

SAUDI ARAMCO COMMUNITY, BUILDINGS & OFFICE SERVICES TOWARD ENERGY CONSERVATION

By

Jamal. E. Al-Jaber
Dhahran Utilities Department
Saudi Aramco

Ali S. Al-Shahrani
Dhahran Utilities Department
Saudi Aramco

Abstract

Energy conservation has been a focal point of Saudi Aramco Community, Buildings & Office Services (CB&OS) for several years to comply with the company Energy Conservation Policy. This paper focuses on the exerted efforts by CB&OS toward energy reduction through the utilization of user awareness programs, energy efficient systems, equipment and products in new projects, upgrades and renovations. Some applications such as Building Management System (BMS), Variable Frequency Drives (VFD), energy efficient equipment and lighting, programmable lighting controllers, HVAC Variable Air Volumes (VAVs) and smart diffusers, programmable thermostats and building and AC duct insulations will be covered in this paper

Introduction

CB&OS has seven departments that provide services and maintenance to Saudi Aramco's communities and non-industrial facilities. The major bulk of CB&OS operations are raw and sweet water production, sewage treatment, air conditioning (AC), and home ownership support along with other support services like emergency generators and elevators. There are also non-utilities services such as housing, recreation, gardening, and food services.

There are about 331,116 tons of AC systems cooled by water and air and estimated 30.2 billions gallons of raw, drinking, and wastewater in annual production for about 110 CB&OS buildings and facilities. The total power consumption of CB&OS represents 6% of total Saudi Aramco annual electric power consumption. Thus, in order to comply with the company Energy Conservation Policy, CB&OS started several years ago implementing some energy conservation measures such as promoting the utilization of:

- User awareness programs intended for all company employees and their dependents;
- Building Management System (BMS) in health care facilities and major office buildings;

- Variable frequency drives (VFD) to drive pumps and fans;
- Energy efficient equipment – efficient HVAC 250 to 600 ton chillers;
- HVAC variable air volume and smart diffusers
- Energy efficient lighting / Programmable lighting controllers;
- HVAC programmable thermostats; and
- Building and AC duct insulations for company buildings and houses.

Based on experience gained from these efforts, CB&OS has set a long-range plan to achieve optimal power consumption reduction.

User Awareness Programs

The objective of the user awareness programs is to increase users' awareness towards energy conservation. These programs encourage Saudi Aramco employees and their families' to conserve power at work and home. This has been carried out through participating in the company periodic Energy Conservation Campaigns started four years ago and using monthly newsletters, flyers, the Saudi Aramco Intranet and general announcements using company e-mail system. User awareness programs educate the users about the importance of saving energy and its impact on the Saudi Arabia economy. Saving energy can free up capacity and defers the need for more power and major capital investment in new power generation projects. These programs provide users with facts and tips on how to save energy at work and home such as:

- The largest invoice Saudi Aramco pays is "purchased power";
- Motors consume 80% of the plants' power;
- Proper heat/cold insulation at home can reduce power consumption by 20%;
- Switch off lights, appliances or electronics and computer equipment when not required;
- Switch off water heaters during warm weather;
- Raising AC thermostats setting by just one degree can save up to 5%; and

- Request utilities users to review their operations and determine opportunities for optimizing operation of equipment, for example: run one central AC plant instead of two running at partial capacity.

These user awareness programs have resulted in significant cost reduction as reflected on the Electric Power Budget Reports. Therefore, CB&OS will plan to keep using these programs and improve them to be more effective for additional saving in energy.

Building Management System (BMS)

BMS is an advanced programmable system that uses software, digital controllers to manage various aspects of a building or building complex operating systems. BMS can be programmed to optimize the settings and sequences of equipment such as boilers, chillers, cooling towers, lighting, and building systems to meet the facility loads as efficiently as possible. The BMS features other energy control capabilities, enabling building managers to accurately identify total energy consumption and develop appropriate energy saving measures.

CB&OS has been using BMS in its major buildings and health care centers to mainly manage HVAC, fire alarm and security access systems. The BMS monitors all HVAC systems in these facilities and gives the operator enough data enabling him to switch off or on AC units as required, resulting in reasonable optimization of the HVAC systems operations in these facilities. A BMS is also used in the new Saudi Aramco Research & Development Laboratory in Dhahran; this BMS has full management capabilities which efficiently run the Central AC Plant in this facility in an auto mode without the need of operator requirement. Study of implementing BMS at one of Saudi Aramco's Buildings at Jeddah shows a saving of a bout \$ 5,000/year.

