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Conservation And Management Of Electrical Energy In Gaza Strip Using Low Cost Investment

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ABSTRACT

The Palestinian electricity sector suffers from many electrical problems such as high electrical deficit rate, transmission losses, and absent energy management strategies. The electrical deficit rate is estimated around 30% of the total demand. Energy efficiency improvement is an important way to reduce electrical deficit with various opportunities available in a cost-effective manner. This paper presents a low cost electrical conservation through energy management to improve electrical energy efficiency in Gaza Strips. Using efficient light technology, reducing air leak, and cooling air source are few approaches available. This paper investigates identifying cost-effective energy efficiency measures and potentials. Energy audits have been performed at Gaza Technical Center (GTC), as commercial sector, and Palestine Factory (APF), as industrial sector. The result of this audits was a potential of 7.5% energy saving. Generalizing this result could reduce the electrical deficit rate in Gaza Strip by 3.3%. This paper leads to devise specific low cost electrical conservation approaches to commercial and industrial sectors; moreover, reduces the electrical deficit rate.

Keywords - Electrical Conservation, energy management, electrical deficit, Gaza Strip.

I. INTRODUCTION

1.4 million Palestinians residents of the Gaza Strip must cope with scheduled electricity cuts of 6-8 hours on daily basis due to the increment in annual demand growth and the rate of electrical deficit reaching up to 30% in the year 2011[1]. Statistic for energy consumption revealed that the electrical energy consumption per person is the lowest indicator in the region and is estimated at 583kWh as the electrical consumption rose by 28% in Gaza strip and West bank during the period 2003-2009 [2, 3, 4].

The ultimate objective as first priority for this research is to reduce the estimated 30% electrical deficit rate. Fig. 1 illustrates the electrical supply and demand pattern with the rate of deficit in Gaza Strip between the years 2008-2011 [4]. Solutions to this problem range from generating more power, reducing losses at transmission and distribution networks, to energy efficiency and management programs.

Due to the siege on Gaza Strip imposed by Israel, Gaza Power Generation Company is unable to expand its facilities and generate more power. Reducing losses on the transmission and distribution networks requires major investments while efficiency and management programs require much less investment with individual paybacks.

In this research, low cost investment is investigated in two facilities in Gaza Strip: an educational institution as medium electric consumption, and a factory as industrial sector. The first selected facility is Gaza Training Center (GTC) which consists of a number of buildings such as commerce, engineering, English and administration, electronic and communication, and other workshops and services. The second selected facility is Automation Palestinian Factory for Interlock tiles and curb-stones which consists of workshop area, supervision room, mixer building, and other places for preparation with most of electrical load are electrical motor and air compressors.

First, we introduce the used research methodology then, we present observations on the outcomes obtained from measurement results and examination.

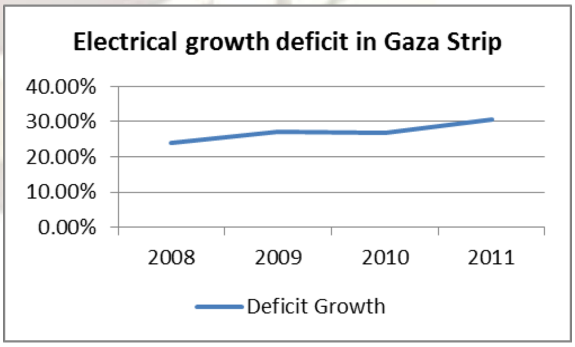

Figure 1: The annual electrical deficit growth in Gaza Strip

The paper includes gathering information or energy audits for the selected facilities including their characteristic and investigates potential opportunities to energy conservation. The data gathered above, then is fed into worksheets to perform analysis using excel office 2010 and Java subscript programs. The tools of collecting information for the research includes review of relevant literature, personal interview with the facilities managers, questionnaire for the electrical equipment rating and consumption, and monthly bill invoice analysis, review of measurement electrical equipment that are indicative of energy consumption in the space. The outcomes of this study can serve as good recommendations for other facilities in Gaza Strip.

This paper is organized as follows: section 2 talks about the methodologies, section 3 shows the obtained results, section 4 discusses the feasibility analysis, and finally section 5 concludes this paper.

