energy audit and the list of parameters to be measured
- Major equipment to be assessed in more detail
- List of main components of the results section of the audit report, for guidance
- Other major concerns and considerations

Conducting the initial walk-through visit

The purpose of the initial walk-through visit is for the energy audit team to become familiar with the facility to be audited. The auditors can go through the processes and equipment that they will audit in detail later. The audit team can observe the existing measurement instrumentation on the equipment and the data recorded, so that they can determine what extra measurement and data collection are required during the audit.

This phase of the audit is quite useful, especially if the auditors are not made up of plant personnel. The audit team can also meet with the managers of the areas to be audited to provide an introduction and establish a common understanding of the audit process. The auditors can solicit comments from the facility staff and can collect readily-available data during the walk-through visit.

Collecting energy bills and available data and information

Energy bills along with other current and historical energy and production related data and information should be collected at the beginning of the audit process. The more historical data available, the better the auditor can understand the performance of the plant at different times of the day, in various seasons, and under diverse production conditions. The data that can be collected at the beginning of an energy audit include the following:

- Energy bills and invoices (electricity and fuels) for the most recent 2 to 3 years
- Monthly production data for the same period
- Archived records with measurements from existing recorders, if any
- Architectural and engineering plans of the plant and its equipment
- Status of energy management and any energy-saving measures implemented
- General information about the plant (year of construction, ownership

status, renovations, types of products, operation schedule, operating hours, scheduled shut-downs, etc.)

Conducting the preliminary analysis

The preliminary analysis helps the energy auditor to better understand the plant by providing a general picture of the plant energy use, operation, and energy losses. This effort provides enough information to undertake any necessary changes in the audit plan.

In the preliminary analysis, a flowchart can be constructed that shows the energy flows of the system being audited. An overview of unit operations, important process steps, areas of material and energy use, and sources of waste generation should be presented in this flowchart. The auditor should identify the various inputs and outputs at each process step. The preliminary flowchart is simple, but detailed information and data about the input and output streams can be added later after the detailed energy audit.

Analyzing energy bills

Energy bills, especially those for electricity and natural gas, are very useful for understanding and analyzing a plant's energy costs. It is important to understand the different components of these bills, so that a correct and helpful analysis can be conducted. It is important to emphasize that plant owners need to invest in energy meters as almost all entities install a single meter, which makes it a real challenge to identify energy saving opportunities from electricity bills.

Electricity bills

Several costs are usually included in the electricity bill. Most electricity rates include a fixed service (or customer) charge that is constant regardless of the amount of electricity used, and a per kilowatt-hour (kWh) rate for the amount of electricity consumed. In the GCC region flat or slab rates are used for billing purposes .

The other item in industrial electric bills is the charge for "reactive power" which is based on the types of electrical loads in a plant. To predict energy cost savings with the highest accuracy, savings must be calculated based on the time they occur and the rates in effect during each time period.

Calculating Electricity Use per day (kWh/day)

- Electricity use in the period covered by the electricity bill can be divided by the number of the days given in the bill.
- kWh/day is more useful for identifying consumption trends than the total billed kWh.
- Can be used later to accurately calculate the monthly electricity use and can also be used for graphical analysis.

Calculating the Load Factor (LF)

- The load factor is the ratio of the energy consumed during a given period (in the electricity bill) to the energy which would have been consumed.
- If the maximum demand had been maintained throughout the period, it will lead to lower electricity bills.

$$\text{Load Factor (\%)} = \frac{\text{Energy Used During The Period (KWh)} \times 100}{\text{Maximum Demand (KW)} \times \text{Time Under Consideration (hr.)}}$$

$$\text{Specific Energy Consumption} = \frac{\text{Total Energy Consumption (KWh)}}{\text{Production Quantity (KWh)}}$$

$$\text{Energy Intensity} = \frac{\text{Energy Consumption Of Product In KWh}}{\text{Total Energy Consumption In KWh}}$$

$$\text{Specific Energy} = \frac{\text{Total Energy Costs In US\$}}{\text{Total Production Costs In US\$}}$$

Fig 7 : Typical formulas for electrical energy calculations

Based on the data and information derived from the electricity bills, several calculations can be made as shown in Fig 7.

Analysis of historical energy use

Graphical analysis of hourly/daily/monthly/yearly energy use for each type of energy used in a plant can help to better understand the energy use pattern in the plant. Sometimes the patterns reveal efficiency gaps that can lead to opportunities to save energy by making necessary modifications.

It is common for a plant's operating conditions or capacities to vary over the year. Therefore, the variation in patterns alone may not truly reflect the condition of energy efficiency in a plant. Thus, it is much better and more accurate to conduct this type of graphical analysis of a plant's energy intensity (EI), which is the energy use per unit of production. Energy intensity can be calculated by using monthly energy consumption data obtained from energy bills and the monthly production data.

Inventory and measurement of energy use

Gathering data through an inventory and measurement is one of the main activities of energy auditing. Without adequate and accurate data, an energy audit cannot be successfully accomplished. Some data are readily available and can be collected from different divisions of the plant being audited. Some other data can be collected through measurement and recording. The energy audit team should be well-equipped with all of the necessary measurement instruments. These instruments may be portable or installed in certain equipment. The most common data measured during the auditing process are:

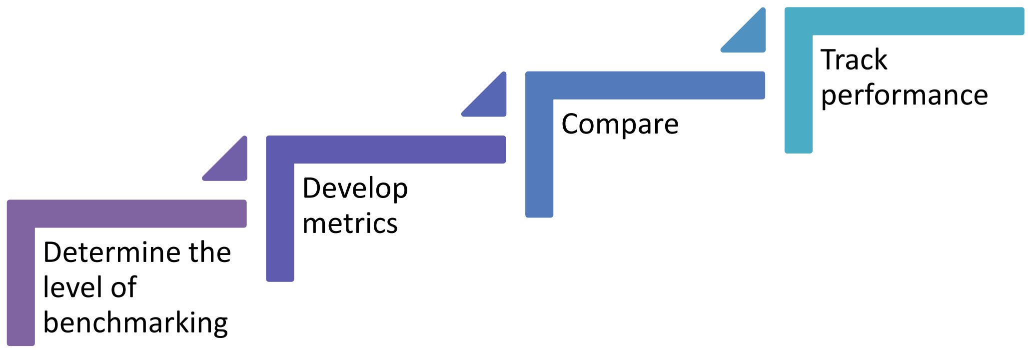
- Electrical measurements, such as the voltage, current intensity and power, as well as power factor
- Exhaust gases emissions (CO_2, CO, O_2 and smoke)
- Liquid and gas fuel flows
- Luminance levels
- Pressure of fluids in pipes, furnaces or vessels
- Relative humidity
- Temperatures of solid and liquid surfaces

9. BENCHMARKING ENERGY PERFORMANCE

Energy efficiency benchmarking and comparisons can be used to assess a company's performance relative to that of its competitors or its own performance in the past. Benchmarking can also be used for assessing the energy performance improvement achieved by the implementation of energy-efficiency measures. International comparisons of energy efficiency can provide a benchmark against which a company's or industry's performance can be measured to that of the same type of company or industry in other countries.

Benchmarking the energy performance of a facility enables energy auditors and managers to identify best practices that can be replicated. It establishes reference points for managers for measuring and rewarding good performance. It identifies high-performing facilities for recognition and prioritizes poor performing facilities for immediate improvement. Benchmarking can be done in a variety of ways. Plant performance may be benchmarked against:

- Past performance: comparing current and previous performance.
- Industry average: comparing performance with an established performance metric, such as the recognized average performance of a peer group.
- Best-in-class: benchmarking against the best in the industry and not the average.
- Best Practice: qualitative comparing against practices or groups of technologies considered to be the best in the industry.



9.1 Key steps in benchmarking

- Determine the level of benchmarking (for example, technology, process line, or facility).
- Develop metrics: select units of measurements that effectively and appropriately express energy performance of the plant (e.g. kWh/ton product).
- Conduct comparisons to determine the performance of the plant or system being studied.
- Track performance to determine if energy performance is improving or worsening over time so that corrective actions can be taken if needed.

While conducting a benchmarking exercise, the key drivers of energy use should be identified and the benchmarking metrics should be standardized. Standardizing data ensures that the comparison is meaningful and avoids comparing "plastic to rubber." Evaluating and acting on benchmarking results are as important as undertaking the benchmarking activity. Successful benchmarking also requires monitoring and verification methods to ensure continuous improvement.

There are several benchmarking tools available. The GOIC also offers the expertise and tool under its GSPX (GCC Subcontracting and Partnership Exchange) program.

Identifying energy efficiency and energy cost reduction opportunities

There are various energy systems that can be found in almost all industrial plants such as motor systems, steam systems, compressed-air systems, pumps, and fan systems. In addition, each industrial sub-sector has its own unique production technologies and processes.

Energy-efficiency improvement opportunities can be product- specific or industry-specific. Since there are many industrial sectors with numerous types of technologies and machinery, it is beyond the scope of this guidebook to discuss in detail the energy-efficiency opportunities for each technology, system, or industry.

10. CHECKLIST FOR AN ENERGY EFFICIENCY PROGRAM

1. Identify and appoint an Energy Manager with clear competencies and the responsibility to evaluate the current energy system.
2. Clarify the reasons for undertaking a detailed analysis and the anticipated result (e.g. no knowledge about energy flows and undertake the analysis to get a clear picture about consumption).
3. State clearly which energy sources and areas to include in the analysis (energy sources such as electricity, natural gas, oil and areas such as production, storage, transportation).
4. Collect relevant data:
    i. Collect invoices for all energy sources of the most recent 3 years.
    ii. Document all measuring points and the associated readings over the past year.
5. Develop an input-output analysis based on invoices, measurements and conversion tables for emissions.
6. Document and calculate:
    i. Collect data or measure the energy consumption of the major individual user (machines, devices) in the departments.
    ii. Calculate the energy consumption for those users where power and operation times are known.
    iii. Draw a flow diagram of the energy flows inside the organization.

7. Write down all figures and indicators which help the organization to monitor the energy consumption over time. Take care to identify those figures which help staff involved in production processes to recognize their influence on energy consumption.

8. Determine where data come from, who collects data, how often they should be collected and who receives the information.

9. Determine calculation and cross-verify:

   i. If you pay for power in kW and for energy in kWh, ask your energy supplier for a power duration curve (yearly and weekly).

   ii. If appropriate, check in your energy contract what load you are paying for, what peaks really occur and if you could decrease the load.

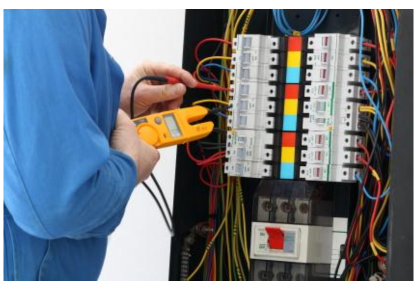
10. Having done these 9 steps you will know for sure which areas to analyze in detail and which improvement activities will help you to decrease your energy costs.

11. TIPS FOR ENERGY EFFICIENCY AND CONSERVATION

There are several routine measures that operations staff can rely on to ensure that the equipment in industrial plants are maintained efficiently in order to deliver best performance.

11.1 ELECTRICAL EQUIPMENTS

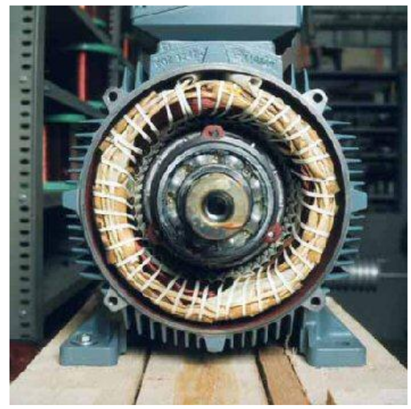
11.1.1 Distribution System



- Check utility electric meters on a regular basis.
- Optimize power factor to at least 90 percent to the rated load conditions.
- Ensure that unused primary power transformers which do not serve any active loads are disconnected.
- Use a demand controller to minimize the maximum demand by tripping loads using automated controllers.
- It is ideal to place transformers close to the main load area.
- Maximize load factor according to demand.
- Set transformer taps to optimum settings.
- Utilize off peak hours to balance the loads.
- Conserve energy by turning off computers, printers, and copiers when not in use.

- Distribute start-up times for equipment with large starting currents to minimize occasions of load peaking.

11.1.2 Motors



- ♥ Install energy-efficient drives.
- ♥ Ensure speed of the motor adjusted to the load.
- ♥ Refrain from use of belts for power transmission from motor to the machine when possible.
- Adjust the load size for optimum efficiency.
    - *(High efficiency motors offer of 4-5 percent more efficiency than standard motors).*
- Install energy-efficient motors whenever affordable.
- Install synchronous motors to improve power factor.
- Check alignment.
- Ensure that proper ventilation measures are in place.
    - *(Every 10^{o}C increase in motor operating temperature above the recommended peak is estimated to reduce motor life by 50 percent).*
- Check and fix under-voltage and over-voltage conditions.
- Use capacitors to improve power factor and reduce reactive power.
- Balance the three-phase power supply.

    - (Imbalance in voltage can reduce 3–5 percent in motor input power)
- Ensure efficiency restoration after motor rewinding.
    - (If rewinding is not done properly, motor efficiency can be reduced by 5–8 percent).
- Do not let your drives run in partial load operation.
- Check the mechanic load first, then calculate the nominal power required of the motor.

11.1.3 Drives

- Check belt tension regularly.
- Eliminate eddy current couplings.
- Eliminate variable-pitch pulleys.
- Use precision alignment between motor and load.
- Synthetic lubricants for large gearboxes to be used.
- Use flat belts as alternatives to v-belts.
- Use high-efficiency gear sets.
- Use variable-speed drives for large variable loads.
- Avoid use of drives that are older than 10 years.

11.1.4 Fans and Blowers

- Ensure proper flow distribution at the fan inlet.
- Test belt tension regularly.
- Clean screens, filters and fan blades regularly.
- Remove any leaks in ductwork.
- Eliminate variable pitch pulleys.
- Reduce bends in ductwork.
- Minimize fan inlet and outlet obstructions.
- Reduce fan speed when possible.
- Use aero foil-shaped fan blades.
- Install energy-efficient motors for continuous or near-continuous operation.
- Use low-slip or flat belts.
- Use smooth, well-rounded air inlet cones for fan air intakes.
- Use variable speed drives for large variable fan loads.
- Install variable speed drives for large variable blower loads.
- Install smooth, well-rounded air inlet ducts or cones for air intakes.
- Use low-slip or no-slip belts.
- Install energy-efficient motors for continuous or near-continuous operation.
- Reduce blower speed.
- Reduce blower inlet and outlet obstructions.

