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ENERGY MANAGEMENT IN THE INDUSTRIAL SECTOR OF NIGERIA'S ECONOMY

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ABSTRACT

Effective use of local energy source by the industrial sector is of vital importance economically and environmentally. Strategies are suggested for better management of industrial energy consumption and use. Cogeneration, waste heat use, industrial integration are some strategies that can be employed to enhance effective energy use and minimize waste heat. Savings can be made by government on initial power generation costs by leveling out power consumption and reducing peak consumption rates. This the government can do by enforcing a time-of-day tariff. Consumer awareness of the strategic importance of energy use can significantly contribute to encouraging industries to pursue energy saving policies.

KEY WORDS: Co-generation, integration, energy, discounted price, buffering

INTRODUCTION

Energy is a crucial need of any society. Civilization had made it possible for man to become familiar with many forms of energy existing in nature. As a result, increasing amount of energy is now available in the form of machines with which tasks that were formerly executed through manual efforts can now be performed. Electricity is one of such forms of energy.

Electricity generation, transmission, distribution and sales in Nigeria are the monopoly of the National Electric Power Authority (NEPA). As at 1985 Nigeria had a total installed capacity of 2800 megawatts and a desired reserve capacity margin of 820 megawatts (Olagoke 1990). According to him, by 1987 the total installed capacity had increased to 4657 megawatts. The vast availability of hydrocarbon energy resources in Nigeria today means that energy cost should not be a major industrial expense as in most industrial countries. The Nigerian energy profile is characterized by rapid growth in energy consumption estimated to be between 15% and 20% increase per annum (Manafa 1978). This rapid growth of power generation and consumption caused by fast population growth and a strong government policy of industrialization in addition to low price for power and other types of energy has resulted in a lack of integration between power production and consumption sectors. This has resulted in a great waste of energy caused by the lack of optimization of power consumption. Many industries could afford such a waste of energy and still be competitive because energy cost in many cases are minor compared to other production costs. In many processes, high temperature energy associated with plant effluent and products is not used and is directly released into the environment. Waste energy results in economic losses and causes major environmental problems.

In this paper, new approaches for

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minimizing wasted industrial energy are proposed. Experiences of other countries are evaluated, and co-generation and integration plants to local industries are proposed.

ENERGY PRICES:

Stable electrical energy generation provides better selection of more efficient power generators. Today the National Electricity grid has a wide variation of minimum and peak daily power consumption. By reducing the gap between the peak and minimum daily power consumption, it will be possible to achieve better raw fuel allocation, fewer power generators and higher power generating efficiencies. Load management is a beneficial technique, which might enhance better energy management.

Another technique for achieving this target is to charge industrial power rates based on the time of the day or year that energy is consumed. Let us now consider the effect of this pricing method in both the small and large industries.

SMALL INDUSTRIES

Many small industries use batch processes during the day or even a two-shift operation. For these industries electrical and fuel consumption peaks during the day and becomes close to zero at night. Offering lower priced energy during low demand time will encourage small industries to shift their operation away from the nation's gross peak demand period. The following equations proposed by Al-Khaldi and Abu-Sharkh (2000) illustrates the general production cost components per unit product.

$$C_p = E_c + C_L + C_v + C_{ps} + C_u \quad \text{----------------(1)}$$

Where

C_p = Final product unit cost
E_c = Regular industrial energy cost
C_L = Labour cost
C_v = Variable cost sensitive to time (e.g., land rentals)
C_{ps} = Cost items sensitive to production capacity.
C_u = Other unclassified cost both fixed and variable.

All the above cost factors are per unit product. The percentage contribution of each factor to the total unit production cost varies from one industry to another, depending on the complexity of the manufacturing process. Simple processes are easier to automate, hence involve less C_L and more Cps percentage share.

When the two-price concept for energy is applied, equation (1) becomes

$$Cp = (1-\mu)\,Ec + \mu E_{Dc} + C_L + Cv + Cps + Cu + C_I \quad \text{----------------(2)}$$

Where

E_{Dc} = discounted industrial energy cost.
μ = portion of energy consumed during the discounted rate period.
C_I = cost of inconvenience resulting from changes in operations.