II. PROPOSED METHODOLOGY

A digital avometer and a power analyzer are used to measure the currents, voltages, power factor, and real power to achieve technical and economic analysis. Electrical energy audits are the first step for our program to investigate the potential for energy conservation opportunities. The auditing includes surveying the electrical data rate of light fittings, electrical motors, and air compressors in both selected case study GTC and APF. Data collected for auditing light fitting includes measurements of currents, voltages, real power, indoor temperature and outdoor temperature parameters at electrical equipment in both GTC and APF. Measurement data of light system and electrical compressors were recorded in worksheets is fed into electrical conservation program in both GTC and APF buildings. The collected data is analyzed using Microsoft Java subscript and the data is uploaded into a database. In addition, determining the percentage saving factor is achieved by comparing the energy saving with the annual electrical consumption of GTC and APF.

2.1 Energy-Efficient Light Approach

The main approach is based on selecting the optimal component for indoor and outdoor light fitting based on power rate and lumen efficiency (lumen/w). Fig. 2 shows a wide variation in the luminous efficacy between the various lamp types. This approach can be implemented indoor and outdoor to achieve energy saving. The indoor light incandescent lamps are inefficient lamps and can be replaced with energy efficient compact florescent lamp (CFL). The outdoor halogen or metal halide lamp are inefficient and can be replaced with efficient high pressure sodium (S.O.N).

The saving power can be calculated according to equation 2.1, and the energy saving can be determined according to equation 2.2:

$$P_{saving} = (P_{inefficient} - P_{efficient}) \times n \qquad 2.1$$

$$E_{saving} = P_{saving} \times oh \qquad 2.2$$

Where:
P_{saving}: saving power in kW.
$P_{inefficient}$: Power rate of inefficient lamp in kW.
$P_{efficieient}$: Power rate of efficient lamp in kW.
n: Number of replacement lamps.
E_{saving}: Annual energy saving in kWh/year.
Oh: operating hours

For the highest energy savings, it's important to look at the recommended power rate when searching for high efficiency lamps.

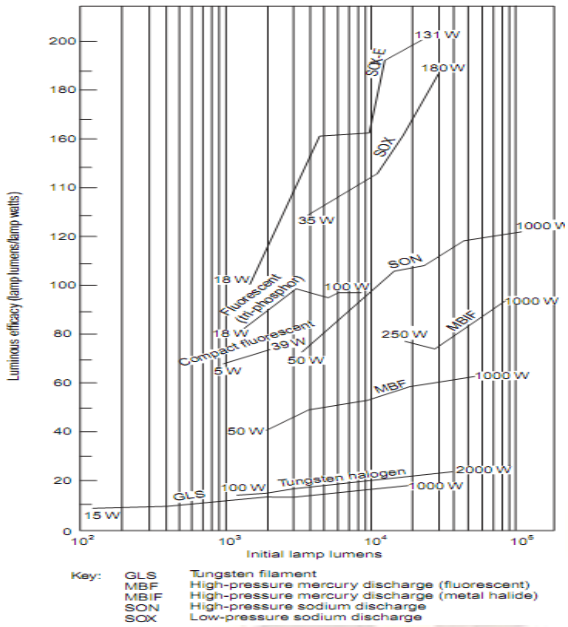

Figure 2: Summary of efficiency indoor and outdoor lamp

2.1.1 Indoor energy efficient light

If all incandescent lamps worldwide were to be replaced by CFLs, an additional 728 TWh of electricity would be saved per annum and global light energy demand would be lowered by 27% [5]. The high efficacy CFLs compared to incandescent lamps means that they will consume one-quarter to one-fifth of the energy while providing the same light quality. About 25% of energy consumed by CFLs is converted to visible light, compared with just 5% for a GLS incandescent lamp. Fig. 2 shows CFLs have an efficiency of approximately 70 lm/W, while tungsten filament lamps exhibit an efficiency of approximately 10 lm/W. Where possible, tungsten lamps should be replaced by compact fluorescent lamps. CFLs power rating ranges from 4 to 120 W and their efficacies from 35 to 80 lm/W. as the rated life of the compact fluorescent lamps is in the region of 8000 – 12,000 hours, eight times longer than tungsten lamps; thus, maintenance costs are greatly reduced [6].

For example if we have 101 incandescent lamps with 60 W rating and the proposed CFLs have 18 W rating. Then, annual energy saving of 8362.8 kWh could be achieved. The same procedure can be followed for the outdoor building in APF. Fig. 3 shows the results from Java model software that includes annual power and money savings.

2.1.2 Efficient outdoor light

High intensity discharge lights include mercury vapor, metal halide, and high pressure sodium light sources. Light is produced by a high pressure gas discharge at high temperatures requiring protective sealed arc tubes. Metal halide lamps fall into a lamp efficacy range of approximately 50-100 lm/W. High pressure sodium (HPS) lamps offer efficiencies that exceed those available from most metal-halide lamps where currently available types offer efficiencies up to 140 lm/W [5,6]. HPS SON lamps have proved particularly useful for lighting large high bay areas, such as factories and warehouses. Standard HPS have the highest efficacy of all HID lamps, with ratings of 70–140 lm/W. Overall, HPS lamps have lifespans of 5000 to 28000 h with typical power ratings ranging from 40 to 400 W.