- Get rid of variable pitch pulleys.
- Eliminate ductwork leaks.
- Check regularly to ensure that screens and filters are clean.
- Check belt tension regularly.

11.1.5 Pumps

- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Balance the system to minimize flows and reduce pump power requirements.
- Increase fluid temperature differentials to reduce pumping rates.
- Enhance pumping to minimize throttling.
- Use Pump near best efficiency point by trimming the pump impeller or employing variable speed drives..
- Check packing and seals regularly to minimize pumped fluid.
- Utilize booster pumps for small loads requiring higher pressures.
- Use siphon effect to advantage: do not waste pumping head with a free-fall (gravity) return.

11.1.6 Compressors

- Ensure that lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (condensation contamination).
- Change the oil filter regularly.
- Variable speed drive can be considered for variable load on positive displacement compressors.
- Inspect compressor intercoolers from time to time for proper functioning.
- Use synthetic lubricants if the compressor manufacturer permits.
- Utilize waste heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.

11.1.7 Compressed air

- Use waste heat of compressors.
- Use the highest reasonable dryer dew point settings.

- Use nozzles or venturi-type devices rather than blowing with open compressed air lines.
- Use drain controls instead of continuous air bleeds through the drains.
- Use a small air compressor when major production load is off.
- Use a properly sized compressed air storage receiver. Minimize disposal costs by using lubricant that is fully de-mulsifiable and an effective oil-water separator.
- Reduce purges, leaks, excessive pressure drops, and condensation accumulation.
- Minimize air compressor discharge pressure to the lowest acceptable setting.
- Load up modulation-controlled air compressors.
- Intake air for compressor from the coolest (but not air-conditioned) location.
- Install a control system to minimize heatless desiccant dryer purging.
- Install a control system to coordinate multiple air compressors.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units, with continuous air purging of lenses and reflectors.
- Examine alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- Establish a compressed air efficiency maintenance programs part of the continuous energy management program.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Check pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Check leakage losses of compressed air system.
- Check for leaking drain valves on compressed air filter/regulator sets; certain rubber-type valves may leak continuously due to aging.
- Change standard v-belts with high-efficiency flat belts as the old v-belts wear out.
- Be sure that air/oil separators are not mixed.

- Avoid over-sizing and match the connected load.
- Assess part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.

11.1.8 Chillers

- Use water-cooled rather than air-cooled chiller condensers when cooling load exceeds approximately 800 tons..
- Use the lowest temperature condenser water available that the chiller can handle.
- Use energy-efficient motors for continuous or near-continuous operation.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest energy consumption. It saves energy cost, fuels a base load.
- Replace old chillers or compressors with new higher-efficiency models.
- Optimize condenser water flow rate and refrigerated water flow rate.
- Isolate off-line chillers and cooling towers.
- Install a control system to coordinate multiple chillers.
- Increase the chilled water temperature set point if possible.
- Establish a chiller efficiency-maintenance program and make it an integral part of your continuous energy management program.
- Do not overcharge oil.
- Clean heat exchangers when fouled.
- Avoid oversizing and match the connected load.

- Reducing condensing temperature by 5.5°C results in a 20-25 percent decrease in compressor power consumption.
- A 5.5°C increase in evaporator temperature reduces compressor power consumption by 20–25 percent.

11.1.9 HVAC (Heating / Ventilation / Air Conditioning)

In most parts of the six GCC countries, HVAC units are usually operated 24 hours on all days during most of the year, with the thermostat set point unchanged. Neither the start and stop hours nor the thermostat set point of HVAC systems are set to match the occupancy hours of building facilities. Energy savings can be achieved by using the following operation schedule of HVAC systems:

Night Setback

Switching off portable air conditioning units, PAC, at night when the building is not occupied, and switching them on in the morning two hours before the start of office hours. This function can be performed manually by using the programmable timers of PAC units, or via a Building Maintenance System, BMS.

Alternatively, night setback can be employed based on normal occupancy times for the area or room. Once activity is detected, and the area or room is identified as occupied, then the space temperature set point shall be set back to the normal set point value. This is achieved by changing the thermostat set points to be 24 °C during occupied periods of building facilities and 28 °C during the unoccupied periods. Use a basic operating rule : i.e. cool to the highest temperature possible and heat to the lowest temperature possible.

Space temperature setback

Automatic temperature reset control functions can be used to minimize the energy consumption of the cooling and heating systems by resetting the space temperature set point based on occupancy within an area for each system; if no activity has been detected for a predetermined time period (e.g. 10 minutes), then the area or room is determined to be unoccupied.

Operation and maintenance

The following measures for HVAC system operation and maintenance are suggested:

i. Clean HVAC unit coils periodically and comb mashed fins

ii. The accumulation of dust and foreign material at the heat exchanger surfaces (coils) reduces the heat exchange efficiency between the refrigerant or cold water and circulated air. This decreases the cooling effect of the refrigeration cycle. For every 1 °C decrease in the temperature of the refrigerant leaving the condenser, the energy consumption is reduced by about 2 percent.

iii. Check HVAC filters according to a regular schedule and clean/change as necessary. Filters need to be cleaned regularly to ensure proper air filtration. Any blockage in the filter would increase the pressure drop across it which will reflect directly on the fan, increasing its power consumption. Thus it is essential to monitor the filter status and periodically replace the old ones if necessary to ensure proper operation.

iv. Maintain air curtains

- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Pneumatic controls to be checked for air compressors for proper operation, cycling, and maintenance.
- Reflectors to be checked on infrared heaters for cleanliness and proper beam direction.
- Introduce desiccant drying of outside air to reduce cooling requirements in humid climates.
- Install a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Study reducing ceiling heights.
- Check and ensure that there are no oversized cooling units.
- Remove obstructions in front of radiators, baseboard heaters, etc.
- Remove or reduce reheat whenever possible.
- Remove simultaneous heating and cooling during seasonal transition periods.
- Introduce an HVAC efficiency-maintenance program and make it an integral part of your continuous energy management program.
- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- Clean, lubricate, and adjust damper blades and linkages.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Install multi-fueling capability and run with the cheapest fuel available at the time.
- Isolate air-conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Minimize HVAC fan speeds.
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use high-efficiency models for HVAC window units.
- Keep HVAC window units on timer control.
- Minimize humidification or dehumidification during unoccupied periods.
- Minimize HVAC system operating hours (e.g. night, weekend).

- Relocate air diffusers to optimum heights in areas with high ceilings.
- Replace loose or damaged flexible connections (including those under air handling units).
- Stop all leaks around coils.
- Repair all leaky HVAC ductwork.
- Maintain HVAC control system periodically.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Use atomization rather than steam for humidification where possible.
- Install building thermal lag to minimize HVAC equipment operating time.
- Use evaporative cooling in dry climates.
- Install local infrared heat for personnel rather than heating the entire area.
- Install professionally-designed industrial ventilation hoods for dust and vapor control.
- Use spot cooling and heating (e.g. consider use of ceiling fans for staff rather than cooling the entire area).
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. computer rooms).
- Zone HVAC air and water systems to minimize energy use.

11.1.10 Refrigeration

- Appropriate loading and avoid unnecessary low temperatures
- Avoid oversizing and match the connected load.
- Challenge the need for refrigeration, particularly for old batch processes.
- Check for correct refrigerant charge level.
- Consider change of refrigerant type if it will improve efficiency.
- In case of availability of natural gas, consider gas-powered refrigeration equipment to minimize electrical demand charges.
- Control of compressor outlet pressure in cold compressor.
- Correct inappropriate brine or glycol concentration that adversely affects heat transfer and/or pumping energy.
- Consider implementing absorption chillers supplied by waste or solar heat?
- Establish a refrigeration efficiency-maintenance program that is made an integral part of your continuous energy management program.
- High efficiency motors for the ventilators and compressors / condensers
- Inspect moisture/liquid indicators.
- Inspect the purge for air and water leaks.
- Insulate all pipes, chillers and chill rooms.
- Minimize cold demand by stronger heat insulation
- Recover the lost heat of compressors.
- Try to recover the lost heat of cooling.
- Use refrigerated water loads in series if possible.

- Use water-cooled condensers rather than air-cooled condensers when cooling capacity exceeds 1000 tons.
- Use evaporative precooling of condenser air
- Consider chilled water temperature reset to reduce evaporator temperature difference when full cooling capacity is not required.

11.1.11 Cooling towers

- Inspect water overflow pipes for proper operating level.
- Consider side stream water treatment.
- Control cooling tower fans based on leaving water temperatures.
- Control optimum water temperature as determined from cooling tower and chiller performance data.
- Cover hot water basins (to minimize algae growth that contributes to fouling).
- Divert clean air-conditioned building exhaust to the cooling tower during hot weather.
- Establish a cooling tower efficiency-maintenance program and make it an integral part of your continuous energy management program.

- If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, dumpsters, etc. that interfere with air intake or exhaust.
- Implement where applicable a cooling tower winterization plan to minimize ice build-up.
- Use new nozzles and clean cooling tower water distribution nozzles to obtain a more-uniform water pattern.
- For old counter flow cooling towers, replace old spray-type nozzles with new square-spray ABS practically-non-clogging nozzles.
- Minimize water evaporation as much as possible.
- Optimize blow down flow rate.
- Optimize chemical use.
- Cooling tower to be optimized for fan blade angle on a seasonal and/or load basis.
- Re-line leaking cooling tower cold water basins.
- Change slat-type drift eliminators with high-efficiency, low-pressure-drop, self-extinguishing, PVC cellular units.
- Change splash bars with self-extinguishing PVC cellular-film fill.
- Control flows through large loads to design values.
- Send blowdown to other uses (Remember, the blowdown does not have to be removed at the cooling tower. It can be removed anywhere in the piping system) .
- Switch off unnecessary cooling tower fans when loads are reduced.
- Use a velocity pressure recovery fan ring.
- Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many.

11.1.12 Lighting

- Control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Replace exit signs from incandescent to LED.
- Consider day lighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Consider using renewable energy, mainly solar and wind on a hybrid solar and wind for lighting.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Minimize excessive illumination levels to standard levels using switching, de-lamping, etc. (Know the electrical effects before doing de-lamping.)
- Assess exterior lighting strategy, type, and control; control it aggressively.
- Use ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Change obsolete fluorescent systems to compact fluorescents and electronic ballasts
- Use task lighting and reduce background illumination.

11.1.13 Diesel Generator sets

- Clean air filters regularly.
- Insulate exhaust pipes to reduce DG set room temperatures.
- Use cheaper heavy fuel oil for capacities more than 1MW.
- Use jacket and head cooling water for process needs.
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.

11.2 THERMAL UTILITIES

11.2.1 Boilers

- Use an economizer to preheat boiler feed water using exhaust heat.
- Recycle steam condensate.
- Assess part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple boilers.
- Preheat combustion air with waste heat using air pre heaters.
    - *(22 °C reduction in flue gas temperature increases boiler efficiency by 1 percent).*
- Install variable speed drives on large boiler combustion air fans with variable flows.
- Burn wastes if permitted.
- Enhance oxygen trim control (e.g. limit excess air to less than 10 percent on clean fuels).
    - *(5 percent reduction in excess air increases boiler efficiency by 1 percent or 1 percent reduction of residual oxygen in stack gas increases boiler efficiency by 1 percent).*
- Automate/optimize boiler blow down. Recover boiler blow down heat.
- Use boiler blow down to help warm the back-up boiler.
- Consider exhaust heat to waste heat recovery boiler.

- Optimize de-aerator venting.
- Check for scale and sediment on the water side
    - (A 1 mm thick scale (deposit) on the water side could increase fuel consumption by 5 to 8 percent).
- Check for soot, fly-ash, and slag on the fire side
    - *(A 3 mm thick soot deposition on the heat transfer surface can cause an increase in fuel consumption to the tune of 2.5 percent).*
- Optimize boiler water treatment.
- Consider multiple or modular boiler units instead of one or two large boilers.
- Start a boiler efficiency-maintenance program which should become part of your continuous energy management program.
- Insulate exposed heated oil tanks.
- Clean burners, nozzles, strainers, etc.
- Check oil heaters for proper oil temperature.

11.2.2 Steam System

- Collect work orders for repair of steam leaks that can't be fixed during the off peak season due to system shutdown requirements. Tag each such leak with a durable tag with a good description.
- Inspect operation of steam traps.

- Consider recovery of vent steam (e.g. on large flash tanks).

- Ensure that condensate is returned or re-used in the process (A 6°C raise in feed water temperature by economizer/condensate recovery corresponds to a 1 percent saving in fuel consumption, in boiler).
- Ensure that process temperatures are correctly controlled.
- Start a steam efficiency-maintenance program and make it part of your continuous energy management program.
- Repair steam leaks and condensate leaks.
- Inspect steam traps regularly and repair malfunctioning traps promptly.
- Installation of a flue gas damper.
- Maintain lowest acceptable process steam pressures.
- Reduce hot water wastage to drain.
- Remove air from indirect steam using equipment (0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall.)
- Remove or blank off all redundant steam piping.
- Use an absorption chiller to condense exhaust steam before returning the condensate to the boiler.
- Use back pressure steam turbines to produce lower steam pressures.
- Use electric pumps instead of steam ejectors when cost benefits permit.
- Use more efficient steam de-superheating methods.
- Use waste steam and flash steam for water heating.

11.2.3 Furnaces

- Check for holes and other leakages in the oven walls.
- Check infiltration of air: Use doors or air curtains.
- Inspect seals.

- Check if there is low feeding.
- Inspect if the surface temperature is too hot.
- Check if the temperature of exhaust gas is higher than 200°C for potential heat recovery and cost-effective opportunity.
- Check if it is possible and cost-effective to install a flue gas damper.
- Check the chimney to see if the oven/dryer is provided with a flue gas damper.
- Ensure that flame does not touch the stock.
- Ensure that the furnace combustion chamber is under slight positive pressure.
- Improve burner design, combustion control and instrumentation.
- Investigate cycle times and their reduction.
- Match the load to the furnace capacity.
- Monitor O_2/CO_2/CO and control excess air to the optimum level.
- Provide temperature controllers.
- Use ceramic fibers in the case of batch operations.

11.2.4 Insulation

- Insulate any hot or cold metal or insulation.
- Eliminate wet insulation.
- Inspect the condition of the thermal insulation and check if a better thermal insulation is possible..
- Ensure that all insulated surfaces are cladded with Aluminum.
- Insulate all flanges, valves and couplings.

- Insulate open tanks.
- Inspect if the thermal insulation is damaged and remove weak points.
- Repair damaged insulation.
- 70 percent heat losses can be reduced by floating a layer of 45 mm diameter polypropylene (plastic) balls on the surface of 90°C hot liquid/condensate.