BMS for new projects and proposed projects and upgrades, however, have been and will be specified to provide full building management capabilities to include all building operating systems including lighting management. Under Phase-I of CFC Phase-out Program, yet to come, all Central AC plants in Dhahran and Udhailiyah will be automated for optimum operation and energy saving. The CFC Phase-out program is intended to phase out the use of all CFC refrigerants in Saudi Aramco Company by 2010. Automation of other Central AC Plants in other areas, Abqaiq, Al-Hasa, Ras-Tanura and Tanajib will also part of Phase-II of the CFC Phase-out Program.

Variable Frequency Drives

Most motors turn at nearly constant speed. However, much of the time the equipment they drive may operate at less than maximum design speed. This speed reduction can be accommodated by a Variable Frequency Drive (VFD) that varies the motor's speed to the driven load. Slowing a pump or fan in this manner reduces energy consumption much more effectively than allowing the motor to run at constant speed. The energy consumed, by fans and pumps, is proportional to the cube root of motor's speed. If motor's speed is reduced by 10%, flow is reduced by 10%, while power consumption is reduced by 27%. If speed is reduced by 20%, power is reduced by 49% [1].

In addition to providing speed control, VFDs provide soft starting. This reduces the mechanical stress on both the motor and equipment driven by the motor, which would prolong equipment life and reduce maintenance costs. Ideal uses of VFDs are for fans, pumps, elevators, cranes, and conveyors [3].

The first CB&OS successful experience with VFDs was in 1994 by installing two (2) VFDs in Dhahran Health Center operating rooms to drive two 50 HP each fan motors for two HVAC air handling units. During the last seven years, 25% to 35% annual saving in energy was recorded in comparison with a conventional system. Later on, CB&OS installed:

- Thirteen (13) VFDs in Abqaiq Regional Sewage Treatment Plant to drive plant process pumps;
- Eight (8) VFDs in two Dhahran wastewater treatment plants to drive sewage treatment water pumps; and
- Twenty (20) VFDs in the Dhahran Tower building, a ten-story office building, to drive HVAC air handling units in conjunction with variable air volume system.

Energy efficient equipment – efficient HVAC 250 to 600 ton chillers

As an effort to save equipment and energy costs, CB&OS has requested and obtained the approval to waive the fouling factor, tube metallurgy and tube thickness requirements specified in 1970's Saudi Aramco Materials Specification for package water cooled centrifugal chillers for Utility Services, and, instead, comply with Air-Conditioning & Refrigeration Institute (ARI). With this approval CB&OS will able to replace ten (10) centrifugal chillers with cheaper and more efficient chillers for one CB&OS projects. The energy consumption of a conventional chiller is 1.02 KW/Ton while the energy consumption for the more efficient chillers is 0.715

KW/Ton. The same approval was also requested and obtained for Phase-I and Phase-II of CFC Phase-out Program, which will replace 69 water-cooled chillers with more efficient chillers.

Purchasing the standard ARI chillers will result significant saving in power costs. Based on vendor data, the ARI chillers will save approximately \$1,500,000 per year in power costs. Assuming a 25-year lifespan for all new chillers, this represents an additional \$37,000,000 in power savings. (9))

HVAC Variable Air Volume (VAV)/Smart Diffuser (SD)

Building air supply systems are designed to supply air to meet peak heating or cooling loads. However, peak loads and average loads can vary greatly. Variable-Air-Volume (VAV)/Smart Diffuser (SD) systems deliver only the volume of air needed for conditioning the actual load reducing overall average airflow. VAV/SD systems reduce the average amount of fan energy required to condition spaces, as well as reducing the amount of heating energy used by most air conditioning systems. A VAV is a motorized and controllable air damper, installed in an AC duct to control one or more areas. A SD is a controllable diffuser that is controlled by self-mechanism which does not require any power supply, installed only as an air diffuser.

Fan speed control is the most efficient form of volume reduction. Airflow in Cubic Feet per Minute (CFM) is proportional to the fan speed in Revolutions per Minute (RPM), and horsepower is proportional to the cube of fan speed [3]. Thus, fan horsepower requirements are drastically reduced as fan speed is reduced.

VAV/SD systems can be designed as new systems, or in some cases as retrofits to existing systems, and can be designed to handle a variety of applications. With VAV/SD, a large air handling system can supply minimum air volume to most of its zones while one or two zones operate at full load.