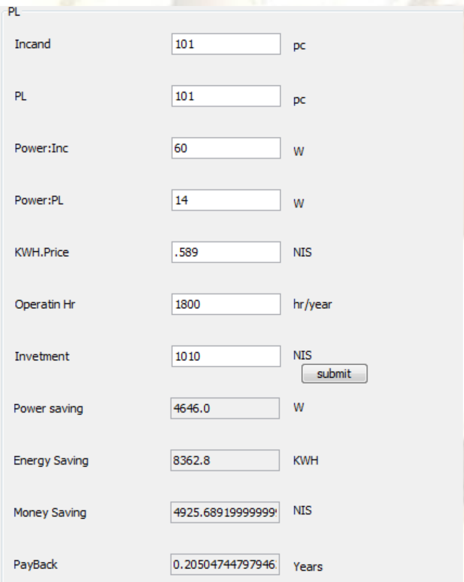

Figure 3: Example results of CFLs replacing incandescent lamps

For example, if we have 10 halogen lamps with 450 W rating and are replaced with HPS SON lamp 250 W. Then, annual energy of saving 5400 kWh could be achieved. Fig. 4 shows the simulated results using Java model software including the annual saving power and money.

2.2 Opportunities for Air Compressor

It is estimated that only 20%–25% of delivered electrical energy input is used for compressed-air energy [7], leaks account for 10%–50% of the waste, and misapplications account for 5–40% of loss in compressed air [8]. Production of compressed air in industry consumes approximately 10% of all electrical energy. A typical compressed-air system wastes approximately 15% of the electrical energy consumed; furthermore, 80% of the remaining energy is discarded as heat that could be easily reclaimed for space or process heating [7, 9].

Several approaches of the energy conservation measures for compressed-air systems are listed below:

1. Repairing air leaks in the distribution lines.
2. Reducing inlet air temperature and/or increasing inlet air pressure.
3. Installing heat recovery systems to use the compression heat within the facility for either water heating or building space heating.
4. Installing automatic controls to optimize the operation of several compressors by reducing part load operations.
5. Using booster compressors to provide higher discharge pressures. Booster compressors can be more economic if the air with the highest pressure represents a small fraction of the total.

This paper concentrates on the first two measures and discusses and evaluates implementing them.

2.2.1 Reducing leak in distribution system

The procedure accounts for loading and unloading time and measuring of real power consumption. Then, it determines delivered wasted power due to air leak of electrical air compressors. Calculation of the additional power demand for the covered wasted energy is done by applying equation 2.3 [9]:

$$\text{Excess (kW)} = (W_{loaded} - W_{unloaded}) \times (T/(T+t)) \qquad 2.3$$

Where:
W_{loaded}: Power requirement during "loaded" mode (kW)
$W_{unloaded}$: Power requirement during "unloaded" mode (kW)
T = Time running "loaded" (sec or mints)
t = Time running "unloaded" (sec r mints)

For example measurement results in average rise and drop time of 2.43, 4.17 minutes, respectively, and the measuring loading power is 4.9 kW. Therefore, the percentage air leaks, according to equation 2.2, is 36%, excess wasted power is 1.76 kW, and an annual energy saving of 1140 kWh could be achieved. Fig. 5 shows the simulated results using Java model software that include annual power and money savings.

2.2.2 Reducing inlet air temperature

Fresh air is drawn into the compressor through an air filter and is usually compressed to a pressure of (700-800 kPa or 7–8 bar) for distribution around the factory. The compression process generates a lot of heat and the compressor may be cooled by air, water, or oil. The intake line for the air compressor should be at the lowest temperature available

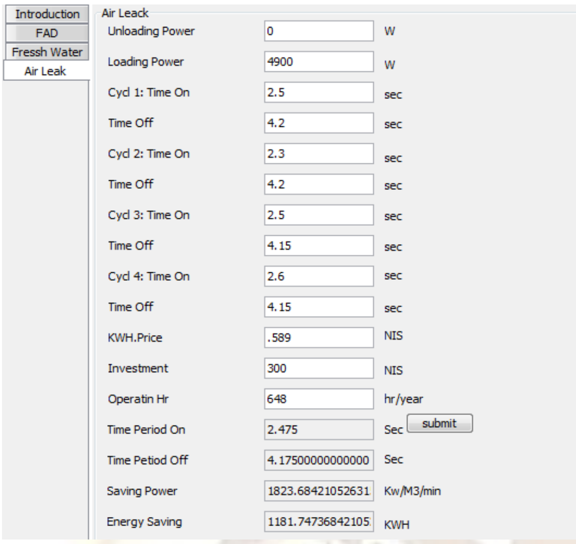

Figure 5: Example of air leak percentage and saving energy.