11.3 Miscellaneous

- Assess alternatives to high pressure drops across valves.
- Check utilities contracts to reflect current loads and variations.
- Consider upgrades of equipment if space lease with equipment will continue for several years.
- Control fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Ensure all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install restriction orifices in purges (nitrogen, steam, etc.).
- Measure any unmetered utilities, know what normal efficient use is and track down causes of deviations.
- Minimize use of flow bypasses and minimize bypass flow rates.
- Remove unnecessary flow measurement orifices.
- Switch off spare, idling, or unneeded equipment.
- Switch off winter heat tracing that is on in summer.
- Use automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blow down, etc.
- Recover heat from incinerator off-gas.

11.4 Buildings

In buildings, Heating, Ventilation and Air Conditioning (HVAC) systems represent the largest component of energy consumption. HVAC system energy savings can be achieved by architectural and building envelope energy conservation measures.

• Added shading (in the form of overhangs) on top of some of the windows on some of the exterior building facades

Fig 8 : Samples of the solar shades that could be used to minimize the direct solar irradiance

• Added shading in the form of trees and vegetation on the outside façade. Fig 8 shows samples of the solar shades that could be used to minimize the direct solar irradiance.

• Increase roof insulation by adding another layer of extruded polystyrene insulation (rigid Insulation, i.e. XPS). The roof receives the highest amount of irradiance on its surface. This can result in potential savings in HVAC loads and costs.

• Use of cool roof system

Replace the roof ballast with brighter colored roof ballast.

Implement a cool roof system. A cool roof can significantly reduce the building's cooling energy costs by reducing temperature fluctuations inside homes. A cool roof is one that reflects the sun's heat and emits absorbed radiation back into the atmosphere.

One measure is to try and paint the roof ballast with a material that has a higher SRI. However, a cool roof need not be white. There are many "cool color" products which use darker-colored pigments that are highly reflective in the near infrared (non-visible) portion of the solar spectrum. With "cool color" technologies there are roofs that come in a wide variety of colors and still maintain a high solar reflectance.

One option is to paint the roof ballast with white roof coatings (like those from Conklin). The coatings reflect 90 percent of sunlight and are expected to reduce cooling costs and electricity bills. Fig 9, shows before and after effects of introducing roof coatings.

Also a roof sprayer system can be part cool roof system.

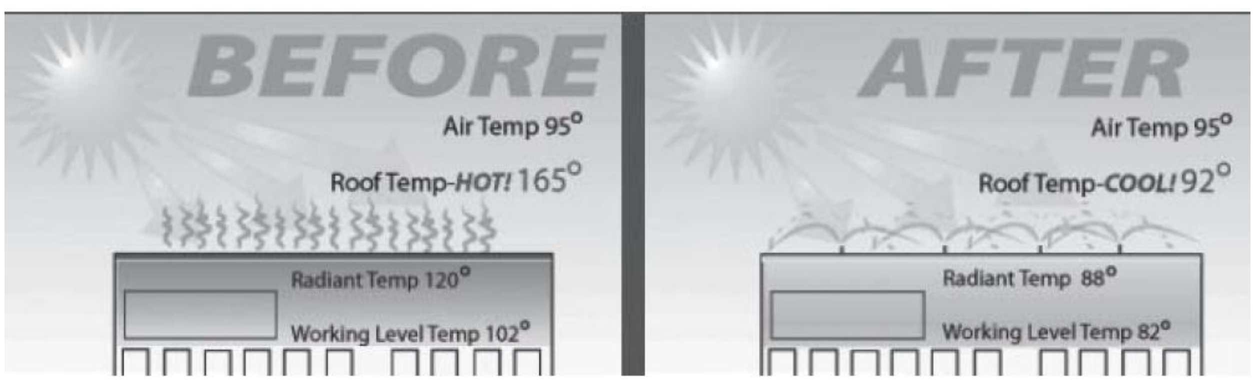


Fig 9: Roof Temperature Control

A roof spraying system

- Install spectrum selective screens on windows
- ♥ Installing spectrum selective screens in the form of films can be installed on all windows. This can reduce the AC load. The benefits offered by solar control films including reducing cooling costs in the warmer months as well as reducing heating costs in the cooler months.
- Minimize Infiltration using additional weather stripping

♥ Replace electric water heating system with solar water heating system as shown in Fig: 9.

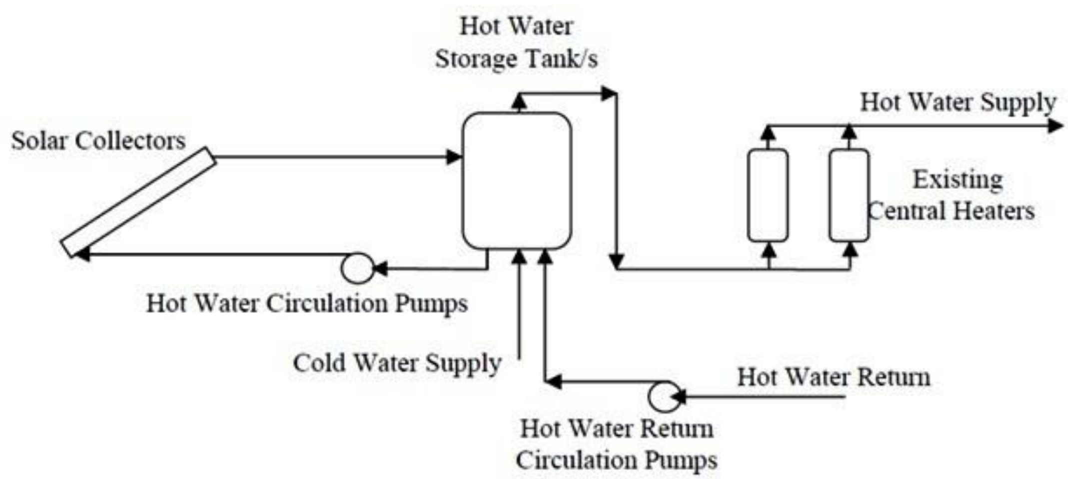


Fig 10 : Domestic central solar water heating system

- Consider the orientation of the building during the design stage to reduce the reacceptance of solar radiation.
- Use revolving doors; consider automatic doors, air curtains, strip doors, etc. at high-traffic
- Clean premises during the working day or as soon after as possible to minimize lighting and HVAC costs.
- Use self-closing doors if possible.
- Consider covering appropriate window and skylight areas with insulated wall panels inside the building.
- Consider appropriate thermal doors, thermal windows, roofing insulation, etc.
- Consider reflective glass, tinted glass, coatings, awnings, overhangs, draperies, blinds, and shades for sunlit exterior windows.
- Consider replacing exterior windows with insulated glass block, if visibility is not required but light is required.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.

- Seal exterior cracks/openings/gaps with caulk, Gasket, weather stripping, etc.
- Use intermediate doors in stairways and vertical passages to minimize building stack effect.
- Use landscaping to protect occupants from dust.

11.5 Water & Wastewater

- Balance closed systems to minimize flows and reduce pump power requirements.
- Check water overflow pipes for proper operating level.
- Consider leased and mobile water treatment systems, especially for deionized water.
- Consider the installation of a thermal solar system for warm water.
- Do not use a central heating system hot water boiler to heat water during the cold season. Install a smaller, more-efficient system to heat water during the cold season.
- Ensure that the water tanks do not overflow.
- Fix water leaks.
- Install efficient irrigation.
- Install pre-treatment to reduce TOC and BOD surcharges.
- Repair leaking toilets and faucets.
- Provide proper tools for wash down, especially self-closing nozzles.
- Recycle water, especially if sewer costs are based on water consumption.
- Recycle water, particularly for uses with less-critical quality requirements.
- Reduce flows at water sampling stations.
- Install seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Check and ensure that there are no underground water leaks.
- Use freeze protection valves rather than manual bleeding of lines.
- Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.

- Use self-closing type faucets in restrooms.
- Use the lowest possible hot water temperature.
- Verify the water meter readings.
- Utilize condensate from air-conditioning units.

12. ENERGY INTEGRATION METHODS

Energy integration methodologies are well established energy management techniques, which have been successfully applied in industry since the late 1970s. They help to achieve the maximum possible energy efficiency of a process, and have led to significant reductions in fuel use and associated atmospheric emissions.

Through energy integration concepts, savings on the order of 10–40 percent can be achieved according to the International Energy Agency (IEA) estimates which are based on successful applications worldwide. These savings can be further increased by applying total site technology, i.e. energy integration across plants, and even further, if energy integration is performed at the level of the industrial zone (or city).

There are proven methods for energy integration such as pinch analysis methods, heat recovery network design, utility systems optimization and co-generation, total site analysis and industrial zone integration.

Pinch Analysis:

The Pinch method was introduced by Linnhoff and Vredeveld in 1979. Whenever there is a process that involves heating and cooling, there is a potential cost saving opportunity. The term “Pinch Analysis” is used to define the minimum energy requirements when designing heat exchangers. Pinch Analysis is used to determine energy cost and heat exchanger network capital cost targets for a process. Using Pinch analysis can provide in advance the scope of energy saving and investment requirements ahead of design. Pinch analysis is used in industries as diverse as petrochemicals and oil, base chemicals, cement, paper, iron and steel, food and drink and textiles.

New developments in the field of Pinch method are being researched and new applications have been introduced. Such uses are in the field of water use minimization, waste minimization, hydrogen management, plastics manufacturing, and others. Some of the new areas that are finding its use in the industry are:

Total Site Analysis

In large industrial sites, many industrial plants are located such as refinery and petrochemical processes. These sites usually consist of several processes connected by a central utility system. The process stream heating and cooling demands, and co-generation potential, dictate the site-wide fuel demand via the utility system. The site imports or exports power to maintain the on-site power generation. The site infrastructure usually suffers from inadequate integration. To improve integration, it is necessary to consider a simultaneous approach to process issues alongside site wide utility planning. Similar to a single process, a Total Site Analysis using Pinch Analysis can be used to calculate energy targets for the entire site.

Regional Energy Analysis

By assessing the net energy requirements of several companies combined, the potential for sharing heat between them can be identified. These analyses lead to the determination of the amount and temperature of waste heat in an industrial area that is available for export. Depending on the temperature of this waste heat, it can be used for district heating or power generation.

Network Pinch

When optimizing energy consumption in an existing industrial process, a number of practical constraints must be recognized. Traditional Pinch Technology focuses on new network designs. Network Pinch addresses the additional constraints in problems associated with existing facilities. This step-by-step method provides an approach for implementing energy savings in a series of consecutive projects.

Top Level Analysis

Gathering data in industrial areas is not an easy task. With a Top Level Analysis, efficiencies and constraints of the utility system are used to determine which utility is worth saving. Data can be gathered from those processes or units that use these utilities. A pinch analysis can then be performed on this equipment.

Hydrogen Pinch

Pinch Analysis can also be applied to hydrogen management. Hydrogen Pinch enables to set targets for minimum hydrogen plant production and/or imports. Methods have also been developed for the design of hydrogen distribution networks in order to achieve the targets. Hydrogen Pinch also lends insight into the effective use of hydrogen purification units.

Optimization of Combined Heat and Power

CHP optimization gives a way to determine the load distribution in a network of turbines with a given total load. Typically, multiple steam turbines are used in complex steam systems.

Water Pinch

In view of high costs of fresh water and strict discharge regulations, Pinch Analysis can help companies minimize freshwater and wastewater quantities. Water Pinch is a technique for analyzing water networks and reducing water costs for processes. It uses advanced algorithms to identify and optimize the best water reuse, regeneration, and effluent treatment opportunities. It has also helped to reduce losses of both feedstock and valuable products in effluent streams.

Electricity and Water Desalination

Gas and steam turbines are widely used throughout the GCC for power generation. The majority of the desalination plants are of the co-generation type, where electric power and fresh water are produced from the same fuel source. Gas turbines can use different fuels and the availability of natural gas has expanded its use in gas turbines which produces electricity and hot exhaust gases. The exhaust gases can be turned into power through a steam turbine and generator. The Combined Cycle power plants include back pressure steam turbines as well as gas turbines.

A combined cycle gas turbine power plant as shown in Fig: 10 is essentially an electrical power plant in which a gas turbine and a steam turbine are used in combination to achieve greater plant efficiency. The electric efficiency of a combined cycle power station may be as high as 58 percent when operating new and at continuous output which are ideal conditions.

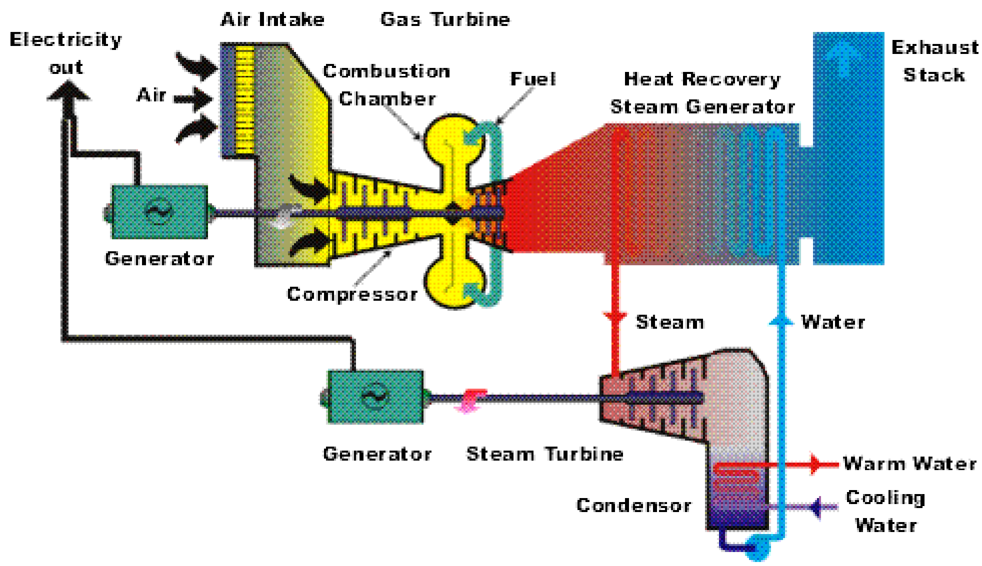


Fig 11 : Combined Cycle Power Plant

Environmental impact is reduced by using combined cycle power plants due to use of less fuel per kWh. The largest co-generation plants are found in the GCC with 10 million m3/d of fresh water and 2000 MW of electric power.

Co-generation benefits include:

- Better use of power.
- During shutdown of the desalination plant, electric power can be generated.
- More electricity can be generated during periods of low water consumption.
- Lower specific cost because of the large plant size.