Equation (2) shows that if a small industry operates during the energy discount period, that is, when μ equals unity, it can lower production costs. This can be achieved by:
(1) Extending the industry's operating hours thereby taking the advantage of the energy discounted rate (E_{DC}) and the time dependent cost factor (Cv). Certainly extended operation will increase Lc, however Ec will create more economical justification for extended operation. The extended operation is governed by increased labour cost factor ($+\Delta Lc$) and savings

in time dependent cost factor (- ΔCv). The economical justification for the extended operation is equal to

$$\Delta Lc - \Delta Cv = 0 \text{ ---------------------------------- } (3)$$

Introducing the two- price concept for energy, equation (3) becomes

$$\Delta Lc + \Delta Ec - \Delta Cv > 0 \text{ -------------------------- } (4)$$

Where the saving from the concept of two energy prices Δ Ec equal

$$\Delta Ec = \mu (Ec - E_{DC}) \text{ ---------------------------- } (5)$$

It is justifiable to extend the industry operation as long as the left hand side of equation (4) remains greater than zero.

(2) Rescheduling, working hours to avoid operating during regular peak demand energy hours. This target can be achieved by altering regular operating hours. Another approach is to redesign an industry's activities to avoid operation that consumed high energy during peak energy demand hours. By operating during low energy peak periods, equation (2) becomes.

$$Cp = Ec + Lc + Cv + Cps + Cu + C_t \text{ -------------- } (6)$$

However extended or rescheduled working hours might cause an additional inconvenience cost (C_t). For instance extended operations might increase lighting requirement, hence increase electrical energy consumption. Therefore C_t should be considered when evaluating equation (6).

LARGE INDUSTRIES.

Large industries, for the purpose of this discussion will be classified into two groups:

(a) Those who depend on NEPA for their energy requirements.

(b) Those who generate their power internally.

(a) NEPA DEPENDENT LARGE INDUSTRIES.

These industries can also benefit from the two-price energy concept developed for small industries. The assumption is that these industries operate in a continuous mode. Therefore for the first instance it might appear that only these industries will benefit from the two-price concept with no advantage for the energy supplier (NEPA).

Each industry involved uses different processes related to each other and integrated to form one complicated process. The discounted price will encourage large industries to operate individual processes that consume more energy during low energy demand periods with buffered storage capacity to maintain the continuity of the process. Applying the buffering strategy requires storage capacity, and that process should have a marginal Capacity to produce more during non-peak energy hours. In such a case equation (2) becomes.

$$Cp = (1-\mu) E_c + \mu E_{DC} + L_C + C_v + C_{PS} + C_u + C_t + C_b \text{ ------------ } (7)$$

Where
C_b = cost due to buffering strategy

From equation (7), the two cost component contributing to the production unit cost are Ec and C_b. Hence the buffering strategy will be more economical for large industries to the extent that the following equation is satisfied.

$$\mu (Ec - E_{DC}) - C_b > 0 \text{ ------------------- } (8)$$

Moreover, through close co-ordination between the energy supplier, (NEPA) and industries' management, a deal can be established to allow discounted rates only for the energy portion shifted fr. ı the peak hour period. Applying different energy price concept in the industrial sector is possible because of the following:

- Industries can be easily identified and monitored. In fact, NEPA has already established close co-ordination and monitoring system for many large industries.
- Programmable metering system can be used for selected industries.