This translates to using outside air by simply installing additional duct directed to outside area or changing the compressor location. The reduced temperature of air intake results in a smaller volume of air to be compressed. As a rule of thumb, each 5°F (3°C) lower air temperature will save 1% compressor energy. In addition to energy savings, compressor capacity is increased when cold air from outside is used. The reduced power requirement can be calculated using equation 2.4, which is derived from the ideal compression power equation [7]:

$$W_2 = W_1 \times \{1 + [0.00341 \times (T_2 - T_1)]\} \qquad 2.4$$

where

- W_1, W_2 = initial and final ideal compression powers (kW)
- T_1, T_2 = initial and final inlet air temperatures (°K).

An example for cooling intake air test is that if the indoor and outdoor temperature measure at 24C^0 and 36C^o, respectively, the loading real power is 5.5kW, and initial ideal power is 4.95 kW. Then, the final ideal power percentage is 5.1 kW, power saving is 0.4 kW, and an annual energy saving of 560 kWh could be achieved. This procedure is followed with other electrical compressors in GTC and APF.

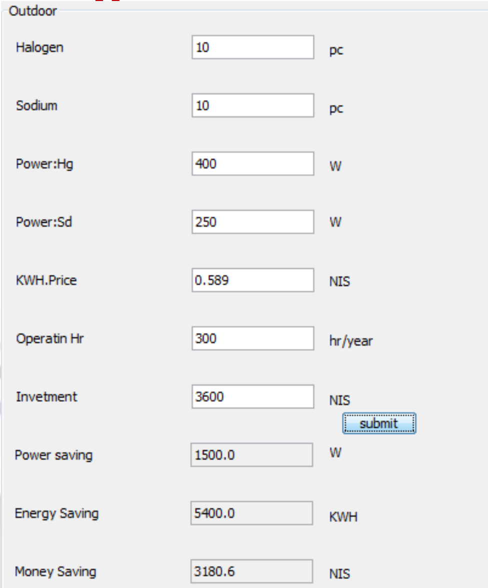

Figure 4: Example results of replacing halogen lamps with HPS lamps

III. MEASUREMENTS AND RESULTS

Distribution of light fittings in commercial sector is higher than in industrial sector; thus, the potential of electrical conservation opportunities is larger than in industrial sector. On other hand, the number of air compressors in factories is larger than in commercial facilities so that the potential of electrical conservation opportunities is higher than in commercial sector. Power rate of indoor incandescent lamp is 60 W but the proposed CFL is 18 W and power rate for outdoor metal halide lamp is 400 W but the proposed high pressure sodium is 250 W. The efficient energy lamps achieved in both indoor and outdoor about 5% and 4% savings in GTC and APF respectively. This is done by replacing only indoor incandescent lamps with CFL and outdoor MHL with SON lamps. The opportunities exist in air leak reduction and cooling air intake of pneumatic system.

The measurement results was analyzed through Java script and excel office 2010 programs to calculate the percentage of saving energy for GTC and APF. The reduction of air leak and cooling air intake achieved 2% and 4% electrical energy savings in both GTC and APF respectively.

Replacing 60W incandescent lamps with 14W CFLs in W.C places achieve energy savings. Measurement results show existing energy saving opportunities for indoor and outdoor light fittings and for air leak of pneumatic distribution system and air intake in GTC and APF. Efficient indoor and outdoor lamps such as CFL and SON achieved 5.5% in GTC and 4% in APF with low cost energy investment. Air leak reduction and cooling air intake in pneumatic distribution network achieved annual saving energy around 2% in GTC and 4% in

GTC and APF. The average energy saving for both various facilities is about 7.5% of the total electrical consumption in both GTC and APF in Gaza Strip.

The commercial and industrial sectors account for 30% of total electrical supply to Gaza Strip. In 2010, the total electrical energy purchased in the Gaza Strip reached 1,544 GWh; thus, the total consumption by commercial and industrial sectors is 0.45 GWh/year.

The energy saving in commercial and industrial sectors cooperates to reduce the electrical deficit. The saving factor achieving in this research is 7.5% and corresponds to 33.75MW/year. Assuming this percentage represents the average saving of electrical energy for commercial and industrial sectors in Gaza Strip achieved by adopting the low cost electrical energy actions, and then the rate of electrical deficit deceases by 3.3 %.