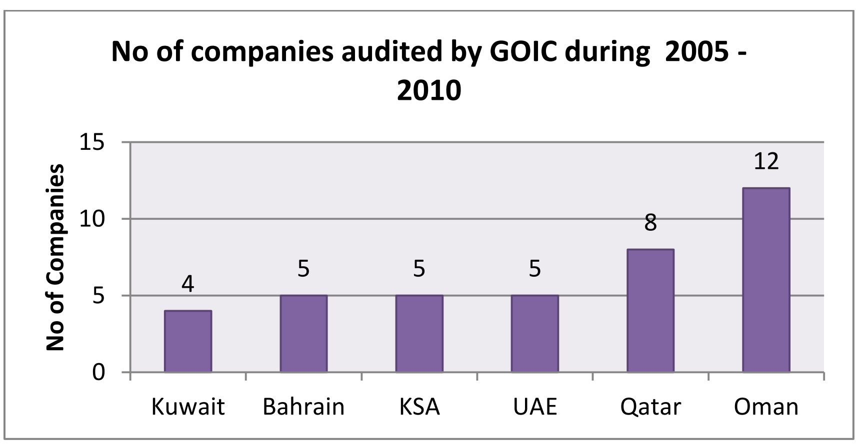
13. CASE STUDIES - Energy Efficiency Audits

About GOIC ITA program

As an organization dedicated to industrial development in GCC countries, GOIC has been working hard for over three decades to conceive and implement projects and programs to support the needs of the region's industries. GOIC has focused on extending advice and value-added services to industries while continuously highlighting new business opportunities.

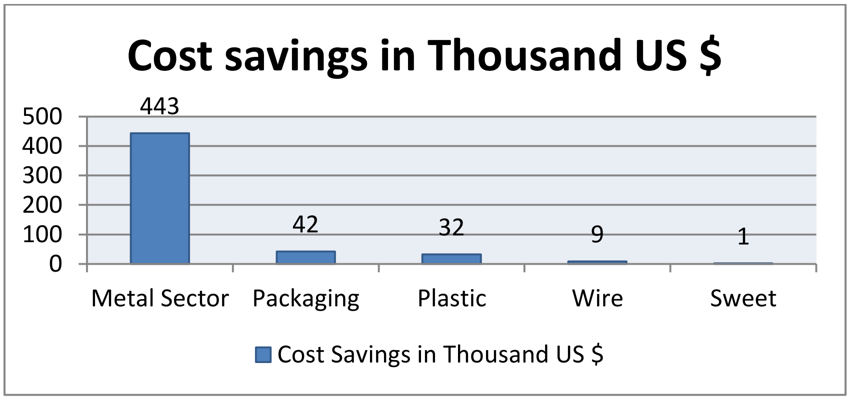
The Center for Industrial Technical Assessment (ITA) specializes in addressing the issue of energy efficiency in GCC. The ITA is a ten-year-old program that has been managed by a pool of in-house and external energy experts. The objective of the center is to identify, evaluate and recommend energy conservation opportunities in the region. The statistical tables and case studies below show the results and achievements from the many energy audits conducted by GOIC across the GCC region.

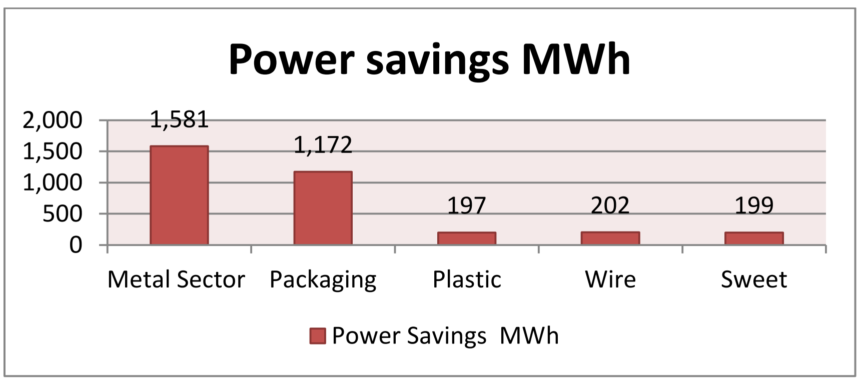
13.1 Summary of case studies

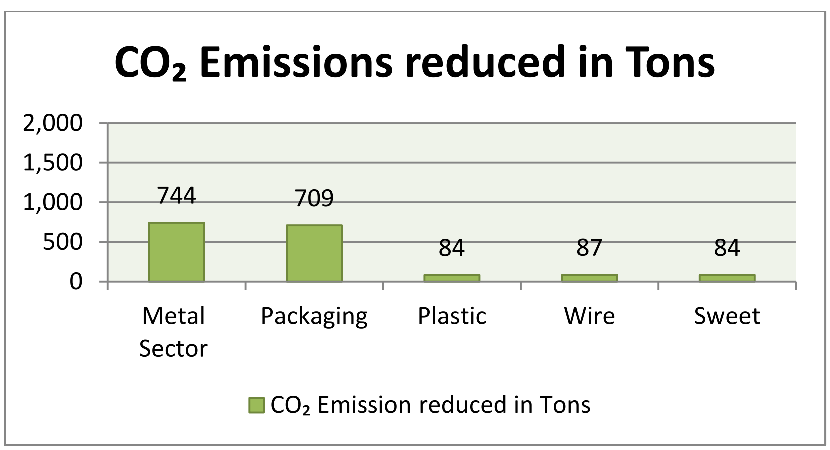


Major savings for the companies audited – consolidated figures

- Reducing energy consumption (7 – 30 percent)
- Reducing water consumption (25 – 80 percent)
- Minimizing waste consumption (4 – 80 percent)
- Productivity improvement (10 – 60 percent)







13.1.1 Case Study 1

Plastics manufacturing industry

The client is a leading plastic manufacturing company in the region, having turnover of about US$ 20 million/year. It produces high quality signage and visual communications displays, and has production facilities in the Gulf and Africa. The objective of the site audit was to identify the most important measures that could improve energy efficiency and productivity while minimizing waste.

GOIC undertook a comprehensive energy conservation study of the plant and recommended priority measures. By implementing the recommendations, the company saved **more than US$ 95,000.** A summary list of recommendations, the saving potential and implementation cost are given below:

ENERGY REDUCTION

SL	Recommendations	ENERGY REDUCTION				
		Estimated annual savings			Estimated cost US$	Payback period (years)
		US$	CO_2 tons	(KWh)		
1	Generate production gases on site	23,765	0	0	106,000	4.5
2	Voltage Optimization	5,337	54.1	125,900	26,500	4.9
3	Compressed air management system	875	8.8	20,660	3,975	4.5
4	Improve lighting control	716	6.7	16,932	3,445	4.8
5	Install skylights	522	5.3	12,344	2,385	4.6
6	Replace high level flood lights	464	4.7	10,979	1,060	2.2
7	Compressed air leaks	437	4.4	10,330	795	1.8
	Total	**32,115**	**84**	**197,145**	**144,160**	**3.9**

WASTE REDUCTION

Priority	Recommendations	WASTE REDUCTION			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	Increased % of income from waste or water		
1	Separate general waste into separate waste streams for recycling or sale.	2780	75% decrease in general waste removal costs	0	0
2	Repair water leaks	630	5% reduction in water use	0	0
	Total	**3,410**		**0**	**0**

PRODUCTIVITY IMPROVEMENTS

Priority	Recommendations	PRODUCTIVITY IMPROVEMENTS			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	% improvement		
1	Install racking	7,950	Cumulative	2,650	0.3
2	Implement energy policy	53,000		26,500	0.5
3	Implement M&T	26,500		26,500	1
	Total	**60,950**	**5**	**55,650**	**0.6**

13.1.2 Case Study 2

Metal industry

The client is a leading producer of structural steel for a range of pre-engineered steel buildings and can construct a 'turnkey' project building including all external cladding and fittings, all produced in the same factory. The company uses leading–edge German and Japanese technologies including precision CNC machinery to ensure high productivity, dimensional accuracy in cutting and automatic precision welding with state-of-the-art robotic torches.

GOIC conducted an audit to identify productivity improvements that could be implemented at reasonable cost. The ISO 9001-certified company has invested heavily in new technology for design and fabrication and follows rigorous quality assurance procedures.

Based on the findings detailed below it is expected that the improvements in energy management and productivity, and introduction of new technology would **save US$ 440,000 for the company. The energy saving would be 1,580,899 kWh and the reduction in CO2 would be 745 tons per year.**

ENERGY REDUCTION, WASTE REDUCTION & PRODUCTIVITY IMPROVEMENT

Priority	Recommendations	ENERGY REDUCTION, WASTE REDUCTION & PRODUCTIVITY IMPROVEMENT				
		Estimated annual savings			Estimated cost US$	Payback period (years)
		US$	CO_2 (tons)	(KWh)		
1	Lighting improvements old and new bays	3,259	36.9	68,839	665	0.2
2	Gas generation on site	367,208	0	0	266,000	0.72
3	Compressor optimisation & leak checks	16,969	192.4	358,400	6,650	0.4
4	Paint drier optimization & solar heating	15,388	174.5	325,000	13,300	0.86
6	Site voltage and power factor correction	11,210	127.1	236,760	13,300	1.18
7	Other equipment	28,025	213.34	591,900	13,300	0.47
	Total	**442,060**	**744.24**	**1,580,899**	**306,565**	**-**

13.1.3 Case Study 3

Sweets, Confection and Pastries

The client is a leading company in the GCC region producing high quality handmade Arabic and Lebanese sweets, confection and pastries.

The site consumed approximately 1,283,405 kWh of energy per annum, costing a total of US$ 15,620. All energy values are in terms of delivered energy. The site water consumption was not added but cost the company US$ 7100 per annum.

GOIC undertook a comprehensive energy conservation study of the plant, identifying **total cost savings of about US$ 895,000.** A summary of recommendations, the saving potential and implementation cost are given below:

ENERGY REDUCTION

Priority	Recommendations	ENERGY REDUCTION				
		Estimated annual savings			Estimated cost US$	Payback period (years)
		US$	CO_2 (tons)	(KWh)		
1	Voltage optimization	590.96	35	83,443	10,680	18
2	Pipe work insulation	405.84	24.5	57,158	1,602	4
3	Air Curtains / PVC strip curtains	295.48	17.9	41,721	1,424	5
4	Lighting	113.92	6.9	16,226	534	5
	Total	**1,406**	**84**	**198,548**	**14,240**	**8**

WASTE REDUCTION

Priority	Recommendations	WASTE REDUCTION			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	Increased % of income from waste or water		
1	Install automatic washing machine	1064.44	15%	3,560	3.3
2	Repair water leaks	708.44	10%	178	0.25
	Total	**17,73**	**25%**	**3,738**	**3.55**

PRODUCTIVITY IMPROVEMENTS

Priority	Recommendations	PRODUCTIVITY IMPROVEMENTS			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	% improvement		
1	Install automatic production machinery	Cumulative	Cumulative	Cumulative	2
2	Bulk LPG storage				
3	Implement M&T				
	Total	**890,000**	**50%**	**1,780,000**	**2**

13.1.4 Case Study 4

Electrical Cables

The client is a leading manufacturer of electrical cables. GOIC carried out detailed production analysis, monitored energy consumption and conducted waste streams audit. **The audit recommended energy savings of 2,022,069 kWh**. With an estimated annual total electrical load of 36,737,111 kWh this represented a reduction of 5.5 percent.

A summary of recommendations, the saving potential and implementation cost are given below:

ENERGY REDUCTION, WASTE REDUCTION & PRODUCTIVITY IMPROVEMENT

Recommendations and key actions	ESTIMATED ANNUAL SAVINGS		
	Cost	CO_2	Energy
	US$	tons	kWh
Hall 1 lighting improvements	1170	13.4	24,966
Bulk on site nitrogen generation		-	70% reduction
Reduce operating temperature of chiller plant	4103	47	87,600
Stores area lighting improvements	1022	11.7	21,840
Hall 1 compressor improvements	616	7	13,140
Plant 2 lighting improvements	1149	13.1	24,528
Plant 2 compressor improvements	616	7	13,140
All sites voltage reduction	86013	986.4	1,836,855
Total	**94,689**	**1,085.80**	**2,022,069**

13.1.5 Case Study 5

Galvanizing

The client is a leading ISO 9001-certified galvanizing company in the GCC region. All galvanizing operations are carried out to BS EN ISO 1461: 1999, ASTM A 123/ A 123M and ASTM A 385 certified standards. With a turnover of US$ 2160000/year, the company boasts a wide range of products including the processing of mild steel fabrications to give a hot dip galvanized finish for corrosion protection.

GOIC undertook a comprehensive energy conservation study of the plant during 2007 with the goal of identifying the most important measures that the plant should adopt to improve production processes, waste generation, waste minimization and energy usage. **The total cost savings identified amounted to US$ 19,701,970**. A summary of recommendations, the saving potential and implementation cost are given below:

Productivity Improvements

Priority	Recommendations	Productivity Improvements				
		Estimated annual improvement		Estimated cost US$	Payback period (years)	Timescale for implementation and by whom
		US$	% Improvement			
1	Convert water wash tank to acid	7,300,000	30	182,500	0.02	0-3 months
2	Provide small component jigs	2,409,000	10	27,375	0.01	0-3 months
3	Improve finishing process operation	7,300,000	30	18,250	0	0-3 months
4	Improve crane speed	481,800	2	91,250	0.2	0-6 months
5	Improve operator training	481,800	2	18,250	0.03	0-3 months
6	Monitor flux bath quality	0	-	18,250	0	0-3 months
	Total	**17,972,600**		**355,875**		**Management**

Waste Reduction

Priority	Recommendations	Waste Reduction				
		Estimated annual savings			Payback period (years)	Timescale for implementation and by whom
		US$	Tons of waste saved or increase % of income from waste	Estimated cost US$		
1	Reduce scrap wire consumption	1648	6 TONS	2060	1.25	Asap
2	Improve scrap price for Zinc	90581	229%	none	0	Asap
	total	**92,229**		**2060**		**Management**

Energy Reduction

Priority	Recommendations	Energy Reduction					
		Estimated annual savings			Estimated cost **US$**	Payback period (years)	Time scale for implementation and by whom
		US$	CO_2 (tons)	(KWh)			
1	Fir individual oil meters	35,040	32.1	128,400	5,840	0.16	0-3 months
2	Carry out combustion analysis on burners	105,120	96.3	385,000	12,775	0.12	0-3 months
3	Install auto control of burners	35,040	32.1	128,400	36,500	1.04	9-12 months
4	Install high efficiency burners	140,160	128.4	513,600	182,500	1.3	6-9 months
5	Move location of combustion air fans	27,375	16	64,200	36,500	1.3	2-6 months
6	Insulate furnace walls	59,751	54.75	219,000	36,500	0.9	0-3 months
7	Provide new insulated cover	101,361	92.8	371,424	27,375	0.3	0-3 months
	Total	**503,846**	**452.45**	**1,810,024**	**337,990**		**Management**

13.1.6 Case Study 6

Dairy products

The client is a leading dairy products manufacturing company in the GCC region with a turnover of US$ million 67.3/year. It produces processes and distributes milk, yoghurt and fruit juice drinks from concentrate. The company was established in 1990 and is one of the largest dairy farms in the region.

