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Energy Conservation Strategies and Peak Loads Management in Sever Climate Countries

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Abstract
Energy conservation aims to reduce energy consumption. Energy conservation can be achieved by the efficient use of energy, as well with the decreased of energy consumption and/or managing consumption of conventional energy sources. Energy conservation is positively enhanced financial capital, environmental quality, national security, personal security, and human comfort. Individuals and organizations that are direct consumers of energy can directly benefit from energy conservation if they choose to conserve energy to reduce energy costs and promote economic security. Industrial and commercial users can also maximize their profit by using energy efficiently. Peak load management is now becoming increasingly important for the Gulf region as well as countries with sever climate, as the growing energy demand is barely met by electric company's capacity. A smart transmission system is needed to cope with the maximum load demands during peak hours; however, such system is very expensive. The utility of the smart transmission cannot be undermined keeping in view of that it can reduce the peak electrical demand and can save tremendous amounts of money for utilities, industry, and ratepayers. It is not enough to give attention to how much energy is consumed, but-now we must also pay more attention to when energy is consumed. Thermal storage has proven to be a commercial method for combating peak load demands. In addition to that the energy conservation strategies are being adopted in Saudi Arabia to cope up with the rapidly increase in electricity consumption. In this paper all the above mentioned have been discussed and solutions have been proposed.
Keywords: energy conservation, energy consumption, peak load management, smart transmission

1. INTRODUCTION

Energy conservation concepts are gaining popularity in Gulf countries as well as sever climate countries, due to fact that the power demand is growing at the rate of 7% per year. Figure 2, shows the forecast for energy demand in S.A. for the next decay. It is shown that S.A. needs 60GW by the year 2020.The investment to get this demand will be huge.

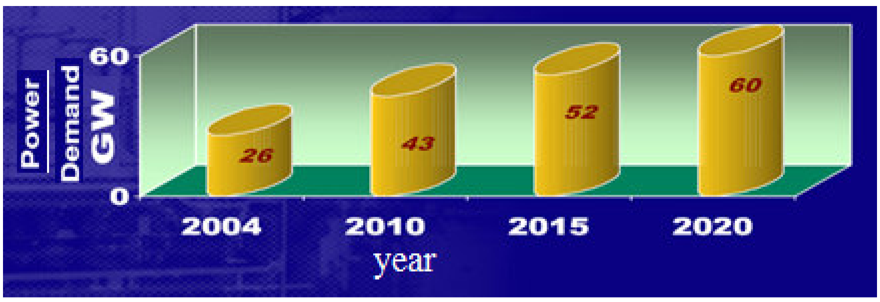
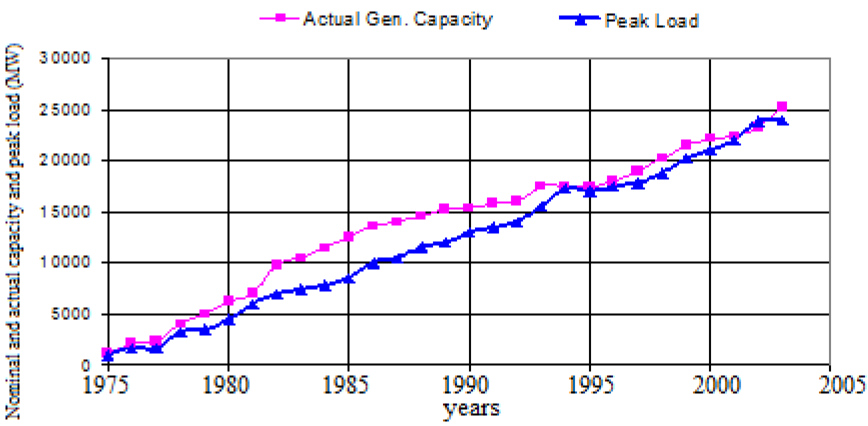
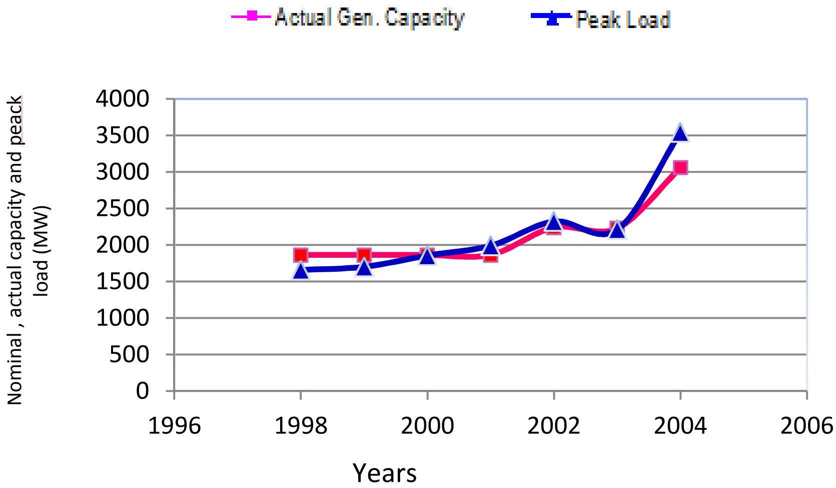


Figure 1, Variation of power demand for KSA

While this high power demand exists, another challenge rises. Peak load issue create unbalancing in power demand and put a huge pressure on the electric company. The power needs reaches their maximum for only couple of hours per day and couple of months per year. This peak demand sometimes reaches double of the regular need. Therefore it is evident that the eventually generation capacity and transmission capacity will not be able to meet demand. Figure 2 depicts the growth of electricity generation and peak load for KSA and Qatar. From the figure it is clear that during many years the peak load matches or become higher than the generated electricity, which causes an overload for electric companies.



(a)



(b)

Figure 2: Growth of electricity generation capacity and peak load, (a) in Kingdom of Saudi Arabia (b) in Qatar.

The per capita energy consumption for KSA is higher than most industrial and developed nations. Interestingly the domestic sector is the major electrical power consumer in the Kingdom. The electrical consumption for various sectors are shown below in Figure 3. With the increased oil prices, the utility rates are increasing and are expected to continue to increase as demand increases. This will put a serious economic burden on the domestic sector. It is to be noted that the Load Factor for KSA Averages 51%, which is a low value. Under these circumstances, it is need of the time to cope up with the energy management strategies as well as make awareness among public for energy conservation methods.