In 2001 CB&OS completed installing around 400 VAV boxes and 20 VFDs for the HVAC system of the Tower Building in Dhahran in an effort to conserve energy. Later on seven SDs were installed in Building 9020 in Dhahran for testing and evaluation of these type smart diffusers. The SDs have been operating, until now, as expected. There is a long-range plan to install VAV/SD systems in all Saudi Aramco office buildings and facilities under CB&OS supervision.

Energy Efficient Lighting/Programmable Lighting Controllers

Lighting accounts for about 25-40% of the electricity used in many office buildings. [3,8] Interior lighting is left on during off-hours on evenings and weekends when it is not needed. This wastes energy and adds heat to the building that must be compensated for by the building HVAC systems. Lighting in common areas, such as corridors, restrooms, and lobby areas is most likely to remain on during periods when the facility is unoccupied.

If advanced lighting technologies and designs were implemented, electricity use for lighting could be reduced by more than 50% [8], electrical demand dramatically reduced, and working environments significantly improved.

Lighting power can be reduced in new buildings and major renovation by (1) optimizing the use of natural day lighting; (2) installing modern, efficient luminaires; (3) replacing ballasts and lamps with modern components; (4) replacing incandescent lamps with compact fluorescent lamps (CFLs); (5) replacing mercury vapor lamps with metal halide or fluorescent lamps; (6) implementing task lighting strategies; and (7) installing state of the art lighting controls.

CB&OS implemented many almost every possible ways to control lighting as efficiently as possible. The following are implemented applications:

- Photocells to control outdoor lighting in all facilities. Photocells switch off outdoor lighting at night and switch them on during the day
- Timers to control indoor lighting to switch the lighting after working hours. Timers were installed in three major office buildings in Dhahran area after some re-wiring jobs.
- In a typical fluorescent lighting fixture the ballast(s) account for as much as 15% of the total electrical consumption. [7] Where as electronic ballasts have higher efficiency and life span than magnetic ballasts, and reduce the undesirable waste heat, flicker and hum associated with traditional fluorescent lighting. High-frequency electronic ballasts require 12 to 25% less energy than their magnetic predecessors. [4] Office Services Department and Consulting Services Department have completed a pilot project in the EXPEC Building in Dhahran to replace existing two F40 magnetic ballasts and three 32-Watt fluorescent lamps, with new energy savings fixtures with one electronic ballast and three compatible 32-Watt fluorescent lamps. The measured power savings was found to be 35% less than the conventional fluorescent lighting fixtures. Office Services Department is currently studying retrofit projects to replace all

conventional lighting fixtures in the Tower Building and the remaining of Saudi Aramco office buildings. CB&OS two years switched from the 40 watt lamps and magnetic ballasts fluorescent lighting fixtures to the energy efficient 32 watt lamps and electronic ballasts fluorescent lighting fixtures.

- Motion sensors in some offices and recommended them in small offices and houses. They switch lights off when occupants don't make movements. Occupancy sensors can result in a wide range of savings, depending on the occupancy pattern of the room and the habits of the occupants. Lighting energy savings of 20-75% [7] are often cited for areas using occupancy sensors. Greater savings are certainly possible, particularly for rooms that are occupied for only limited periods. Occupancy sensors are recommended for individual spaces such as a private offices, conference rooms, restrooms, lounges, or small storage areas. Use "User Awareness" to ask users to switch off lighting, PC monitors and printers after working hours
- Energy efficient compact fluorescent bulbs, where applicable. They consume less power and generate less heat and have longer service life than incandescent bulbs. A compact fluorescent bulb can save 60% on power when compared with an incandescent bulb, but have higher initial costs.
- CB&OS used and recommends the use of natural light to illuminate lobbies of office buildings during the daytime, such office buildings are Al-Mujamma, Star and North Park Buildings in Dhahran.
- CB&OS used well-designed lighting control systems in all its new office buildings. A well design lighting control system has the potential to reduce lighting energy use by 30-50% [8].