GOIC undertook a comprehensive energy conservation study of the plant in 2008. The study was carried out with a focus on proposals which required low and medium investment. **The total cost savings identified amount to US$ 3.6 million.** A summary of recommendations, the saving potential and implementation cost are given below.

PRODUCTIVITY IMPROVEMENTS

Priority	Recommendations	PRODUCTIVITY IMPROVEMENTS			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	% improvement		
1	Shrink wrap bottles	3,337,308	Cumulative	1,890,000	0.6
2	Loading bottles				
3	Pre-Labelled bottles				
4	Manual loading of bottles into crates				
	Total	**3,337,308**	**5**	**1,890,000**	**0.6**

WASTE REDUCTION

Priority	Recommendations	Waste Reduction			
		Estimated annual savings		Estimated cost US$	Payback period (years)
		US$	Increased % of income from waste or water		
1	Use final rinse water for 1st rinse of next cycle	51,240	25% decrease in CIP water	54,450	1.1
2	Compaction of PET bottles and separation of waste	22,358	75% decrease in waste costs	2723	0.1
3	Return refrigeration compressor chilled water to chilled water system	18,690	<1% decrease in water usage	13,612	0.7
4	Water wastage – leaks awareness campaign	12,295	2% decrease in water usage	272	0.01
5	Return homogeniser chilled water to chilled water system	2825	<1% decrease in water usage	5445	1.9
	Total	**107,400**		**76,504**	**1.4**

ENERGY REDUCTION

Priority	Recommendations	ENERGY REDUCTION				
		Estimated annual savings			Estimated cost US$	Payback period (years)
		US$	CO_2 (tons)	(KWh)		
1	Install solar concentrators	51,054	160.5	642,000	405,000	7.9
2	Install an economiser into exhaust gas flue	25,888	81.3	325,553	40,500	1.5
3	Insulate all steam pipe work	25,434	79.9	319,849	3,780	0.15
4	Insulate all chilled water pipe work	25	119	277,479	3,780	0.15
5	Install Variable Speed Drives (Frequency Inverter) on water pumps	10,741	51.8	120,554	19,440	1.8
6	Juice compressors sequencing	8,056	38.8	90,417	1,890	0.2
7	VSD for vacuum pumps in Milking Parlour	2,569	12.3	28,828	8,100	3.1
8	Lighting – install sensors onto external lights	1,463	7	16,425	2,700	1.8
9	Dairy air compressors – pipe work, sequence and VSD	1,121	5.4	12,579	5,400	5
10	Lighting – install sensors dry store	520	2.5	5,837	270	0.5
	Total	**126,871**	**559**	**1,839,521**	**490,860**	**2**

14. GUIDELINES FOR PRELIMINARY ENERGY AUDIT REPORT

1. Title Page

- Audit Report title
- Name of the company, facility or factory audited
- Location of facility or factory
- Date of report
- Name of Energy Manager

2. Executive Summary

The Executive Summary should summarize the information in the full report. It should also cover a brief description of the preliminary audit including:

- Name of company, location of facility or factory audited
- Objective of the audit
- Dates of actual and preliminary audit
- Key systems and equipment assessed

3. Table of Contents

- Introduction
- Existing systems in practice
- Scope of work for energy audit
- Data review and analysis
- Recommendations and the associated costs and savings
- Conclusions

4. Introduction

- Objectives
- Description of audited facility
    - Numbers of Machines / Devices/ Equipment
    - Age of machines / devices
    - Type of usage
    - Capacity utilization
    - No of hours of operation
    - Details of Air-conditioning
    - Details of lighting and associated features
- Previous year's energy consumption and cost
- Breakdown of energy (electricity and fuel) consumption

5. Existing systems in practice

- Dates of preliminary audit
- Data collected from manufacturers' design specifications
- Data collected from facility or factory manager

6. Scope of work for detailed energy audit

- Schedule of work
- Description of phases to be followed and expected results from the audit
- Duration of each phase
- Resources required for each phase
- Equipment and instrumentation plan
- A layout of the location of installation of instruments and devices, with pictures

7. Recommendations and associated costs and savings

- Description of the current situation and identified problems
- Findings from the audit, observations and assessment of the performance of systems or equipment
- Initial recommendations on energy saving measures with estimated energy and cost savings, investment cost and payback period for each measure
- Information supporting all calculations and explanation of assumptions made if any

8. Summary

- Summary of recommendations, estimated annual kWh and estimated cost savings, estimated investment cost and payback in table form

9. Appendices

- Audit to be performed by Internal Energy Manager or external consultant. If it is external consultant, copy of the contract between the company and the consultant)
- External consultant costs and breakdown of total cost recommendations including technical and financial criteria where relevant
- Attach copies of year's energy bills
- Layout plan of the facility or factory
- Any previous energy audit reports

10. General Notes

- All calculations in the report should be checked for mathematical accuracy
- The report should be written in clear, concise and understandable language

15. GUIDELINES FOR DETAILED ENERGY AUDIT REPORT

1. Title Page

- Audit Report title
- Name of company audited
- Location of facility
- Date of report
- Name of Energy Manager
- Audit team and their project designations
- Statement by the company accepting the report and verifying that the energy audit recommendations meet the company's technical and financial criteria
- Signature of company's representative

2. Executive Summary

The Executive Summary should be prepared from the detailed information in the full report. The Executive Summary contains a brief description of the audit, including:

- Name of client, location of facility audited
- Audit objectives
- Key equipment analysed
- Date of audit
- Summary of recommended energy conservation measures, annual energy and cost savings as shown in the table format below:

No.	Recommended measure	Estimated annual energy savings	Estimated annual cost savings	Estimated implementation cost	Payback period
1					
2					
3					
4					
Total					

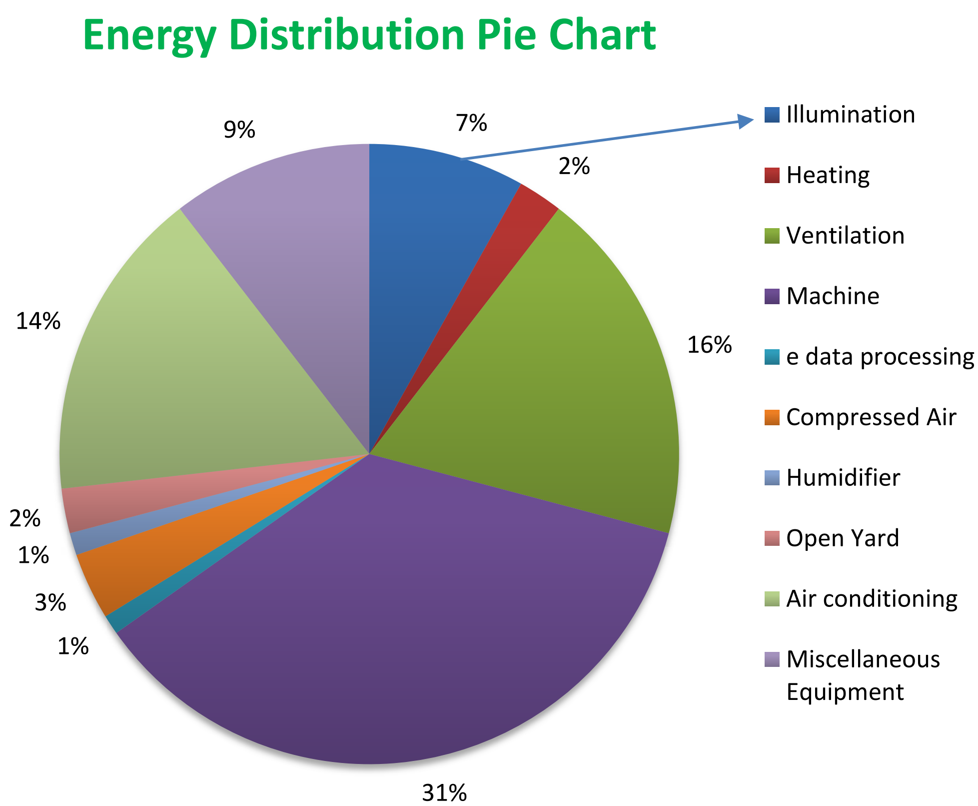
3. Table of Contents

- Introduction
- Methodology and instrumentation
- Data analysis and findings including graphs and plots
- Identified saving measures
- Summary of recommendations and the associated costs and savings
- Conclusion
- Appendices

4. Introduction

- Objectives of the audit – e.g. to study the energy consumption of the facility or system with a view to identifying energy conservation measures for implementation, meeting the client's financial criteria and taking into consideration technical and operational aspects
- The financial criteria and technical/operational aspects and limitations
- Description of facility audited – number of machines/equipment, age of equipment , type of usage, occupancy, hours of operation, air-conditioning and lighting features and other relevant details
- Past year's energy consumption and costs, including tariff rates used for financial calculations

- Breakdown of energy (energy distribution Chart) consumption in pie-chart form:



* If the "miscellaneous equipment" category amounts to more than 10 percent of the total consumption, provide a further breakdown and elaboration.

- Scope of audit, elaborating what equipment were studied

5. Methodology

- List of instruments
- Procedure for instrument installation and measurement
- Photos and location schematics for the installed instruments and sensors
- Measurement error analysis (mandatory)

6. Analysis and findings

- Date of audit
- Dates of data collection and logging
- Baseline energy consumption and the methodology used to establish the same
- The energy efficiency index (EEI – kWh/m2/year) of factory, defined as the amount of energy consumed annually per machine or device of the factory
- Description of systems or equipment audited, their capacities and ratings, design and operating conditions, equipment schedules, etc, including information such as the type of systems, controls, type and number of auxiliary equipment, etc.
- Performance of systems or equipment audited e.g. kW/ton
- Outcomes and observations

16. GUIDELINES FOR DETAILED ENERGY AUDIT REPORT FOR CHILLER PLANT

a. Details of the equipment

i. Details of the equipment, age and future replacement dates; description of controls, type and number of chillers, pumps, cooling towers and operating schedules.

Description	Qty	Rated kW or RT	Operating Hours	Year Installed
Chillers model no and type				
Chilled water pumps model no and type				
Condenser water pumps model no and type				
Cooling towers (model no and type				

b. Details of the cooling load

i. Details of the cooling load profile of facilities audited, illustrated with the following graphs:

1. Plot of cooling load (kW) profile over at least one week
2. Super-imposed plot of daily cooling load (kW) profile

c. Chilled water plant system performance

- System performance measurement error shall not exceed **±5percent**.
- Use of high accuracy thermometers and calorimeters.
- Detailed method statement explaining how the required degree of accuracy was achieved with the instruments and data acquisition hardware employed.
- Data required to establish system performance must be sampled and acquired simultaneously and continuously for a minimum of 1 week at one-minute intervals.

d. Required data points

i. Chilled water temperature, flow rate and pressure differential

- Each chiller
  - Supply and return temperature profiles as well as temperature differential profile (super-imposed)
  - Supply/return temperature histogram in percentage
  - Chilled water temperature differential histogram
  - Chilled water flow rate profile

- Main chilled water supply and return header
  - Supply and return temperature profiles (super-imposed)
  - Supply/return temperature histogram in percentage
  - Chilled water temperature differential histogram
  - Chilled water flow rate (supply header only)
  - Flow rate histogram in percentage
  - Pressure differential profile
  - Flow rate vs. pressure differential

- In systems with primary and secondary pumps, and bypass lines
  - Bypass flow (from temperature and flow measurement)
  - Histogram of bypass flow as percentage of total flow

ii. Condenser water temperature, flow rate and pressure differential

- Each chiller
  - Supply and return temperature profiles as well as temperature differential profile (super-imposed)
  - Leaving water temperature histogram in percentage
  - Condenser water temperature differential histogram
  - Condenser water flow rate profile

- Each condenser water branch
  - Supply temperature profile of each branch using super-imposed plot
  - Supply temperature histogram in percentage
  - Return temperature profile of each branch using super-imposed plot
  - Return temperature histogram in percentage

iii. Chiller

- Histogram of individual chiller efficiency
- Average values in table format

	Parameter	Design	Chiller 1	Chiller 2	Chiller 3
Chilled Water	Supply Temp (^{0}C)				
	Return Temp (^{0}C)				
	Flow rate (l/s)				
Condenser Water	Supply Temp (^{0}C)				
	Return Temp (^{0}C)				
	Flow rate (l/s)				
Operating Performance	Capacity (kW)				
	Power (kW)				
	Efficiency (kW/kW)				
	Evaporator dP (Pa)				
	Condenser dP (Pa)				

iv. Power Measurement

- kW profile for each chiller

v. Chilled water calorimetry

- Cooling kW profile of each chiller using super-imposed plot
- Cooling kW histogram in percentage

vi. Chilled water pumps (CHWP)

Parameter		Flow Rate (l/s)	Pump Head (m)	Motor Power (kW)	Efficiency (kW/kW)
Design	CHWP 1				
	CHWP 2				
	CHWP 3				
Actual	CHWP 1				
	CHWP 2				
	CHWP 3				

For pumping systems with variable speed drives, provide

- Flow rate vs. kW

vii. Condenser water pumps (CWP)

Parameter		Flow Rate (l/s)	Pump Head (m)	Motor Power (kW)	Efficiency (kW/kW)
Design	CWP 1				
	CWP 2				
	CWP 3				
Actual	CWP 1				
	CWP 2				
	CWP 3				

For pumping systems with variable speed drives, provide

- Flow rate vs. kW

viii. Cooling towers (CT)

Parameter		Condenser Water Supply (°C)	Condenser Water Return (°C)	Flow Rate (l/s)	Power (kW)
Design	CT 1				
	CT 2				
	CT 3				
Actual	CT 1				
	CT 2				
	CT 3				

- Ambient temperature and relative humidity profile taken over the measurement period

ix. Overall chiller plant

(kW_c refers to cooling load; kW_e refers to energy consumed)

- Daily chiller plant system efficiency profile vs. time (24 hours)
- Histogram of chiller plant system efficiency
- Plot of kW_c/kW_e vs. kW_c (chiller part load efficiency)
- Plot of kW_e vs. kW_c
- Plot of (cooling load + all motor loads except fan motors) vs. heat rejection to verify the measured values

e. Air-handling units (AHUs)