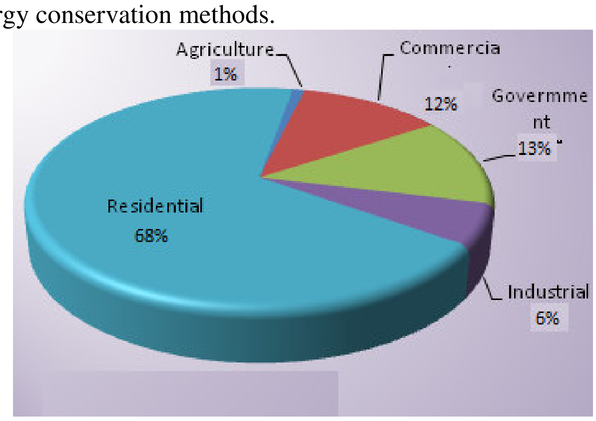


Figure 3: Electric Power Consumption for KSA

The demand for energy, the consumption of fossil fuels and the release of pollutants continues relentlessly. In the industrialized world, the requirement for high rates of employment demands high rates of consumption of energy and raw materials. As a result of which prices of fuels and electricity remain at artificially low levels, encouraging even greater demands. So we have to adopt different Energy Conservation techniques (in industrial units, commercial & residential buildings and transportation system) which would result in saving energy and money whilst reducing environmental pollution. The ability of any nation to survive economically depends upon its ability to produce and manage sufficient supplies of low cost safe energy and raw materials.

Energy conservation is given much attention in countries of sever climate. The same is true for growing countries in which the production of power is not managed well. Many stratigeis were utilize in such countries, i.e.: different Tarrif rates and using insulation materials in building. Altough these stratigies were efficient and important, but they did not regulate the consumption rate and sometimes causing unbalance in livestyle. Sometimes they causes unhapennies for people and reduce the income rate. The need of long term strategies that can survive is an issue. The goal is to develop strategies that the people will like them and reduce the cost on them. The comfort of people should not be touched as well as their productivity. Some strategies were developed to achieve these goals. Some of them concern with construction of the new building and the others concern with the existing buildings. For new building, new technology in constructions like using Termodeck slabs and using thermal insulation are encouraged. In addition, adopting efficient HVAC system and using smart electrical equipment are required. Thermal storages are given high attention and are encouraged to be adopted while building huge buildings.

AlQdah et al., (2010) discussed about rising concern about energy resource availability and energy prices in Jordan. In their study, energy auditing in a meat production factory related to poultry company was carried out. Based on the collected data and the conservation laws of energy, the performance of steam boilers, domestic hot water boilers, compressors, refrigeration systems, chillers, pumps, daily consumption of diesel and water were reviewed. The percentage of energy consumed by the refrigeration units, with respect to the total energy consumed, has been estimated. The results demonstrated a normal operation with thermal efficiency of 80.66% for the steam boiler, ability to save 18818.99 JD by installing economizer with payback period of 0.637 year and a 12.3% reduction of the energy cost achieved by reducing the blow down rate. This study demonstrated that energy saving can be considered as an ideal choice to increase profit and promote competition within the poultry industry if the company adopts all the proposals and recommendations that have been offered by this study.

Balat et al., 2010 discussed about energy security which has recently gained importance for many commercial, industrial, and government facilities. Increasing the security of energy supply is essentially a strategy to reduce or hedge risks that derive from energy use, production and imports. The aim of the work was to identify the main challenges concerning the security of energy supply in Turkey and to offer solutions. Rapid population growth and economic development in the country have resulted in rapid increases in energy demand in recent years. Ghandoor et al., (2012) presented the detailed analysis of the energy and exergy utilizations of the Jordanian. Small-Medium Enterprises (SMEs) by considering the flows of energy and exergy through the main end uses in the Jordanian industrial sector. To achieve this purpose, a survey covering 180 facilities was conducted and energy consumption data was gathered to establish detailed end-use balance for the Jordanian industrial sector. The energy end-use balance provides a starting point to estimate the site and embodied energy and exergy efficiencies. Hassouneh et al., (2010) studied the influence of windows on the energy balance of apartment buildings in Amman is investigated by using self developed simulation software (SDS) based on the ASHRAE tables. It was found that choosing a larger area facing south, east and west can save more energy and decrease heating costs in winter using certain types of glazing, while decreasing the glazing area facing north can save money and energy.

Peak load is receiving considerable attention in the hot regions weather as well as cold region weather. Strong growth in demand matched with very little growth in transmission capability is eliminating the margin of extra capacity that guarantees the supply system's reliability. One or two major failures (such as the loss of a major cross-mountain transmission line) during periods of high demand could cause a major voltage collapse, resulting in loss of power throughout the region. To address the issue of the peak load, plans are being developed by some countries/energy producing companies. Claus et al. (2010) addressed future power systems with additional wind power capacity. There will be an increased need for large scale power management as well as reliable balancing and reserve capabilities. Different technologies for large scale electricity storage provide solutions to the different challenges arising with high wind power penetration. They presented a review of the electricity storage technologies relevant for large power systems.

2. ASPECTS OF ENERGY CONSERVATION

When dealing with the design of energy conversion systems, several complex aspects must be considered, ranging from energy concerns to economic evaluations, social benefits and environmental requirements. Different approaches have been developed and are presently used for the analysis of each aspect, but no consensus exists within the scientific community about the need or even the possibility of a unified evaluation

procedure. The problem and the way of considering different viewpoints in the design and operation of energy systems are therefore crucial.
Energy conservation measures can be classified into the three broad action categories depending upon the required level of investment and associated cost's saving. These are shown in Table 1 .

Decisions on investment will be aided by comparing values of energy consumption with those available from best practice programs for the same area of activity. Such data are normalised to parameters taking into account differences in site conditions. For example:

$$\frac{\text{hWh}}{\text{employee}}, \frac{\text{kWh}}{\text{unit floor area}}, \frac{\text{kWh}}{\text{manufactured article}}, \frac{\text{kWh}}{\text{mass of product}}$$

Historical data for the same site provides useful indices to assess changes in energy consumption with time. Cost benefit analysis should always be undertaken on energy conservation measures and, for significant investment; this should include discounted cash flow methods of financial appraisal.

Table1 Categories of energy conservation in relation to investment

Action	Investment Level	Possible Energy Saving % of Total Consumption
Good housekeeping - monitoring of energy use, correct temperature control setting for equipment, assess thermal plant efficiency, improve maintenance schedules, energy audit ...	Nil	15%
Improvements to measurement and control of energy flows assess insulation thicknesses and increase if necessary, staff training....	Moderate - purchase of controllers and instruments, pipe insulation, short training courses in energy saving for company staff.	40%
New equipment and employment of energy manager.....	High - purchase of high efficiency thermal plant, energy recovery equipment, staff costs.	> 40%

3. STRATEGIES OF ENERGY CONSERVATION

3.1 Peak Load Management

Although peak load is currently a big hassle for Gulf region, it will be increasingly important in other areas with growing demand. The peak load can occurs in daily basis or in annual cycles of the year. As Figure 4 illustrates, in summer the greatest demand typically occurs at noon-afternoon time during hot weather (other regions tend to have winter heating peaks). Shifting loads away from that time period reduces peaks. Residential water heat, space cooling, and industrial processes are all good candidates for load shifting.