Programmable Thermostat (PT)

Programmable Thermostats (PTs) have recently been introduced and installed in some of the company residential houses in Abqaiq and Dhahran Camps to control AC units for experimental purposes. One type of PT can be programmed to provide certain air temperature for certain time of day, day(s) of week, month or year. The saving in energy from using these PTs depends on the cooperation from the user. In 2001 year in Abqaiq Camp, two PTs were installed in two houses (one occupied and one vacant) to measure the saving in energy. At the vacant house a saving of 33% was recorded. And at the occupied a 13% saving was recorded. Both of these two results proved the PT potential saving in energy. Another type of PT has the same functions stated above, but this type of PT can be called remotely via any phone to set the desired AC

temperature setting before arriving home. The occupant can program the PT to raise the AC setting when leaving the house, and then call the PT half an hour or so before arriving home to lower the AC setting to the desired level. Only one PT installed in a utility shop in Dhahran in year 2001 for testing and evaluation. There are future plans to install this type of PTs in residential houses.

Building & AC Duct Insulation

Insulation used in residential and commercial construction ranks as one of the best means of saving energy in buildings, reducing utility bills up to 40% [6], and improving air quality [8]. By reducing energy needed for heating and cooling the operating cost will be reduced as well. Insulation provides resistance to the flow of heat from a building's walls, ceilings, air conditioning ducts, and floors exterior to their interior, and vice versa.

The use of insulation in CB&OS is a standard requirement for all Saudi Aramco residential units and offices, including all air conditioning ducting. With the new direction toward conserving energy, CB&OS has made it a common practice to inspect and test the integrity of existing insulations of all kinds during renovation projects. For new projects and installations, applicable insulation will be specified to assure energy savings along with the original purposes of insulation uses.

Summary

Although its total power consumption represents only 6% of Saudi Aramco annual electric power consumption, CB&OS is committed to compliance with Saudi Aramco Energy Conservation Policy. The efforts exerted in saving energy presented in this paper represented only what could have been done in the short-term planning of CB&OS when considering the low electricity tariff. With a long-term planning, CB&OS is intending to exert even more efforts toward energy saving such as:

- Utilize new BMS with full management capabilities or upgrade exiting BMS to manage all operating systems and equipment, such as lighting and HVAC in major office buildings in the company. Use programmable lighting Panel boards in new facilities without BMS to manage lighting.
- Utilize Plant Management System such as, Supervisory Control And Data Acquisition (SCADA), to monitor and control or automate all CB&OS central AC and water treatment plants, water wells and lift stations.
- Convert all 40-watt lamps and magnetic ballasts fluorescent lighting fixtures to the energy efficient 32-watt lamps and electronic ballasts fluorescent lighting fixtures, replace

incandescent lamps with compact fluorescent lamps (CFLs) and replace mercury vapor lamps with metal halide or fluorescent lamps through upgrades and renovations.

- Conduct an Energy Audit Review every five years for all CB&OS facilities for energy conservation.

Bibliography

- [1] Alliance to Save Energy
<http://www.ase.org>
- [2] Energy Efficiency and Renewable Energy Network (EREN)
<http://www.eren.doe.gov>
- [3] Federal Energy Management Program
<http://www.pnl.gov>
- [4] Lighting Research Center
<http://www.lrc.rpi.edu>
- [5] Nabil A. Al-Nuaim. "Power Monitoring System (PMS)." Saudi Aramco, CSD-36/97-T, 1999.
- [6] North American Insulation Manufacturers Association
<http://www.naima.org>
- [7] Southern California Gas Company, "Efficiency Buildings Program."
<http://www.beea.socalgas.com>
- [8] U. S. Department of Energy. Greening Federal Facilities, second edition. Brattleboro, Vermont: Building Green, Inc., 2001
- [9] Facility Planning Department Letter # FPD-IPD-125-00, Dated August 2, 2000.
- [10] Saudi Aramco CS Innovation Workshop, Bahrain – December 8, 1994. "Geothermal Heat Pump Systems".
- [11] Saudi Aramco Consulting Services Department, "Conserving Energy -----HVAC Application-----using Geothermal Air Cooled System", Case Study-2001, by Adil Al-Hamid & Khalid Al-Mulhim
- [12] Saudi Aramco Office Services Department, "Office Services Energy Conservation Efforts", 2001, by Anwar Al-Bahar
- [13] Saudi Aramco Southern Area Community Services Department, "The Future Is Now – Power Conservation Program", 2001, by Ali Al-Jassim
- [14] Contributors: Saudi Aramco Dhahran Utilities Department, Southern Area Community Services Department, Northern Area Community Services Department, Community & Building Maintenance Department and Office Services Department
- [15] Waleed Al-Rumaih, "Energy Assessment At Petrochemical Plant", Saudi Aramco Consulting Service Department