AHU No.	Air Flow (CMH)		AHU Motor (kW)		On-coil		Off-coil	
	Design	Measured	Rated	Measured	°C	RH (%)	°C	RH (%)

Include, air pressure drop across the coils in AHUs, floor area served (m^2), operating hours and index ($kWh/m^2/year$).

f. Mechanical ventilation systems

Details of the number, rating, operating hours, efficiency of fans

Description and Location	Air Flow (CMH)		Motor (kW)		Floor area served (m^2)	Operating Hours	Efficiency
	Design	Actual	Rated	Actual			

g. Basic indoor air quality

Location	Humidity	Air Temp (°C)	CO_2 Level (ppm)	CO Level (ppm)
Store				
Quality unit				
Factory				
Office				
Computer room				

h. Exhaust systems

Details of the type and purpose of exhaust systems; number of exhaust fans, performance of the exhaust fans

Fan: Location, Purpose	Static pressure (Pa) (near suction manifold of fans)	Rated power (kW)	Measured power (kW)	Efficiency
General exhaust 01				
General exhaust 02				
Acid exhaust 01				
Caustic exhaust 01				

i. Boiler systems

Details of the type, number, capacity and rating of boilers; number of feed water pumps, condensate return pumps, de-aerators, condensate return tanks and water softening plants

Parameter	Design	Measured		
		Boiler 1	Boiler 2	Boiler 3
Steam capacity (kg/s)				
Water flow rate (kg/s)				
Operating pressure (Pa)				
Blower fan (kW)				

Boiler performance

Parameter	Boiler 1	Boiler 2	Boiler 3
CO_2 (%)			
CO (ppm)			
O_2 (%)			
Excess air (%)			
Flue gas temperature (ϕC)			
Temperature difference between flue gas and air intake (ϕC)			
Estimated boiler efficiency (%)			

Feed water pumps performance

Parameter	Design	Feed water pump 1	Feed water pump 2	Feed water pump 3
Flow rate (kg/s)				
Head (m)				
Power (kW)				
Pump efficiency				

Overall boiler system performance

Description of parameters	Measurements
Steam production (kg/s)	
Feed water flow rate (kg/s)	
No. of feed water pumps in operation	
Total feed water pump (kW)	
Feed water temperature (ϕC)	

Include information on the heat and mass balance of the boiler and steam-condensate systems including temperatures and pressures.

j. Compressed air systems

Details of the type, number, capacity and rating of air compressors

Description	Qty	Rated kW / Capacity
Air Compressor (Model no and type)		
Air Compressor (Model no and type)		

Performance of air compressors

Description	Measured Total Compressor Load (kW)	Air Pressure at Receiver Tank (bar)	Air Pressure at Furthest End User (bar)	Pressure Drop (bar)
4 screw compressors in operation				
2 screw compressors in operation				

k. Lighting systems

Details of the type, number and rating of lighting for different areas, type of control gear (ballast etc) and operating hours

Location		Type of Lamp	Nos.	Rated W	Average Measured W	Type of Control	Operating Hours
1st Floor	Driveway						
	Mail room						
2sd Floor	Workshop						
	Office						
Factory	Store						
	Quality unit						
	Factory1						
	Factory2						
	Tool room						

7. Identified Energy Saving Measures

- Description of the current situation and problems identified
- Recommended energy saving measures with detailed and clear calculations of the predicted annual energy and cost savings, investment cost and payback period for each measure. All calculations must be supported by data and assumptions.

8. Conclusions

- Summary of recommendations, projected annual kWh savings, estimated cost savings, projected investment cost and payback in table format
- Recommended action plan and implementation schedule
- Statement by the company on which recommendations will be implemented and timeframe for implementation

9. Appendices

The appendices should include:

- Schematics and equipment layout drawings of facility audited.
- Details of instrumentation used – parameters monitored and duration of monitoring for each parameter.
- Design data of performance of systems or equipment audited.
- Energy efficiency of major equipment compared against industrial benchmarks.
- Measurement and verification plan for monitoring and verifying energy savings for each of the recommendations.
- Attach a soft copy of raw measurement data.

10. General Notes

- All calculations should be supported by documents; this covers energy savings, cost savings, investment and payback information.
- SI units must be used in all parts of the report.
- Ensure measurement and instrumentation accuracy.
- The language should be clear, concise and understandable.
- Label all graphs and plots and show the dates of the readings.
- Examples shown in this guideline are for guidance purposes; ideally the tables should show more detailed information.

17. GUIDELINES FOR POST-IMPLEMENTATION REPORT

1. Title Page

- Title of Report
- Name of company audited
- Location of facility
- Date of report
- Name of Energy Manager
- Name of project team

2. Executive Summary

The Executive Summary is prepared from the detailed information in the full report. It should contain a brief description of the following:

- Name of company or client, location of facility audited
- Measures implemented
- Summary of energy saving measures, and the measured annual energy and cost savings in table format

Measure No.	Measure	Actual annual energy savings	Actual annual cost savings	Actual implementation cost	Updated Payback period
1					
2					
Total					

3. Table of Contents

- Measures implemented and cost of implementation
- Measurements and calculations
- Savings achieved
- Attach a soft copy containing raw measurement data collected after implementation

4. Measures implemented and cost of implementation

- Details of measures implemented
- Description of equipment modified, their capacities and ratings, design conditions, equipment schedules, including information such as the type of systems, type of controls, type and number of auxiliary equipment, etc.
- Schedule of implementing the modifications

- Cost breakdown of each measure in table format

5. Measurements and calculations

- Details of the measurement and verification system adopted to measure and compare actual savings to savings projected
- key data used for calculations
- Detailed instrumentation plan
- Parameters monitored and duration of monitoring of each parameter
- Dates of data collection and logging
- Performance of systems or equipment
- Findings and observations

6. Savings achieved

- Summary of the measures implemented, the predicted and actual annual kWh savings, and the predicted and actual annual cost savings
- Statement by the company on whether or not the energy auditors' recommendations meet the company's savings target stated in the detailed report

7. Appendices

Appendices should include:

- Design data of performance of equipment
- Design data of energy consumed vs. time before and after implementation of audit recommendations
- Energy efficiency of major equipment compared against benchmarks set during the detailed audit
- Current energy bills

8. General notes

- The report should focus on the measures stated in the detailed energy audit report.
- All calculations should be supported by documents; this includes all energy and cost savings, investment cost and payback information.
- All calculations in the report should be checked for mathematical accuracy.
- The language should be clear and understandable.
- All graphs and plots should be properly labelled and named.

18. LIST OF KEY ENERGY PLAYERS IN THE GCC REGION

SL	Name	Contact details	Profile
	Bahrain		
1.	The Bahrain Petroleum Co.	P.O. Box 25555 Awali - Bahrain Email: info@bapco.net T:+973 17704040 F:+973 17704070	BAPCO, a wholly owned Company by the Government of Bahrain, is engaged in the oil industry including exploration and prospecting for oil, drilling, production, refining, distribution of petroleum products and natural gas, sales and exports of crude oil and refined products. The company owns a 250,000 barrel-a-day refinery, storage facilities for more than 14 million barrels, a marketing terminal, and a marine terminal for its petroleum products.
2.	Bahrain National Gas Co. (B.S.C)	P.O. Box 29099, Kingdom of Bahrain T:+973 17756222 F:+973 17756991 E-Mail: bng@banagas.com.bh	Bahrain National Gas Expansion Company S.P.C., is solely owned by the Oil and Gas Holding Company (Noga holding). The primary objective of the company is to use the large quantities of associated gas extracted from the Bahrain Oil Field. Now this valuable natural resource, through maximum utilization, produces a substantial contribution to the national economy.

3.	Kingdom of Bahrain Electricity & Water Authority	Electricity and Water Authority (EWA) Customer Services Directorate P.O. Box: 2 Manama, Kingdom of Bahrain T:+973 17515555 F:+973 17997710 E mail: customercare-ewa@ewa.bh	The main objectives of EWA is to provide electricity and water services to all Sectors in the Kingdom of Bahrain using optimum utilization of the available resources. To support the Kingdom of Bahrain's economic development through: 1) Smart investment in key infrastructure. 2) Improve customer experience. 3) Efficient dynamic processes. 4) Skilled people working together in a safe environment.
4.	National Oil & Gas Authority	T:+973 17312644 F:+973 17293007 P.O. Box 1435 Manama-Bahrain E-Mail info@noga.gov.bh	The National Oil & Gas Authority goals are to encourage petroleum companies to explore offshore blocks under exploration and production sharing agreements (EPSA), and endeavor to increase petroleum reserves. Its mandate includes: Co-ordination with operating companies to develop the capacity of the refinery, the Liquefied Petroleum Gas Plant and other petroleum projects. Optimize consumption and ensure fair and cost-effective distribution of natural resources.
5.	Tatweer Petroleum, Bahrain	PO Box 25888, Awali, Kingdom of Bahrain T:+973 17148000 F:+973 17148001 E:info@tatweerpetroleum.com	Tatweer Petroleum brings together the unique experience, knowledge and expertise of its partners. The company utilizes the latest enhanced oil recovery technologies to develop the Bahrain Field and support the vision of economic growth and social prosperity of the Kingdom.

6.	Chevron Bahrain	P. O. Box 25125 Awali, Bahrain T:+973 17753101 F:+973 17753122 Email: nmquadros@chevron.com	Chevron is one of the world's leading integrated energy companies, applying innovative technologies and capturing new opportunities. Chevron is into exploration, production and transportation of crude oil and natural gas; refining, marketing and distribution of fuels and lubricants; manufacture and sell petrochemical products; generate power and produce geothermal energy; provide energy efficiency solutions; and develop energy resources , including research for advanced biofuels.

	Kuwait		
7.	Ministry of Oil	P.O. Box: 5077 13051- Kuwait E-mail: alnaft@moo.gov.kw	The main objectives of the Ministry of Oil are to propose the general policy of oil and gas sector and achieve the right balance in exploiting the country's oil resources to fund economic development. The Ministry also strives to maintain the level of Kuwait oil prices so as to fulfill the financial obligations of the State and development plans, provide the needs of next generations, maintain the position of oil as a strategic commodity and main source of energy and enhance Kuwait's position in the international market. The Ministry works to reinforce the respectable international position occupied by the State of Kuwait, strengthening its role in the regional and international organizations and associations concerned with oil field such as OPEC, OAPEC, GCC countries, and organizations affiliated to United Nations in the fields of oil and energy.
8.	Ministry of Electricity and Water (MEW).	Ministry of Electricity and Water Building, South Al Sourra Street, Ministries Area-12 Kuwait P.O. Box: 13001-Safat T:+965 25371000 F:+965 25371420 F:+965 25371421 F:+965 25371422	Ministry of Electricity and Water (MEW) is the main authority on electricity and water utility in Kuwait.
9.	Kuwait Petroleum Corporation (KPC)	T:+965 1858585 P.O. Box: 26565, Postal Code: No. 13126, Safat, Kuwait Email: media@kpc.com.kw td@kpc.com.kw	Kuwait Petroleum Corporation (KPC), has several subsidiaries including: Kuwait Oil Company (KOC), Kuwait National Petroleum Company (KNPC), Petrochemical Industries Company (PIC), Kuwait Foreign Petroleum Exploration Company, Kuwait Petroleum International, Kuwait Gulf Oil Company, Oil Development Company; it is fully owned by the State of Kuwait. Its business interests are diverse and range across all aspects of the hydrocarbon industry, from onshore and offshore upstream exploration through production and refining, marketing, retailing, petrochemicals, as well as, marine transportation.

10.	Kuwait Oil Company (KOC)	P.O. Box 9758 Ahmadi 61008 Kuwait T:+965 23989111 F:+965 23983661 E-Mail: kocinfo@kockw.com	A subsidiary of the Kuwait Petroleum Corporation (KPC), a Government-owned holding company. KOC is a large oil exporter. The company activities are in exploration operations, on-shore and off-shore surveys, drilling of test wells, and developing of producing fields in addition to crude and natural gas exploration.
11.	Kuwait National Petroleum Company (KNPC)	P.O. Box 70 Safat 13001 Safat – Kuwait T:+965 23989900 F:+965 23986188	Kuwait National Petroleum Company KNPC was established in October 1960 as a joint venture between the government and the private sector. KNPC is part of KPC Downstream Sector that includes other three KPC subsidiaries:. KPI, PIC and KAFCO. Within the Downstream Sector, KNPC is responsible for Domestic Refining and Gas Processing. The main objectives of the company are three themes of Integration, Performance & People/Partnership.
12.	Petrochemical Industries Company (PIC)	P.O. Box: 1084 Safat 13011 Kuwait T:+965 23211000 F:+965 23211171 Email: mia9999@bic.com.kw qurianep@pic.com.kw	PIC, as a subsidiary of Kuwait Petroleum Corporation, is involved with downstream high value petrochemical business. Maximizing value addition of Kuwait hydrocarbons resources.
13.	Kuwait Foreign Petroleum Exploration Company (KUFPEC)	Administrative Shuwaikh – Area 4 – Street 102 - Building No. 9 P.O. Box 5291 Safat, 13053 Kuwait T:+965 1836000 F:+965 24951818 Email: kufpec@kufpec.com	Established by its parent company KPC, KUFPEC is an international oil company, engaged in exploration, development and production of crude oil and natural gas outside Kuwait, active in Africa, Middle East, Asia, and Australia. KUFPEC participates in joint ventures with similar companies in E&P of Oil and Gas both as an operator and partner.

14.	Kuwait Petroleum International (Q8)	PO Box 1819 Safat 13019 Kuwait T:+965 233 2800 F:+965 233 2776	Established in 1983, Kuwait Petroleum International is the international subsidiary of Kuwait Petroleum Corporation. Kuwait Petroleum International, known by the trademark Q8, refines and markets fuel, lubricants and other petroleum derivatives outside Kuwait. The main activities are focused on Europe and the Far East.
15.	Kuwait Gulf Oil Company (KGOC)	P.O. Box 9919 Ahmadi – 61010, Kuwait KGOC Main Office, Building W T:+965 25454253 M+965 94055477 M+965 94055699 F:+965 25454250 Email: kgocrd@kgoc.com	The Kuwait Gulf Oil Company is responsible for the management of Kuwait's share of the natural resources in Wafra Joint Operations located in the divided zone (DZ), and Khafji Joint Operations located near Khafji, Saudi Arabia, that straddles the border between the State of Kuwait and the Kingdom of Saudi Arabia. The two countries share the reserves equally, working together to extract, refine and market them for mutual benefit.
16.	Oil Development Company (ODC)	P.O. Box 9220 Ahmadi, 61008, Kuwait T:+965 3982317 F:+965 3982916 E-Mail: ahkhajah@kockw.com	The Oil Development Company is responsible for the Operational Service Contract (OSC) with the International Oil Companies (IOCs) in accordance with Kuwait's constitution and laws; and to administer and manage the OSC to the optimum benefits to the State of Kuwait.
17.	Kuwait Institute for Scientific Research (KISR)	P.O Box 24885 Safat 13109, Kuwait T:+965 24836100 T:+965 24818630 publicrelations@kisr.edu.kw	Kuwait Institute for Scientific Research is a research and development (R&D) organization that has an Energy Center and its main focus is on energy conservation and alternative energy R&D works.