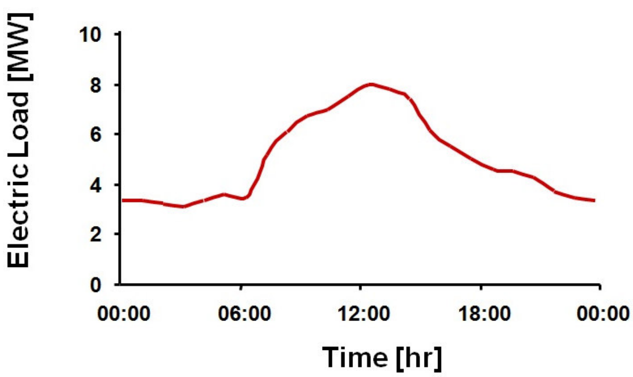


Figure 4, Electric Consumption during Summer Day during for King Abdulaziz city for science and technology, in Riyadh

This is the actual available power used to meet minimum expected customer requirements at a given time (baseload demand). Baseload supply is not the opposite of baseload demand. It's actually the opposite of peak supply. Price structures for baseload supply tend to run in the opposite direction of prices for peak supply. Baseload supply tends to be steady and relatively cheap, although the fixed costs are normally much higher than peak supply prices. Peak supplies tend to be costly, but fixed costs are relatively low since the facilities used to generate peak supplies don't have to be in steady operation.

These two terms are used interchangeably to denote the maximum power requirement of a system at a given time, or the amount of power required to supply customers at times when need is greatest. They can refer either to the load at a given moment (e.g. a specific time of day) or to average load over a given period of time (e.g. a specific day or hour of the day).This term does not refer to the amount of energy available when supply is at peak. Instead it refers to the party who supplies energy used to meet peak demand requirements. In other words, a peak supply is a supply of energy which will be used to augment existing energy sources during periods of peak demand. As examples, the noontime output of a hydroelectric generator is not considered to be a peak supply.

M. Kellow and D. Jarrar (1990) performed a design optimization and a cost effectiveness analysis for a solar air-conditioning (A/C) system intended to operate in combination with a conventional A/C system in a peak load time, shaving mode under Kuwait's environmental conditions. A basic design was prepared, and a computer simulation model was used in optimizing system design. They investigated type and size of component equipment, mode of operation and control in terms of energy efficiency and cost effectiveness. The optimally designed solar system proved to be marginally more expensive than the conventional cooling system, though it held a good potential of becoming cost effective. The design for peak load shaving operation resulted in significant improvements in the energy efficiency and cost effectiveness of the system in relation to an equivalent system for standalone operation.

The peak supply is instead the generating unit which produces output for noontime use.A generating facility operated expressly for the purpose of providing peak energy supply. Peak load stations are typically operated only during particular times of day or at times of the year when there is a spike in the demand for energy for heating or cooling systems. Peak load stations tend to be cheaply-constructed turbine generating units that do not use steam as an intermediate carrier of energy, and are thus less fuel-efficient and more costly to operate. The fact that they are only operated at particular times also makes them more costly to maintain, and these extra costs are typically factored into the energy costs of the heaviest consumers of energy during peak demand periods. This term does not refer to the amount of energy available when supply is at peak. Instead it refers to the party who supplies energy used to meet peak demand requirements. In other words, a peak supply is a supply of energy which will be used to augment existing energy sources during periods of peak demand. As examples, the noontime output of a hydroelectric generator is not considered to be a peak supply. The peak supply is instead the generating unit which produces output for noontime use.

M.R. Amin-Naseri and A.R. Soroush (2008) presented a hybrid neural network model for daily electrical peak load forecasting (PLF) using a self-organizing map for classifying the days of the year based upon two factors, peak load and temperature at the time of the peak load. Since peak loads usually follow similar patterns, classification of data improves the accuracy of the forecasts. Several factors in peak load, e.g. weather temperature, relative humidity, wind speed and cloud cover, were introduced into the model in order to enhance forecast quality. The Davies–Bouldin validity index was introduced to determine the best clusters. To evaluate the effectiveness of the proposed hybrid model (PHM), forecasting has been performed by developing a feed forward neural network FFNN that uses the un-clustered data. The results proved the superiority and effectiveness of the proposed hybrid model PHM. Linear regression (LR) models have also been developed for PLF, and the results indicated that the PHM produces considerably better forecasts than those of LR models. Furthermore, the results show that the suggested clustering approach significantly improves the forecasting results on regression analysis too.

Load shifting is considered as one of the simplest methods of load management which is meant to reduce customer demand during the peak period by shifting the use of appliances and equipment to partial peak and off-peak periods. Therefore, no loads are being switched off, but they are only shifted or rescheduled, and hence the total production is not affected. S Ashok and R Banerjee (2006) developed an indigenous plan for the load shifting and compared it with the actual data obtained from a local fertilizer and chemical industry plant. The results were promising and showed that the load factor can be improved and also reduced the electricity costs.

Surekha Dudhani et al, 2006 suggested to use renewable energy sources such as, small hydel power, solar photovoltaic, wind power, co-generation and biomass energy as an alternative solution to meet the peak load. The renewable sources were meant to fill the gap between peak load power demand and availability of power at the regional level. The results indicated that the power generated by renewable resources was quite suitable to meet the peak load demand and in fact some of regions had the potential to transfer electricity to other regions utilizing the existing transmission line network.