IV. FEASIBILITY ANALYSIS

Although prices vary considerably among energy-efficient light sources such as fluorescent and HID lamps, the major factor that determines lighting costs is not lamp or fixture cost but energy cost. Most organizations are reluctant to invest in energy-efficiency because of the uncertainty and risk associated with these investments. Investments in energy efficiency reduce energy costs, increase cash flows and increase the capital value of facilities. In this paper, replacing inefficient light fittings and improving performance and functioning of electrical air compressors don't incur any costs for GTC and APF. The payback period is less than 6 months and can achieve high profits through increasing cash flow. Tables 4 and 5 illustrate economic analysis including annual energy and money saving by adopting low cost saving programs.

4.1 Relation of kWh versus operating hours

The electrical energy saving in light distribution system in commercial sector is particularly more feasible than industrial sector but the saving in electrical equipment in industrial is more feasible in commercial sector. Figure 6 displays the annual electrical consumption before and after implementing low cost saving energy investment in APC.

Figure 7 displays the annual electrical consumption before and after implementing low cost saving energy investment in APF.

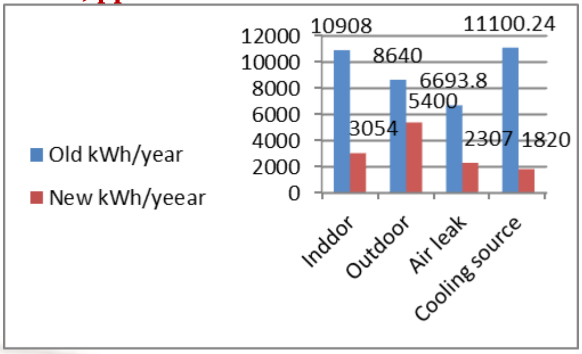

Figure 6: Energy savings using low cost investment in GTC

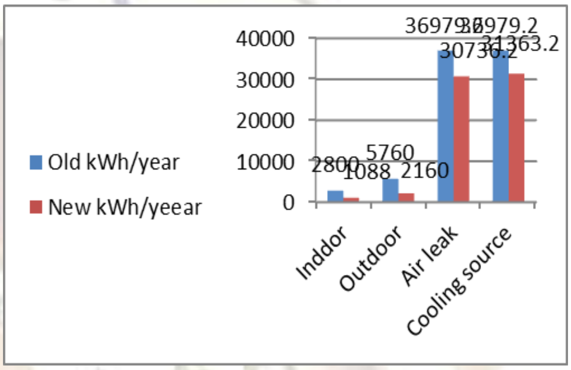

Figure 7: Energy savaging using low cost investment in APF

4.2 Return of investment cost

The above approaches assure that low investment cost is required and the return payback period is less than 6 months. Figure 8 presents the final results of energy saving for both GTC and APF. Low cost energy saving investment achieved about 7.5% of annual electrical consumption in the selected facilities; this investment cooperates to reduce the electrical deficit in Gaza Strip by approximate 3.3%.

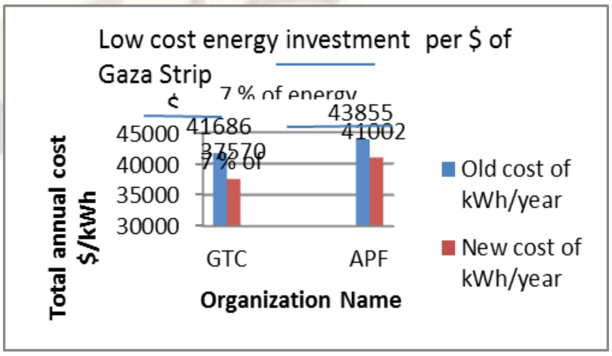

Figure 8: Summary of low cost investment in GTC and APF.

V. CONCLUSION

This paper dealt with reducing the electrical deficit rate of deficit using low cost energy saving programs. This program included improvements of inefficient indoor and outdoor light fittings and performance of electrical air compressor. Results showed that the investment in low cost electrical conservation programs didn't have any risk and can reduce the energy cost and increase the cash flow of the facility. Low cost energy saving actions achieved an annual average energy saving of 9% with 18603 kWh and equivalent to $2400. Assuming these results is adopted in other places, and then an electrical deficit rate is deceased by 3.3%. The main outcome of this paper is the reduction of the electrical deficit rate while achieving good investment in commercial and industrial sectors.

Future Work will investigate major investment schemes to reduces power losses and decrease electric power deficits rates.

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