18.	Kuwait University	Email: username@ku.edu.kw T:+965 24814475 T:+965 24985071	Kuwait University conducts programs and courses that focus on the academic and training aspects related to energy issues.
19.	Public Authority for Applied Education & Training (PAAET)	T:+965 21806611 F:+965 22528915 Postal Address P. 23,167 - Safat Code 13092 Kuwait Adailiya - Third Ring Email: feedback@paaet.edu.kw	Public Authority for Applied Education and Training conducts programs and courses that focus on the academic and training aspects related to energy matters.

	Oman		
20.	Ministry of Oil & Gas Oman	Al-Khuwair, Ministry Streets, Opposite Sultan Qaboos Street. P.O Box: 551 Postal Code: 100 T:+968 24640555 F:+968 24691046	Ministry of Oil and Gas (MOG) is the main authority responsible for all oil and gas exploration and development, infrastructure and projects in the Sultanate of Oman.
21.	Petroleum Development Oman	Bait Saih Al Maleh Building Mina Al Fahal Street Watayya Roundabout 81 Oman City: Muscat T:+968 24678111 F:+968 22475654 Website: www.pdo.co.om	Petroleum Development Oman is the main exploration and production company in the Sultanate. It accounts for more than 70% of the country's crude-oil production and nearly all of its natural-gas supply. The company is owned by the Government of Oman (which has a 60% interest), Royal Dutch Shell (which has a 34% interest), Total (which has a 4% interest) and Partex (which has a 2% interest).
22.	Oman Oil Company (S.A.O.C)	PO Box 261 PC 118, Sultanate of Oman Muscat Qurum Area, Opposite to Qurum City Centre T:+968 24573100 F:+968 24573101 Email: info@oman-oil.com	Oman Oil Company S.A.O.C. (OOC) is a commercial company wholly owned by the Government of the Sultanate of Oman. The company was incorporated in 1996 to pursue investment opportunities in the energy sector both inside and outside Oman. Through participation in energy and energy-related projects, the company plays an important role in the Sultanate's efforts to diversify the Omani economy and to promote Omani and foreign private sector investment.
23.	OXY Oman	Occidental of Oman, Inc. and Occidental Mukhaizna, LLC: P.O. Box 717 Al Athaybah, Postal Code 130, Muscat, Sultanate of Oman.	Oxy Oman operations are concentrated at the Mukhaizna Field in south-central Oman, and the Safah and Wadi Latham fields and Block 62 in northern Oman. During its more than 30-year tenure in Oman, Oxy has increased production and reserves, and today is one of the country’s largest oil producers.

24.	Petro Gas E&P Oman	T:+968 24527900 Address: Way No: 6826, Building No: 1742/ 18-Nov Street, Azaiba P.O. Box: 353, PC112 Ruwi Sultanate of Oman. E-mail: petrogas@petrogas.com.om www.petrogasep.com.om	Petro gas LLC is established in January 1999. Petro gas E&P LLC is the holding company of MB Holding Company, for its oil & gas exploration and production assets in Oman and overseas. Producing from central Oman oil field in Sahma.
25.	Public Authority for Electricity & Water (PAEW)	P.O. Box: 1889, PC: 130, Al-Azaiba, Sultanate of Oman, T:+968 24611100 F:+968 24611133 Email: enquiries@aer-oman.org www.aer-oman.org	The Public Authority for Electricity and Water is a governmental institution mandated to provide electricity and water to the public, institutions and facilities of all kinds. Its primary objective is to secure the production of potable water in accordance with the Oman standards and proportionate to the expansion of development and population growth. It implements the Government's policy in respect of securing electricity supply to cover the maximum possible sections of the society. It consolidates Government policy in respect of the development of both the water and the electricity- and water-related sectors and aims to promote them and utilize modern and efficient technology in these two areas.
26.	Daleel Petroleum L.L.C	P.O. Box 543, PC 112, Ruwi, Sultanate of Oman T:+968 24394200 F:+968 24394357 Email: daleel@dapeco.com.	Daleel Petroleum L.L.C. is a joint-venture project between Mezoon Petrogas SAOC (Subsidiary of MB Holding) and Mezoon Petrogas BVI (Subsidiary of China National Petroleum Corporation). The main stakeholder is the Government of the Sultanate of Oman. The core business of the company is the production of hydrocarbon fluids and optimization of future reserves, which is the key Daleel Petroleum contribution to the socio-economic development of the country.

27.	Petroleum Thailand (PTT)	P.O. Box: 1067 Zip/Postal Code: 133 AL KHUWAIR Muscat-Oman T:+968 24494632 F:+968 24493276	PTTEP is the national petroleum exploration and production company of Thailand operating the Shams oil and gas field in Oman with partnership with the Government of Oman.
28.	Authority for Electricity Regulatory Board	P.O Box 954, Postal Code 133 Al Khuwair, Sultanate of Oman T:+968 24609700 F:+968 24609701 Email: enquiries@aer-oman.org	The Authority for Electricity Regulation, Oman ("the Authority") is the Authority established for the regulation and privatization of the electricity and related water sector The Authority regulates the electricity and related water sectors and ensures the security of energy demand for the country.
29.	Sultan Quboos University (SQU)	P.O. Box 50 Muscat 123 Sultanate of Oman T:+968 24141111 F:+968 24413391 Email: chrsd@squ.edu.om	Sultan Qaboos University is the major research and higher education center in the Sultanate of Oman. Sultan Qaboos University is involved in all areas of teaching, learning, research and community service. It also promotes scientific analysis and creative thinking, participate in the production, development and dissemination of knowledge.

	Qatar		
30.	Ministry of Energy & Industry	Department of Industrial Development: T:+974 44846444 did@mei.gov.qa Department of Industrial Zones: T:+974 44234111 die@mei.gov.qa Department of Common Services: T:+974 44846444 djs@mei.gov.qa Department of Energy T:+974 44846444 nobidy@mei.gov.qa	The Ministry's main goals are the development and support of industrial ventures to diversify national income sources. It aims to maximize value addition of intermediate materials and to encourage the private sector to increase its contribution to industrial development. The Ministry seeks to increase the manufacturing sector's contribution to Gross Domestic Product (GDP) and encourage, support and develop clean and energy intensive industries.
31.	Qatar Petroleum	Qatar Petroleum P.O. Box 3212, Doha, Qatarwww.qp.com.qa T:+974 44402000 F:+974 44831125 Mesaieed Industrial City P.O. Box 50070, Mesaieed, Qatar www.mic.com.qa F:+974 44773213 Ras Laffan Industrial City (RLC) P.O. Box 22247, Doha, Qatar www.raslaffan.com.qa T:+974 44733438 F:+974 44733339 Dukhan City	QP mission is to ensure that the State of Qatar the gets maximum benefit from its petroleum resources by engaging directly or indirectly in all activities that would add value to these resources. The main objective is to maximise contribution to the national wealth of the State of Qatar, through the safe, efficient and environmentally acceptable exploitation of Qatar's hydrocarbon reserves and through related activities. Other objective are: To provide the state with a reliable cash flow, of maximum value, from diversified business interests. To build an organization with internationally competitive business and technical expertise. To maximize the employment of capable Qatari nationals, and develop them to the competence level of the leading international oil company employees.

32.	RasGas	RasGas Tower Conference Centre Street, West bay Doha, State of Qatar PO Box 24200 T:+974 44738000 F:+974 44833855	Supply LNG to global markets. RasGas oversees and manages all the operations associated with seven LNG trains, two sales gas production facilities, helium production facilities, as well as major shipping contracts and global commercial partnerships.
33.	Qatar Gas	Ras Laffan address: Qatargas Operating Company Qatargas Road Ras Laffan Industrial City Doha address: Qatargas Doha Head Office West Bay, Doha Postal address: PO Box 22666 Doha State of Qatar T:+974 44736000 F:+974 44736666 Email: info@qatargas.com.qa	Involved with Liquefaction of Natural Gas (LNG) in Qatar. Qatargas, established in 1984, pioneered the Liquefied Natural Gas (LNG) Industry in Qatar. Qatargas is the largest LNG producing company in the world, with an annual LNG production capacity of 42 million tons per annum (MTA).
34.	Qatar Foundation (QF)	P.O. Box 5825 Doha, Qatar T:+974 44540000 F:+974 44806117 e-mail: info@qf.org.qa	Qatar Foundation, established in 1995 to promote Education, Science and Community Development (QF), aims to support Qatar on its journey from a carbon economy to a knowledge economy by unlocking the human potential.

35.	Qatar University (QU)	P. O. Box: 271 T:+974 44033333 Email: info@qu.edu.qa	Qatar University is involved in all areas of teaching, learning, research and community service. It also promotes scientific analysis and creative thinking, and participates in the production, development and dissemination of knowledge. It is also involved in studying and teaching energy aspects affecting the world and the region.
36.	Texas A&M University Qatar	PO Box 23874 Education City Doha, Qatar	Texas A&M University in Qatar is concerned with teaching, learning, research and community service. It aims to develop exemplary engineers and leaders through internationally respected undergraduate and graduate degree programs. It focuses on generating new knowledge by conducting research and disseminating results. It participates in the energy research requirements for the region .
37.	Qatar Environment & Energy Research Institute (QEERI)	PO Box 5825, Doha, Qatar T:+974 44541540 F:+974 44541528 Email: qeeri-info@qf.org.qa www.qeeri.org.qa	Launched in 2011, QEERI is the member of Qatar Foundation for Education, Science and Community Development (QF) entrusted to conduct and coordinate long-term and multidisciplinary research that addresses critical national priorities concerning energy and the environment, by integrating knowledge of the energy, environment, food and water resources in ways appropriate for Qatar and the region.
38.	Qatar Dolphin Energy Limited	Dolphin Energy Tower - West Bay Area number 61, Block number 7 P.O. Box 22275 Doha, Qatar T:+974 44949494 F:+974 44949490 Email: info@dolphinenergy.com http://www.dolphinenergy.com	Dolphin Energy is a subsidiary of UAE's Mubadala, and a joint venture project in Qatar with QP.Its strategic energy initiative aims to produce, process and supply substantial quantities of natural gas from offshore Qatar to the United Arab Emirates and Oman over 25 years.

39.	Energy City Qatar	T+974 44999111 Email: investments@energycity.com http://www.energycity.com	ECQ's vision is to create Middle East's first energy business centre catering to commercial, technical and human resources needs of the oil, gas and hydrocarbon business which is the backbone of the Qatari economy.
40.	ExxonMobil	P.O. Box 22500 Doha-Qatar	ExxonMobil Qatar Inc. (EMQI) is a subsidiary of Exxon Mobil Corporation, the world's largest publicly traded petroleum and natural gas company.
41.	Qatar Science & Technology Park	T:+974 44547070 F:+974 44547011 E-mail: info@qstp.org.qa	Qatar Science & Technology Park (QSTP) is the national agency charged with executing applied research and delivering commercialized technologies in four areas: Energy, Environment, Health Sciences, and Information and Communication Technologies.
42.	Shell in Qatar	P.O. Box 3747 Al Mirqab Tower - 1st Floor Corniche Road-West Bay Doha-State of Qatar T:+974 44957777 F:+974 44957778	Involved with Pearl Gas to Liquids (GTL) which is the largest project launched in Qatar. The Shell's global expertise is supporting the region's energy development and the company has established a world-class research and development facility and a learning centre at the Qatar Science & Technology Park.

43.	Maersk Oil Qatar	Al Jazi Tower, 950 Asia Street, P.O. Box 22050 Doha, Qatar T:+974 44013301 F:+974 44013403	Maersk Oil is an international oil and gas company with operated production of about 625,000 barrels of oil equivalent per day. It produces oil and gas in Denmark, the UK, Qatar, Kazakhstan, Brazil and Algeria. Exploration activities are ongoing in Angola, Norway, the US Gulf of Mexico, Greenland and in the producing countries.
44.	Al Shaheen Holding Co. Qatar	1st Floor, Al Emadi Financial Square (opposite Holiday Villa) 'C ' Ring Road, Doha , State of Qatar P.O Box No - 27100, T:+974 44521618 F:+974 44293460	In line with QP’s strategy to maximize Qatar’s natural resources and diversify its participation in related industries, Al-Shaheen Holding (formerly Al-Shaheen Energy Services Company) was established as a 100% owned subsidiary of QP in 2006 to develop as a leading national energy services provider by establishing or acquiring companies, either wholly owned or joint venture partnerships with the world’s leading energy services providers. The portfolio of companies operate in the following sectors: Oil & Gas services Pipeline Integrity Solutions Assembly of heavy equipment for oil & gas plants Mechanical construction Plant and oil & gas heavy equipment maintenance

45.	Qatar General Electricity & Water Corporation	Corniche Street, Number 61 Sheraton Roundabout P.O. Box 41 Dafna Area Doha, Qatar F:+974 44845496 T:+974 44845555 Email: contactus@km.com.qa	The Ministry of Electricity and Water was created in 1971. KAHRAMAA works to provide customers high quality electricity and water services, and value for its shareholders. KAHRAMA is a commercial entity that complies with health, safety and environmental standards locally and internationally.

	Kingdom of Saudi Arabia (K.S.A)		
46.	Kingdom of Saudi Arabia Ministry of Petroleum and Mineral Resources	P.O. Box 757, Airport Road, Riyadh 11189	Established in 1960, the Ministry of Petroleum and Mineral Resources is responsible for establishing and administering policies related to oil, gas and minerals. The Ministry oversees affiliate companies by monitoring activities related to petroleum and petroleum products, from exploration and development to refining and distribution. The Ministry is responsible for national planning in the area of energy and minerals, including petrochemicals. Specifically, the Ministry monitors: ♥ Saudi Arabian Oil Company (Saudi Aramco) ♥ Saudi Texaco ♥ Aramco Gulf Operation Ltd (AGOC) ♥ Saudi Geological Survey Both the Ministry of Petroleum and Mineral Resources and the Supreme Council for Petroleum and Minerals have oversight of the oil and gas sector in Saudi Arabia.
47.	Saudi Aramco	P.O. Box 5000 Dhahran 31311 Saudi Arabia T:+966 38720115 F:+966 38738190 Email: webmaster@aramco.com	The major oil and gas company in KSA. Operating and delivering petroleum energy since 1933.
48.	Aramco Gulf Operation Company (AGOC)	Aramco Gulf Operations Company Ltd. Third Floor, Office Park Building PO Box 688 Al Khafji 31971 Kingdom of Saudi Arabia alsultanbf@kjo.com.sa	Aramco Gulf Operations Company is incorporated as 100% subsidiary of the Kingdom's national oil company Saudi Aramco and operates as an independent entity with its own Board of Directors, responsible to Saudi Aramco as shareholder.