Several regions have well established peak load management programs, although most are oriented to summer peaks. Strategies that are often used in these regions and their advantages and disadvantages are listed below in table 2:

Table. 2 , Strategies for peak load management that are used in several regions and their advantages and disadvantages

No.	Strategies	Advantages	Disadvantages
1	Contractual agreements with industry to reduce consumption when needed	Provides quick, inexpensive way to reduce peak loads. Nothing new is needed to implement.	The disadvantage is that if asked to reduce loads too often, industry will cancel the contracts.
2	Utility controlled dispatch able loads is also one of the option	Reduces peak loads and gives BPA the ability to respond to emergencies.	Disadvantage is that if asked to reduce residential loads for long time periods, customers will complain about loss of hot water and cold houses.
3	Time of Use (ToU) rate structures with lower electricity rates off-peak to encourage users to shift consumption away from peak time periods (most industrial and large commercial customers already have this)	Residential-allows homeowners a choice--encourages change of habits.	Residential TOU rates require a more expensive meter (typically $200 more than the standard residential electric meter) and customer education.
4	contractual agreements with customers who have backup generators to bring those on line when needed	Power is generated where consumption occurs doesn't rely on a transmission system.	Emergency backup generator use is often limited by pollution and noise restrictions.
5	Thermal storage system	Availability for customers , not related with networks	High cost
6	TermoDeck	Availability for customers , not related with networks	Not getting familiar with
7	use of renewable technology	Decentralized production, no fuel cost	High Initial cost, Not continuous

3.1.1 Thermal Storage system

One strategy that has so far received high attention in Gulf regions is residential and small commercial building thermal storage. Space cooling with thermal storage is relatively suitable, and commercially available. Such storage can be charged late at night when the supply system has excess capacity, eliminating the noon/afternoon cooling load. A schematic of the thermal storage system with the location of the storage tank is shown in Fig.5.

If lower rates were charged at night, such a unit could pay for itself within 2 years. Residential space cooling is the largest single load during summer peaks, representing about two third of the total electrical demand on hot summer noon/afternoon. Matched with Tariff rates to motivate customers, this approach could significantly reduce peaks.

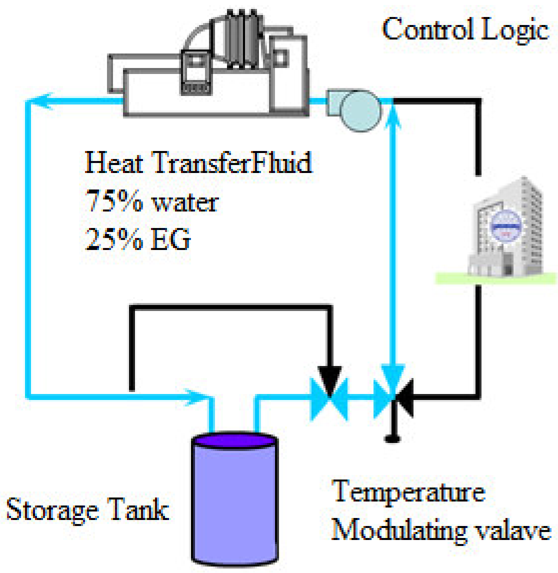


Figure 5, Schematic of the thermal storage system showing the storage tank.

Thermal storage systems offer building owners the potential for substantial operating cost savings by using off-peak electricity to produce chilled water or ice for use in cooling during peak hours. The storage medium determines how large the storage tank will be and the size and configuration of the HVAC system and components. The options include chilled water, ice and eutectic salts (see Table 3). Overall, ice systems offer the densest storage capacity but the most complex charge and discharge equipment. Water systems offer the lowest storage density but are the least complex. Eutectic salts fall somewhere in between.

Table 3: Comparing storage media

Storage medium	Volume (feet^3/ ton-hour)	Storage temperature (degrees F)	Discharge temperature (degrees F)	Strengths
Chilled water	10.7–21	39–44	41–46	Can use existing chillers; water in storage tank can do double duty for fire protection
Ice	2.4–3.3	32	34–36	High discharge rates; potential for low temperature air system
Eutectic salts	6	47	48–50	Can use existing chillers

© E Source

Chilled-water systems

Chilled-water systems require the largest tanks among the other two types, but they can interface with most existing chiller systems. They use the sensible heat capacity of water to store cooling capacity. They operate at temperature ranges compatible with standard chiller systems and are most economical for systems greater than 2,000 ton-hours in capacity. The capacity of the chilled-water thermal energy storage (TES) system is increased by storing the coldest water possible and by extracting as much heat from the chilled water as practical.

Ice Storage System

Ice thermal storage systems use the latent heat of fusion of water— 333.55 kJ/kg ()—to store cooling capacity. In order to store the energy at ice temperature, refrigeration equipments need to cool mixture brine (water/glycol) to low temperature below temperature of the conventional air-conditioning equipment. Usually special ice making equipments are needed. The low exit air temperature from ice storage system, (mid 4.44° C (40°F), versus the mid 10° C (50 °F) for conventional systems), leads to the advantage of smaller fans and ducts for the supply air.

Several technologies available for charging (creating ice) and discharging (using the ice to cool circulated fluid) storage, when ice is used as the storage medium. They are described as follows: :

- Ice harvesting systems are used to form ice. The ice is then periodically released into a storage tank that is partially filled with water.

- Ice on-coil system has emerged in recent years that offers compatibility with prepackaged direct expansion units and is capable of shifting up to 96% of peak load by charging the ice-storage system during cooler night time temperatures and meeting the entire daytime cooling load by discharging the stored ice. In charging mode, ice forms on the heat-transfer surface as either evaporating refrigerant or a water/glycol solution flows through the coils, freezing up to 95% of the water. After the ice is formed it is discharged either externally or internally. For the external discharge, a circulating warm return water over the formed ice, causing the ice to melt from outside. For the internal discharge, condensing refrigerant or warm water/glycol solution flows through the coils, melting the ice from inside to outside and delivering cooling to the distribution unit the .The resulted cold coolant in both cases is pumped to the air handling unites to cool the building.

Ice on-coil systems are available in ready tanks with capacities ranging from 50 to 500 ton-hours. Multiple tanks are used to meet the required cooling load. Multiple tanks are flexible in location, in which they can be spread throughout available space in many locations. The tanks are then piped together to form a single cooling system.

Ice slurry systems store water or water/glycol solutions in a slurry state—a partially frozen mixture of liquid and ice crystals. To meet cooling demand, the slurry may be pumped directly to the load or to a heat exchanger that cools a secondary fluid that circulates through the building's air handling unites. In order to male the slurry ice , a high cost emulsion needs to be produced. Tetradecan, $C_{14}H_{30}$ can be used with certain surfactant to create emulsion that can frozen in about 7^oC, same as exit temperature of chiller.

It is well know that accumulating ice around tubes will reduce the heat transfer coefficient, since the ice will act as insulation layer because of its low thermal conductivity. This is not the case for the ice slurry systems in which the ice will not stick to the pipes and it will formed and falls into the tank directly, which in this case increases the heat transfer coefficient. Due to lack of options of materials and surfactants that can make ice slurry, more investigation and research is needed in that area to come up with low price emulsion.

Internal melt ice-on-coil systems are the most commonly used type of ice storage technology in commercial applications. External melt and ice harvesting systems are more common in industrial applications, although they can also be applied in commercial buildings and district cooling systems. Ice slurry systems have not been widely used in commercial applications.