(b) LARGE INDUSTRIES THAT GENERATE OWN POWER :

Many large industries especially the chemical process industries (CPI) generate their own power rather than depend on NEPA. One reason advanced for this is the epileptic nature of NEPA power supply. These industries use either the steam turbine or the gas turbine in the cogeneration mode or in the combined cycle mode. The cogeneration mode is however more popular because of its

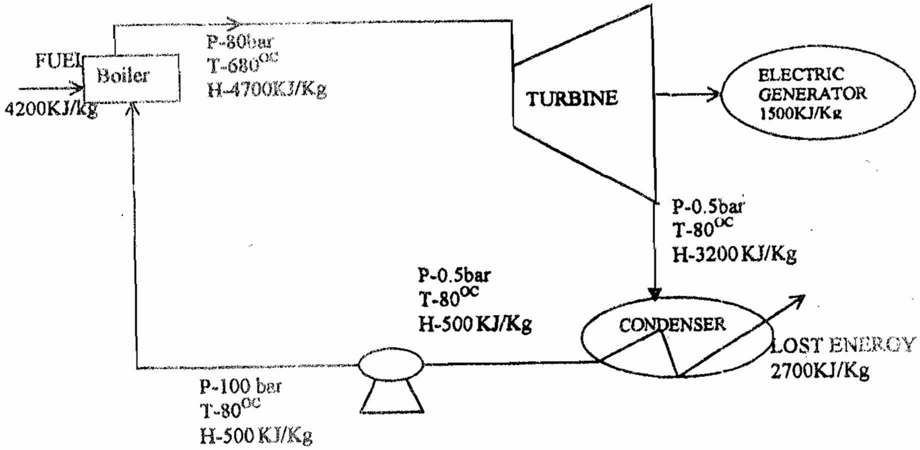

Fig 1: Energy balance of a simple steam turbine plant.

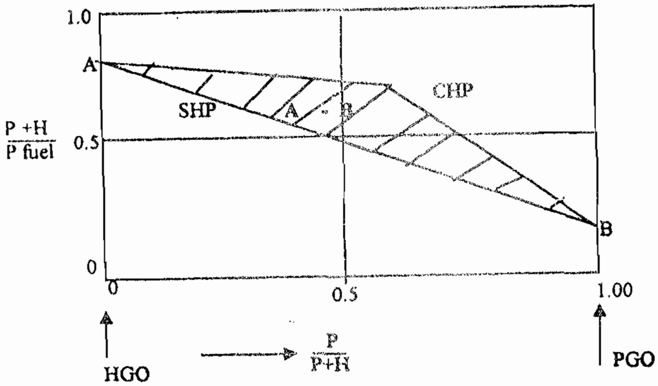

Fig 2: Comparison of fuel utilization of cogeneration and separate heat and power generator.

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CHP- Combined heat and power generator

HGO- Generated heat output

PGO- Generated power output

$\frac{P+H}{P\ fuel}$ Fuel conversion ratio (utilization)

$\frac{P}{P+H}$ CHP ratio.

P - Generated power –MW.

H - Generated heat (steam) - MW.

P_{fuel} - Heat supplied by fuel – MW.

A-B - Improved primary energy utilization with CHP.

distinctive advantages. In comparing the steam turbine plant and the cogeneration plant used by the Warri Refinery and Petrochemical Company (WRPC), it was found that the cogeneration plant has the highest thermal efficiency, low fuel utilization and reliability (Oghenejoboh 1998). In the conventional steam turbine a lot of energy, which would have been judiciously utilized in the system, is lost to the atmosphere. Consider an energy balance of a simple steam turbine cycle below.

In figure 1. , 64% of input energy is ejected to the environment through the condensation process. This phenomenon is due to the low-pressure steam downstream of the turbine which is condensed and sent back to the boiler to complete the cycle. In the cogeneration mode the lost energy is almost fully recovered in the Heat Recovery Steam Generators (HRSG) for the production of steam for process heating or for use in a steam turbine for generation of more power. Comparatively co-generation mode, has been found to allow an improvement in fuel utilization which translates into a major saving (Rohrer 1996). Figure (2) compares the fuel utilization ratio of cogeneration and separate heat (steam) and power generation for different heat –to – power ratios.

In figure 2, point (A) represents pure heat generation with a boiler at approximately 90% efficiency, point (B) a steam power plant generating just electricity. Connecting these two points represent the relationship between the fuel utilization and P/(P+H) for power plants for heat and power generation. The upper line shows the same relationship for cogeneration plants. Fuel utilization is seen to be significantly better for cogeneration plants than for separate heat and power generation plants: the fuel utilization benefit being given by the area between the two line (A-B).