49.	AL Khafji Joint Operations (KJO)	P.O. Box 256 or P.O. Box 688 Al-Khafji 31971 Kingdom of Saudi Arabia T:+966 37652000	KJO is a joint operation between two national companies comprising of Kuwait Gulf Oil Company (KGOC) and Aramco Gulf Operations Company (AGOC) , were (AGOC) runs the Saudi share and the Kuwait Gulf Oil Company (KGOC) runs the Kuwaiti share. The main business of KJO is oil & gas production in the ALKhafji zone stranded between Kuwait and the Kingdom of Saudi Arabia.
50.	Saudi International Petro -Chemical Co.	AL-RIYADH OFFICE P.O. Box: 251 Riyadh-11411 Saudi Arabia T:+966 12037736 F:+966 12037738	Established in 1999, Saudi International Petrochemical Company (Sipchem) manufactures and markets methanol, butanediol, tetrahydrofuran, acetic acid, acetic anhydride, vinyl acetate monomer, as well as carbon monoxide through its various affiliates. It has been listed on the Saudi stock market since 2006. It serves its customers in the construction, solvents, automotive, electronics, polymer, coatings, and pharmaceutical industries.
51.	King Abdullah City for Science and Technology	King Abdulaziz City for Science and Technology, Kingdom of Saudi Arabia P.O Box 6086, Riyadh 11442 T:+966 14883555 F:+966 14813274	King Abdulaziz City for Science and Technology (KACST) is an independent scientific organization administratively reporting to the Prime Minister. KACST is both the Saudi Arabian national science agency and its national laboratories. The science agency function involves science and technology policy making, data collection, funding of external research, and services Mandate includes: 1. Coordinate with government agencies, scientific institutions and research centers in the Kingdom to enhance research and exchange information and expertise. 2. Conduct applied research and provide advice to the government on science and technology matters. 3. Support scientific research and technology development.

52.	Ministry of Water & Electricity	Saud Mall Center Ministry of Water and Electricity Building King Fahad Road Mohammadiah Area Riyadh, Saudi Arabia City Suffix: 11233 T:+966 12038888 T:+966 12052981 T:+966 14040180 F:+966 12050557 F:+966 12052748 Email: info@mowe.gov.sa www.mowe.gov.sa	The Ministry is in charge of providing electricity & water utilities in the Kingdom of Saudi Arabia covering major water and electricity projects.
53.	King Abdullah City for Atomic and Renewable Energy (K.A. CARE)	Email: info@energy.gov.sa T:+966 18085555 F:+966 14615969	K.A.CARE was established with a mandate to contribute to sustainable development in the Kingdom. Located in Riyadh, K.A.CARE endeavors to meet Saudi Arabia's future electricity demand, projected to nearly triple in the next 20 years. It aims to focus on renewable energy, taking advantage of the Kingdom's abundant natural resources—such as high solar intensity and promising wind and geothermal resources—and atomic energy to achieve a balanced energy mix in the Kingdom.
54.	SABIC	PO Box 5101 Riyadh 11422 Kingdom of Saudi Arabia T:+966 (0)1 225 8000 F:+966 (0)1 225 9000 www.sabic.com.sa	SABIC was established in 1976 with the objective of adding value to Saudi Arabia's natural hydrocarbon resources. Headquartered in Riyadh, SABIC today is among the leading petrochemical companies in terms of sales, profitability and product diversity.

	United Arab Emirates (UAE)		
55.	Supreme Petroleum Council (SPC) Abu Dhabi	Supreme Petroleum Council Corniche Road ADNOC building Abu Dhabi P.O. Box: 26555 T:+971 26020000 F:+971 26661001 E-Mail: spc@adnoc.com	The Supreme Petroleum Council was established under law No. (1) of 1988. The Council is the superior authority responsible for the petroleum industry in the emirate of Abu Dhabi. The Council formulates and oversees the implementation of Abu Dhabi's petroleum policy and follows up its implementation across all areas of the petroleum industry to ensure that the set goals are accomplished. The Supreme Petroleum Council received all roles, duties, and authorities of the Board of Directors of Abu Dhabi National Oil Company (ADNOC) and the Petrol Department.
56.	Abu Dhabi National Oil Company (ADNOC)	P.O. Box : 898. Abu Dhabi United Arab Emirates T:+971-26020000 F:+971-26023389	Abu Dhabi National Oil Company (ADNOC) was established in 1971 to operate in all areas of the oil and gas industry and creating an integrated oil and gas industry in the fields of exploration and production, support services, oil refining and gas processing, chemicals and petrochemicals, maritime transportation and refined products and distribution.
57.	Abu Dhabi Company for Onshore Oil Operations (ADCO)	P.O. Box 270, Abu Dhabi United Arab Emirates T:+9712-6040000 F:+9712-6665523	The Abu Dhabi Company for Onshore Oil Operations (ADCO) operates onshore and in the shallow coastal waters of the Emirate of Abu Dhabi.
58.	Abu Dhabi Gas Liquefaction Company	P.O. Box 3500, Abu Dhabi, U.A.E. T:+971 26061111 F:+971 26065500 http://www.adgas.com	Abu Dhabi Gas Liquefaction Company (ADGAS) was established in 1973, with LNG marketing agreements with Japan. The plant was commissioned in1977, and the first LNG shipment left Das Island to Tokyo in April 29 of the same year, marking ADGAS a pioneer of LNG industry at the time.

59.	Abu Dhabi Gas Industries Ltd.	P.O. Box 665 Abu Dhabi, United Arab Emirates. GASCO Head Office is located on Khalifa Street near Sheraton Hotel on Corniche Road. Head Office Reception: T:+971 26037337 T:+971 26037399 F:+971 26037414	Abu Dhabi Gas Industries Ltd. (GASCO) was established in 1978, in Abu Dhabi for the utilization of the Emirate's significant gas resources. The incorporation and establishment of GASCO as a joint venture between the Abu Dhabi National Oil Company (ADNOC), Shell, Total, and Partex, and the integration of ATHEER (a wholly owned ADNOC Company) .in 2001, supported GASCO in realizing the vision to be one of the most innovative, respected and caring companies in the gas and hydrocarbon industry.
60.	Masdar	Masdar City Opposite Presidential Flight Khalifa City A P.O. Box 54115 Abu Dhabi, UAE MASDAR (627327) T:+971 26533333 T:+971 26536002 Email: info@masdar.ae	Established to make Abu Dhabi the pre-eminent source of renewable energy knowledge, development, implementation and the world's benchmark for sustainable development. To advance renewable energy and sustainable technologies through education, research and development, investment, commercialization and adaptation.
61.	Dolphin Energy	Abu Dhabi Trade Center Building East Tower, 2nd & 3rd Floor P.O. Box 33777 Abu Dhabi, UAE T:+971 26995500 F:+971 26446090 Email : info@dolphinenergy.com	The Dolphin Gas Project of Dolphin Energy Limited is a strategic energy initiative to produce, process and supply substantial quantities of natural gas from offshore Qatar to the United Arab Emirates and Oman . Dolphin is a subsidiary of Mubadala.
62.	Abu Dhabi Water & Electricity Authority (ADWEA)	PO Box6120 Abu Dhabi UAE T:+971 26943333 F:+971 26943192 www.adwea.ae	ADWEA is dedicated to providing water and electricity, guidance, collaboration and partnership. The Abu Dhabi Water & Electricity Authority researches and develops ways to more efficiently produce, distribute and consume water and electricity. Owned by the Abu Dhabi Government, ADWEA operates independently with financial and administrative autonomy.

63.	Crescent Petroleum Company	Crescent Tower P.O. Box 211, Corniche Al Buhaira Sharjah, United Arab Emirates T:+971 65727000 F:+971 65726000 e-mail: mail@crescent.ae	Crescent Petroleum has been operating as a regional upstream oil and gas company in the United Arab Emirates for almost 40 years. It began its activities in the early 1970's and engages in the acquisition, exploration and development of petroleum concessions; and the production and sale of crude oil, petroleum products and natural gas.
64.	Rak Petroleum	RAK Petroleum Public Limited Company 23rd Floor Festival Tower Dubai Festival City P.O. Box 62042 Dubai United Arab Emirates T:+971 42932000 F:+971 42932001 info@rakpetroleum.ae	Founded in 2005, RAS ALKHAIMA Petroleum is a Public Limited Company is an energy holding company with a proven track record and strong connections in the Middle East. RAK Petroleum has active exploration and production operations in seven concessions across three Middle East-North Africa countries.

19. GLOSSARY

The definitions below explain the basic terminologies used in this guidebook:

Energy management

Energy management is the use of management and technology to improve an organization's energy performance. Usually it pertains to integration, proactively, energy procurement, energy efficiency and renewable energy. Energy management is very important to control costs and ensure legal compliance, and can enhance the organization's reputation.

Energy efficiency

Energy Efficiency is defined in terms of use of engineering and economic principles to control the direct and indirect cost of energy without any compromise to the function. The objectives of energy efficiency is to maximize the output from each unit of energy consumed; i.e., to achieve the same output with less energy.

Energy Manager

Energy Manager is used to refer to the person responsible for implementing the organization's energy program. In most cases, organizations do not have a dedicated Energy Manager as the task is considered a part-time assignment.

Renewable energy

Renewable energy is energy that exists naturally in the environment and is not finite. They include wind, water waves, the sun and geothermal heat from the ground. Unlike energy from fossil fuels, renewable energy occurs in abundance in nature.

20. ACRONYMS

ABS	Acrylonitrile Butadiene Styrene
AHUs	Air Handling Units
ASME	American Society of Mechanical Engineers
BAS	Building Automation System
BOD	Biochemical Oxygen Demand
CHWP	Chilled Water Pump
CIPEC	Canadian Industry Program for Energy Conservation
CNC	Condensation Nuclei Counter
CT	Cooling Towers
CWP	Condenser Water Pumps
DG	Diesel Generator
ECMs	Energy Conservation Measures
EEI	Energy Efficiency Index
EI	Energy Intensity
EMS	Energy Management System
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GOIC	Gulf Organization for Industrial Consulting
GSPX	GCC Subcontracting and Partnership Exchange
HVAC	Heating Ventilation Air-conditioning
IEA	International Energy Agency
ITA	Industrial Technical Assistance
KW	Kilowatt
KWH	Kilowatt-hour
LED	Light Emitting Diode
LF	Load Factor
LNG	Liquefied National Gas
MW	Megawatt
PAC	Portable Air-conditioning Unit
PVC	Poly Vinyl Chloride
SMEs	Small and Medium Enterprises
TOC	Total Organic Carbon

21. REFERENCES

- *Barriers to Energy Efficiency Guide for Industry in Asia:www.energyefficiencyasia.org UNEP , June 2006.*
- *Energy Conservation Program, Code of Practice MEW/R-6/2010, Second Edition. Ministry of Electricity and Water, Kuwait.*
- *Global Industrial Energy Efficiency Benchmarking, An Energy Policy Tool working paper, UNIDO ,November 2010.*
- *Energy Audit Practice in China: National and Local Experiences and Issues, Energy Policy, volume 46-July 2012, page 346-358.*
- *A guide for Egyptian Enterprises "How to become an Energy Efficient Company , Deutsche German Technical Corporation, Federal Ministry for Economic Cooperation and Development.*
- *Energy Efficiency in developing countries for the manufacturing sector, Nicola Cantore, Overseas Development Institute, UNIDO , Vienna, 2011.*
- *Energy Efficiency Planning and Management Guide – A publication of Canadian Industry Program for Energy Conservation (CIPEC), the office of Energy Efficiency of Natural Resources Canada.*
- *The UNEP program "Energy Efficiency Guide for Industries in Asia" in 2006.*
- *Options for Energy Efficiencies in India and Barriers to their Adoption: Scoping Study, Soma Bhattacharya and Maureen L. Cooper, April-2010.*
- *Energy Subsidies in the Arab World, Bassam Fattouh & Laura El-Katiri. Research Paper Issued by Regional Bureau for Arab States Arab Human Development Report Research (ASDR).*
- *Energy Saving Tool Box – An Energy Audit Manual and Tool: Canadian Industry Program for Energy Conservation (CIPEC) and Canadian Industry and Office of Energy Efficiency of Natural Resources Canada.*
- *National Action Plan for Energy Efficiency Vision for 2025: A Framework for Change. A Recourse of the National Action Plan Energy Efficiency, November 2008.*
- *Energy Security Initiative (ESI) Options for Low–Carbon Development in Countries of the Gulf Cooperation Council, Policy Brief Series – June, 2011.*
- *Industrial Energy Audit Guide Book: Guidelines for conducting an Energy Audit in Industrial Facilities, Ali Hasanbeigi, Lynn Price, China Energy Group Energy Analysis Department. Issued by Ernest Orlando Lawrence Berkeley National Laboratory, October 2010.*
- *Key World Energy Statistics, 2012 published by International Energy Agency (IEA)*
- *Manual for the Development of Municipal Energy Efficiency Projects - INDIA, 2008 presented by International Finance Corporation (IFC).*
- *Industrial Development Report – 2011, "Industrial Energy Efficiency for Sustainable Wealth Creation" published by UNIDO.*
- *Indian Energy Efficiency Institute, checklists for Energy Efficiency.*
- *American Society of Mechanical Engineers (ASME) energy assessment standards.*
- *An Energy Efficiency Guide for Industrial Plant Managers in Ukraine, by Meredyd Evans, June 1999*
- *EMAS Energy Efficiency Toolkit for SMEs, European Communities 2004*

22. FEEDBACK

Energy Efficiency Guidebook For Industries

GOIC welcomes comments and feedback from readers and users of this guide. Your feedback is valuable as it will help us improve the contents of this guidebook in future editions.

Please send your feedback to:

Director of Industrial Support
PO BOX 5114,DOHA, QATAR
Tel: +974 4485 8748 , Fax: +974 4485 7602
Email : ita@goic.org.qa

منظمة الخليج للاستشارات الصناعية
Gulf Organization For Industrial Consulting

Gulf Organization for Industrial Consulting
PO BOX 5114,DOHA, QATAR
Ph: +974 4485 8888 , +974 4485 8748
Fax: +974 4485 7602
Email : ita@goic.org.qa

www.goic.org.qa