Eutectic salts systems

Eutectic salts systems also known as phase-change materials; use a combination of inorganic salts, water, and other elements to create a mixture that freezes at a desired temperature. The material is encapsulated in plastic containers that are stacked in a storage tank through which water is circulated. The most commonly used mixture for thermal storage freezes at 8.3°C (47°F), which allows the use of standard chilling equipment to charge storage, but leads to higher discharge temperatures. That in turn limits the operating strategies that may be applied. For example, eutectic salts may only be used in full storage operation if dehumidification requirements are low.

Operating Strategies

Several strategies are available for load charging and load discharging to meet cooling demand during peak hours. They are described below.

Full storage. A full-storage strategy, also called load shifting, shifts the entire on-peak cooling load to off-peak hours (see Figure 6a). The system is typically designed to operate at full capacity during all nonpeak hours to charge storage on the hottest anticipated days. This strategy is most attractive where on-peak demand charges are high or the on-peak period is short.

Partial storage. In the partial-storage approach, the chiller runs to meet part of the peak period cooling load, and the remainder is met by drawing from storage. The chiller is sized at a smaller capacity than the design load. Partial storage systems may be run as load-leveling or demand-limiting operations.

In a load-leveling system (see Figure 6b), the chiller is sized to run at its full capacity for 24 hours on the hottest days. The strategy is most effective where the peak cooling load is much higher than the average load.

In a demand-limiting system, the chiller runs at reduced capacity during on-peak hours and is often controlled to limit the facility's peak demand charge (see Figure 6c). Demand savings and equipment costs are higher than they would be for a load-leveling system and lower than for a full-storage system.

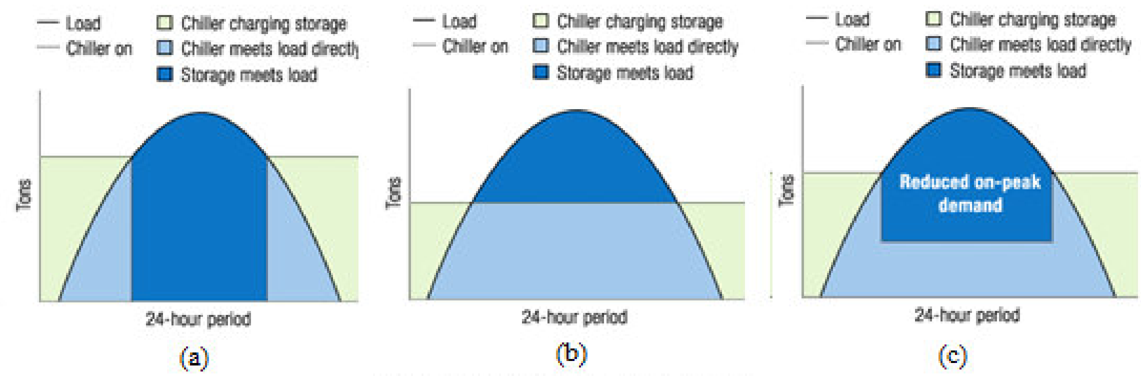


Figure 6: The available strategies for charging and discharging storage to meet cooling demand during peak hours. (a) Full-storage operating strategy, (b) Partial-storage load-leveling operating strategy, (c) Partial-storage demand-limiting operating strategy.

3.2 Using TermoDeck to manage peak load

TermoDeck system is a technology that has been widely spread in severe weather countries like Saudi Arabia. It is integrated with the heavy structure of a building. The duct part of the cooling or the heating system consists of hollow core concrete slabs instead of traditional steel ducts. The supply air passes through the hollow cores before entering the room as in Fig.7 . The hollow slabs serve as a roof of the room as well as a floor for the above room.

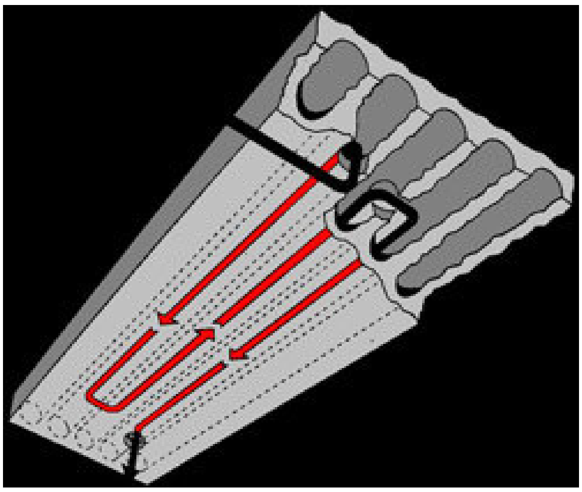


Figure 7, A schematic of airflow inside the slab

By this way , TermoDeck can regulate the internal temperatures of the building, in which the slabs work as heat exchangers between the supply air and the rooms. The floor/ceiling slabs serve many purposes: Besides from being the structural floor it conveys fresh air into the building and it serves also as an energy store. No ducts and therefore no false ceilings are required in individual rooms. The only duct is needed on the corridor to transfer air from the air handling unite and the hollow slabs. This allows total freedom for the interior designer to locate, or re-locate in the future, the internal wall partitions.

TermoDeck can be combined with all types of air-conditioning (AC) units. From the AC-unit, generally placed on the roof, supply air ducts run in vertical shafts down to each floor inside the building and then to horizontal ducts placed in central corridors usually within false ceilings as shown in Fig. 8 . Small branch ducts feed air into each slab and the air then enters a room via diffusers fixed to the soffit of the slab. Diffusers are normally located close to external walls. The exhaust air is normally removed into the central corridor plenum and is returned to the AC-unit in the conventional way. The main distribution ductwork in the corridor is similar in construction to that found in conventional systems. The main difference with TermoDeck is that every individual structural hollow core slab is supplied with a small quantity of air from the main supply duct; in other words a small 'feed' duct every 1200mm along the length of the corridor.