Given the general overview of the various advantages of the cogeneration over the conventional steam turbine plant as discussed above, many large companies opt for the cogeneration plant. It is however sad to say that a lot of energy is still wasted by these industries at a time that the other section of the economy are in dare need of energy. Wastage results from the producing company's inability to utilize all the energy generated. For example, the WRPC, which has a 90 megawatts capacity power plant, utilizes only 20 megawatts. The wasted energy in terms of power and heat can be utilized in one of the following ways:

- Industrial integration
- Partnership energy management
- Energy recovery.

Industrial Integration

Industrial integration involves energy use within or across different industries. For instance wasted energy from one industry can satisfy the energy requirements of another. Moreover arranging two different processes or industries in an integrated single process may enhance better energy use. Industrial integration between refinery processes and glass or metallurgical industries represents a good example of waste heat use across different industries. This type of integration provides good opportunities for optimum energy use. The required independence can be achieved with co-ordination between these companies. Locating such industries close to each other permits such co-ordination and integration.

Partnership Energy Management

Big industries that generate their own power can enter into a partnership deal with NEPA to buy their surplus power at a subsidized rate. This process will boost NEPA's power output and eliminate energy wastage by the generating company. Under this arrangement WRPC mentioned above could run their plant at full capacity knowing that market exists for their surplus power. It is heartwarming to know that the gas turbine project currently being built by the Rivers State Government has a provision for a tie-in to the national grid should NEPA request for such partnership. The Lagos State Independent Power Project (IPP) which has similar provision is reported to have delivered 230 megawatts to the national grid (Vanguard, 2001) This type of partnership is already in place in many countries. The National Power Logen in the United Kingdom (UK) has applied a similar concept called Partnership Energy Management (PEM). Under this partnership the power generating company builds power plants at customer sites and sells electricity and utility heat. On-site power plants are normally operated by customer operations personnel. To ensure safe operations the power company provides training. After more than ten years of experience, Tony Thompson, the regional manager of National Power Plant concluded that what was initially seen by their competitors as being somewhat unwise is now being adopted by some of them (Thompson, 1996).

Energy Recovery:

Energy consuming industries that have the potential to recover electricity should use available energy recovery techniques to reduce external energy requirements. Most industries are not endothermic in nature, in which no real transformation of energy to the processed matter takes place. However these industries require the transformation of energy from one form to another or the energy is required to establish a temperature change in phase or state where the target industrial process takes place.

In the steel industry for example, high temperature is required to separate steel from associated materials that burn or melt before steel melts. The steel is then molten by raising the temperature even higher before it is shaped into various shapes or forms. The reformed steel is then cooled. Although this industry requires a huge energy input, energy consumed is ejected out of the plant during the steel clean up process and in the cooling process. Steel factories can use Waste Heat Boiler (WHB) and steam turbine to recover wasted energy and to generate electricity. Even if the steel factory is incapable of installing the power generating facilities, NEPA might consider providing these facilities.

Process/Process Heat Exchange:

In petroleum refineries, petrochemical plants and other industrial sectors, heating and cooling are used in different processing stages. Steam for instance is used in refineries to heat crude oil before distillation process. After distillation, cooling separates refined products. Water and air are two common cooling media employed. Using process/process heat exchangers would reduce the required heating steam, which eventually reduces energy required.

CONCLUSION

Better management of current and potential sources of energy, better planning of future industrial projects, promoting and enforcing energy conservation policies can realize better industrial use of local energy resources. Cogeneration has a main role in improving energy use in which high temperature and low temperature industries can be built to work side-by-side, and is also an efficient way to use waste energy.

Regulating power prices as a function of time can be very useful in saving capital cost by reducing peak hour demands and guaranteeing more even distribution of consumption with time. Partnership energy management when well implemented will not only eliminate industrial energy waste but also boost the national power output.

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