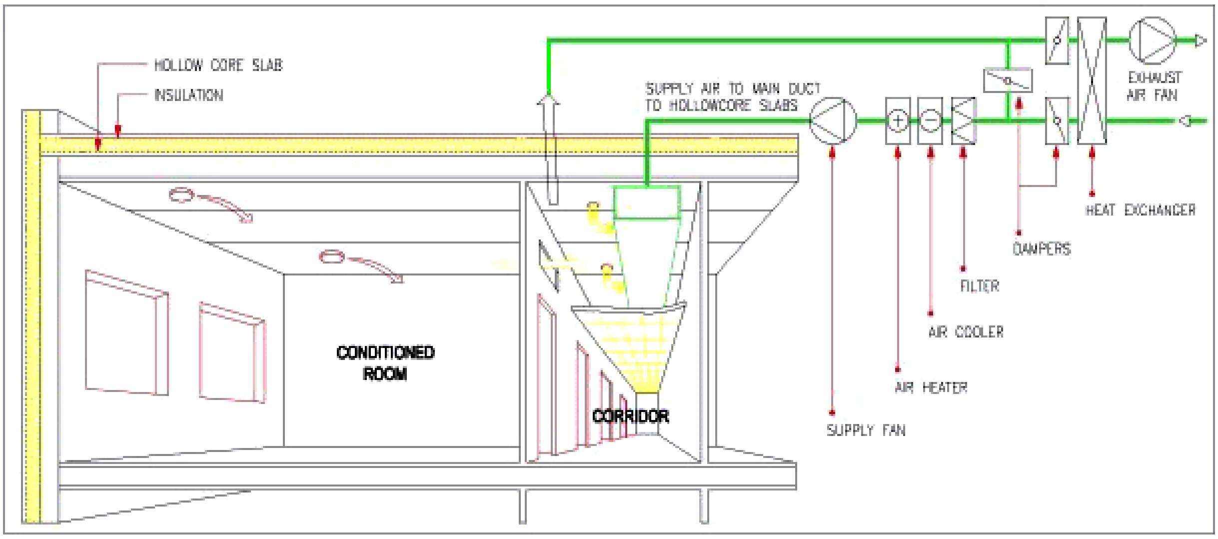


Figure 8, A schematic of air system distribution in the building using TermoDeck.

TermoDeck acts as heat storage of the heat gains in the concrete floor slabs. This allows for free night cooling and off peak cooling while the building will be mainly heated by persons, lights, equipment and sun radiation. TermoDeck differs from other energy saving systems because the overall construction cost is not higher than conventional buildings as no extra equipment is added. TermoDeck is proven in all types of climatic conditions around the world and is intended for new buildings.

According to www.termodeck.com, TermoDeck reduces the installed electrical power and cooling capacity by 45-50% . During the peak load time in the midday period, the consumed energy reduction can be as high as 70-90%. TermoDeck projects in Europe have up to 50% lower energy consumption for heating & cooling. TermoDeck projects in Middle East have 30-50% lower energy consumption for cooling than equally sized conventional buildings. Due to a lower energy consumption, it reduces CO_2 emissions. TermoDeck has proven that it reduces the capital cost of the building. Since there is no ceiling required, the storey heights may be reduced by 15-25% per floor. Also, there exists significant reduction in fans, chillers and duct sizes (in hot climates 40-50%), [6]. TermoDeck also achieved occupant satisfaction. It provides comfortable and stable indoor temperatures all year round. It has very quiet operation since the slabs act as silencers against noise from fans and dampers.

Peak Power Reduction

The installed cooling capacities for some TermoDeck projects in Saudi Arabia (one of the hottest climates in the world) have been compared with the design capacities using conventional HVAC systems. Cooling capacities have been more than halved leading to a reduction in Peak Power Load by over 50%.

Project Location Area	**Cooling Capacity**		**Difference**
	Conventional (Tons)	**TermoDeck (Tons)**	**TermoDeck / Conventional (%)**
Lotus Centre Jeddah	**180**	**76**	**42%**
Gulf Centre Jeddah	**2 200**	**1000**	**45%**
SNS Offices Riyadh	**23**	**11**	**48%**

Source: ASA Consulting

Energy Consumption

TermoDeck has the advantage of storing the energy in its structure and utilized later. It reduces the energy consumption. The energy consumption can reach in some areas to 30-50 kWh/m^2 per year, which is lower than the regular consumption with 40%.

In the graph shown below, (from the New Practice Final Report 106) the energy consumption of the Elizabeth Fry building in United Kingdom (UK) is compared with mean values of typical good practice offices. The energy consumption for TermoDeck is less than 50% of the other offices.

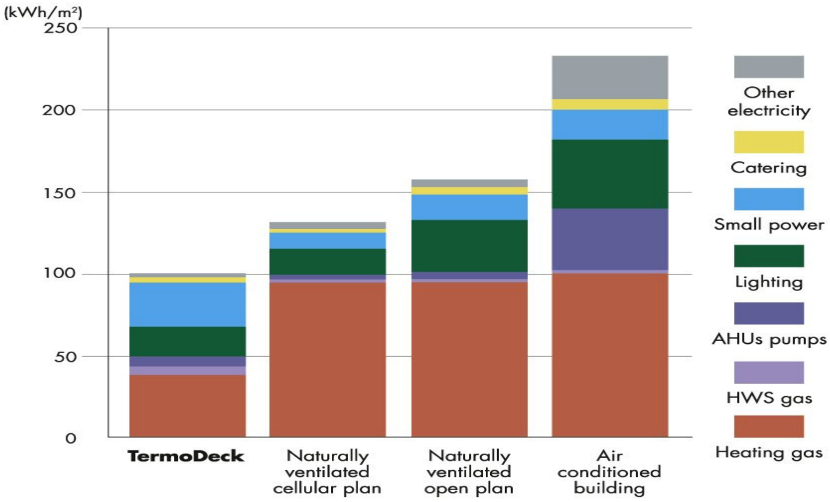


Figure 9, The energy consumption of the Elizabeth Fry building in United Kingdom (UK) is compared with mean values of typical good practice offices.

3.3 Energy Auditing

An energy audit is a fundamental part of any energy conservation & management program of any organization which wishes to control its energy costs. The construction of complete and detailed energy audit is an intricate, tedious but necessary procedure so that major energy use activities can be identified. The energy audit is a balance sheet of energy inputs, throughout and outputs. Its fundamental equation is as follows

Fuel energy input = energy losses during combustion + energy losses during conversion + energy losses during distribution + energy losses during utilization + energy losses from utilization

In these cases, the environmental evaluation is recommended after the technological assessment to decide on the possible optimization actions based on the need for improving the environmental performance of the system. It could, instead, have been usefully performed at the very beginning of assessment, if more options were possible and the environmental performance were likely to become the determining factor.

3.4 Energy Audit

3.4.1 Types Of Energy Audits

The term energy audit is commonly used to describe a broad spectrum of energy studies ranging from a quick walk-through of a facility to identify major problem areas to a comprehensive analysis of the implications of alternative energy efficiency measures sufficient to satisfy the financial criteria of sophisticated investors. The only way to insure that a proposed audit will meet your specific needs is to spell out those requirements in a detailed scope of work. Taking the time to prepare a formal solicitation will also assure the building owner of receiving competitive and comparable proposals.

Preliminary Audit

The preliminary audit alternatively called a simple audit, screening audit or walk-through audit, is the simplest and quickest type of audit. It involves minimal interviews with site operating personnel, a brief review of facility utility bills and other operating data, and a walk-through of the facility to become familiar with the building operation and identify glaring areas of energy waste or inefficiency.

Typically, only major problem areas will be uncovered during this type of audit. Corrective measures are briefly described, and quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided. This level of detail, while not sufficient for reaching a final decision on implementing a proposed measure, is adequate to prioritize energy efficiency projects and determine the need for a more detailed audit.

General Audit

The general audit alternatively called a mini-audit; site energy audit or complete site energy audit expands on the preliminary audit described above by collecting more detailed information about facility operation and performing a more detailed evaluation of energy conservation measures identified. Utility bills are collected for a 12 to 36 month period to allow the auditor to evaluate the facility's energy/demand rate structures, and energy usage profiles. Additional metering of specific energy-consuming systems is often performed to supplement utility data.

This type of audit will be able to identify all energy conservation measures appropriate for the facility given its operating parameters. A detailed financial analysis is performed for each measure based on detailed implementation cost estimates; site-specific operating cost savings, and the customer's investment criteria. Sufficient detail is provided to justify project implementation.

Investment-Grade Audit

In most corporate settings, upgrades to a facility's energy infrastructure must compete with non-energy related investments for capital funding. Both energy and non-energy investments are rated on a single set of financial criteria that generally stress the expected return on investment (ROI). The projected operating savings from the implementation of energy projects must be developed such that they provide a high level of confidence. In fact, investors often demand guaranteed savings.

The investment-grader audit alternatively called a comprehensive audit, detailed audit, maxi audit, or technical analysis audit, expands on the general audit described above by providing a dynamic model of energy use characteristics of both the existing facility and all energy conservation measures identified. The building model is calibrated against actual utility data to provide a realistic baseline against which to compute operating savings for proposed measures.

Extensive attention is given to understanding not only the operating characteristics of all energy consuming systems, but also situations that cause load profile variations on both an annual and daily basis. Existing utility data is supplemented with sub metering of major energy consuming systems and monitoring of system operating characteristics.

Environmental Audit

It is becoming increasingly common to carry out an assessment of the environmental impacts of changing patterns in fuel consumption at the same time as the assembly of the energy audit inventory. Companies are often asked to demonstrate their environmental credentials and this can be done by publishing the outcomes of an environmental audit. Once the details of the energy audit inventory are established it is a simple matter to convert fuel consumptions to gas emissions using emission indices. Typical values of such indices related to the combustion of natural gas, oil and a steam raising coal are given in Table 4.

Table 1: Typical emission indices for fossil fuel combustion

Fuel	kg/kWh		
	CO_2	**Nitrogen Oxides**	**Sulphur Dioxide**
Natural Gas	0.20	1.7×10^{-4}	Zero
Fuel Oil	0.28	2.6×10^{-4}	7.0×10^{-4}
Coal	0.35	1.1×10^{-3}	1.6×10^{-3}

It is noted that other impacts from the fossil fuel combustion process should be included in the audit. For example the burden of coal ash disposal and the liquid effluent from any exhaust gas treatment plant.

Emissions of SO_x and NO_x from boiler plant of size 50MW or greater are regulated under the terms of the Large Combustion Plant Directive (88/609/EEC). This gives limit values according to the fossil fuel used. For example the NO_x limit values are shown in Table 5 below:

Table 5 NO_x limit values (88/609/EEC) - mg/m^3

Coal (6% O_2)	650
Oil (3% O_2)	450
Gas (3% O_2)	350

The reference temperature and pressure for volume in Table 3.5 are 25^{o}C and 1.013 bar respectively. Measured values are adjusted to these reference conditions using the Equation of State. The Equation is also used to change measured volume units, for example parts per million or percentage by volume, to mass units.

Reference values for exhaust gas oxygen concentrations are given in brackets in Table 5. These take into account differences in dilution of exhaust gas measurements due to changing excess air levels in oil, coal and gas fired plant. The Equation below can be used to convert emission values at a measured oxygen concentration (b%) to the reference oxygen concentration (x%) shown in Table 6. According to Eq. 1 all measurements refer to percentage dry flue gas composition.

$$NO_x\,\% = \frac{e\,(x - 21)}{b - 21} \qquad (1)$$

Where: NO_x% = corrected value at the reference oxygen condition

e = measured NO_x% value at b% oxygen concentration

Table 2: Performance analysis of cold fired plant (100 - 300 MW)

kWh/m²		
Good Performance	Satisfactory Performance	Poor Performance
< 325	325 - 355	> 355

Some care is required in the application of the regulatory standards given in Table 5, since they are occasionally updated to take into account improvements in pollution control technology. For example the NO_x limit for coal fired plant of capacity 100 - 300 MW shown in Table 6 was proposed as 300 mg/m^3 (6% O_2) from 1st January 2000. The units are kWh/m^2, where area refers to the building floor area and energy refers to space heating energy usage.

4. Legislation Concerning Rational Energy Use

The legal basis for the energy efficiency requirement for end-use equipment is concerned with rational use of energy by factories, buildings, and equipment. Here, "the rational use of energy" means improving efficiency to the maximum level in the process of consuming energy for a specific objective for the purpose of achieving the same objective with less energy consumption. The legislation should govern the activities related to extraction, production, refining, storage, transport, transmission, distribution and consumption of thermal and electric energy. Legal regulation in the field of rational energy use must be aimed at:

- Ensuring the efficient and environmentally sound use of energy in its production and consumption;
- Ensuring accuracy and uniformity of measurements, as well as accounting of energy produced and consumed in terms of both quality and quantity; and
- Execution of supervision and control by law over the efficiency of energy production and consumption, as well as over the state of energy equipment and energy supply and consumption systems.

Naspolini et al., 2010 studied the widespread use of electrical showerheads in Brazil for providing hot water for domestic consumption contributes to a load curve that peaks in the early evening, imposing a considerable burden to generation, transmission, and distribution utilities. The paper suggests that on average, over 73% of Brazilian households use these 3–8 kW electrical resistance showerheads. Furthermore, due to their very low load factor (typically below 2%), each of these high-power showerheads results in considerably low return on the high investment costs in terms of infrastructure for the electricity sector. Particularly in low-income dwellings, electrical showerheads represent by far the highest electrical loads, resulting in a considerable component in the monthly energy bill. The results also show that the avoided power costs, a benefit for the distribution utility company, might be more substantial than the avoided energy costs, a benefit for the end user. In the energy constrained onpeak hours period, the utility company might benefit from being able to sell this energy to other higher paying tariff consumers.

Energy efficiency characteristics can be established for energy producing and using equipment in accordance with legislatively established procedure. Energy efficiency characteristics can be put in standards to indicate the efficiency of energy use in its production and consumption. There is also a need to understand the energy consumption characteristics for technological processes, provision of heat and hot water supply, cooling, provision of electricity supply, lighting of buildings and works. Observing standards, technical rules and norms concerning the efficiency of energy use should be subjected to compulsory certification as regards the compliance with the relevant energy efficiency characteristics. The compliance of equipment produced with the requirements set by the relevant standard as regards energy efficiency requirements needs to be stated by the producer by means of energy labeling. It is also needed to develop a national policy for the rational use of energy. The main elements of the national policy in the field of rational energy use can be summarized as follows:

- Implementation of national, regional and sectoral targeted programs and projects;
- Stabilization of energy production and consumption at the level necessary for the intensive development of national economy.
- Optimization of energy production and consumption conditions, organization of energy accounting;
- Stimulating production of energy efficient equipment and less energy intensive goods;
- Putting energy efficiency characteristics in standards for energy producing and using equipment and goods;
- Institution of control by the state over energy quality, energy efficiency of production and energy intensity of produce;
- Introduction of energy audit of enterprises and organizations;
- Rendering energy examination of products, facilities in operation and under reconstruction, also of equipment and technologies;
- Establishment of energy efficiency demonstration zones for implementing high energy efficiency projects. Stimulating the development of energy efficient and environmentally sound technologies and manufactures and organization of energy production and consumption monitoring.

5. Need of Energy Manager

It all starts or fails with energy managers ! No energy manager in a firm means no voice to invest in energy efficiency. No voice implies no annual budget for energy conservation measures. Having no annual budget means no energy efficiency measures are implemented. No implementation results in less profit and no energy cost reduction. It is expected from an energy manger to follow a sequential and iterative procedure and suggest design improvements in existing energy systems.

Energy Management is all about how to make the best use of our present and future energy sources. It address critical economic and environmental problems due to energy use by considering the technical, economical, environmental and social factors that affect the usage and demand for energy. However, the Energy Manger as it stands presently is expected to be familiar with the following broader areas of energy and thermo economic analysis, energy auditing and planning and environmental evaluation. It is expected from an energy manger to follow a sequential and iterative procedure and not only suggest design improvements in existing energy systems but also to get the buy-in of top management to implement these improvements. As such an Energy Manager must be able to cut across all divisions / sections / disciplines within the organization to be able to formalize optimimal energy programmes.

With the proposed introduction of Efficient Management of Electrical Energy Regulation, labeling of electrical appliances and the use of high-efficient motors, the focus on energy efficiency within the commercial and industrial sector would be further enhanced. These developments coupled with the recent increase in energy cost, spells a real need to develop local experts with the required knowledge and experience in energy efficiency. As energy and environmental problems intensify, there is urgent demand nationwide for energy managers who can set up and implement real practical solutions. It is not just concerned with saving energy, but also with increasing productivity, improving standards of living and saving money.

The Energy Manger as it stands presently is expected to be familiar with the following broader areas:

- Energy analysis (Electrical and Thermal Systems).
- Thermo economic analysis (Cost generation processes).
- Energy Practice (Audit and legislation)
- Energy Resources and Environmental evaluation
- Energy Economic and Planning
- Applications of Information Technology in energy management

It is expected from an energy manger to follow a sequential and iterative procedure and not only suggest design improvements in existing energy systems but also to get the buy-in of top management to implement these improvements. As such an Energy Manager must be able to cut across all divisions / sections / disciplines within the organization to be able to formalize optimum energy programs. Any Energy Manager Training course should be holistic in nature, i.e. cover all aspects of the aforementioned areas in energy use within an organization.

As it is the intent to set a comprehensive program in Energy Efficiency for the commercial and industrial sector, the introduction of any workable program that brings the optimum results within the Pakistan contexts should be well thought out and opinions weighted before initiating the program rather than working on the idea of implementing first and adjusting as we go along. This may in fact be counterproductive in so far as to start with the right foot and steer an energy efficient culture within the commercial and industrial sector.

A typical energy survey for various industries resulted in useful results. The main findings of the survey were:

- Almost all companies participating in the survey are focusing on how to increase the energy efficiency in the company and reduce the energy costs.
- Most companies do not have a designated position in charge of energy matters within the company; however it is usually assigned to an existing position as a joint function or part function of other designated jobs viz. Technical Services Manager, Electrical Manager, Production Manager.
- All companies are aware of the need for further education/ training in the fields of energy efficiency for its personnel involved in energy matters and have the following priorities in getting the necessary knowledge;
  - I. Send existing staff for specific training and upgrading - Most companies have sent they staff for training to one of the two major energy managers training institutes.
  - II. Recruit new qualified personnel
  - III. Outsource such tasks

It is also the opinion of the author that the emphases of each sub-topic by each of these training institutes vary by a considerable amount. It is suggested that a detailed review be carried out to ensure that the minimum learning objective be met, as the TOC is merely an indication and may not reflect the depth of coverage of each the sub-sections. Towards this end the EC or a designated independent body needs to establish the minimum learning objective, minimum duration and methods of assessment for each of the objectives. The learning objectives for each of these sub-sections should cumulate to an overall learning objective for the energy manager, which should have its main focus on his/her ability to gain better control and structure of the company's energy use by assessing current use/operating practices, and by taking the necessary steps to incorporate energy efficiency into the corporate culture.

Energy auditing is an important aspect; however, a certified energy manager should also possess Expertise in,

- Policy analysis,
- Project management,
- Regulatory including environmental issues,
- Financing, and
- The ability to "champion" the energy culture with the organization.

It must be stated that there is a difference between an energy auditor and an energy manager. Energy auditing can be stated as more of a science while management is more of an art that requires different skills as compared to an auditor. As they are two distinct fields of specialization, it would be prudent to specifically look at the time allocation versus the require learning objective of each subsection and if there is a need to separate the training to focus on Energy Auditing and Energy Management.

CONCLUSIONS

Energy conservations and managing the peak load are two issues that are highly considered in Gulf countries. The utilization of energy conservation strategies such as implementing thermal storage and TermoDeck in constructing new buildings and energy auditing in the existing buildings involves initiative from electric companies and government and support to consumers. The consumers will be convinced to apply one or more of the energy conservation strategies if they think they will gain benefit out of them. Legislation is required and will enhance the application of those strategies. Companies and governmental organizations are highly encouraged to have energy manager position to help in utilizing the energy conservation strategies.

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