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Energy Conservation as a Viable Pathway Towards Energy Stability

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Abstract: This study looked at energy conservation as being concerned with ways to reduce energy demand, but yet achieve the same objectives, thus serving as a veritable means of achieving energy stability. The trends of several energy forecasts with a projected annual growth rate from 2.5-4% had been an indication for the application of energy conservation measures. This study takes a look at the national energy outlook of a country like Nigeria vis-a-vis the world energy outlook and presented several energy conservation opportunities to cause energy savings and identified about 6 major areas through which energy conservation measures can effectively cause some savings in energy and allow for its stability. Such areas of focus for application of energy conservation measures include: Manufacturing/industrial set-up, office and residential buildings, transportation, power generation and distribution, energy conservation through waste control etc. Finally, various measures have been recommended among which were energy use in heating and ventilating equipment, lighting, electrically operated machines, design for energy efficient buildings etc.

Key words: Energy conservation, energy stability, conservation opportunities, conservation measures, savings

INTRODUCTION

There has been a large number of forecasting projecting world energy for the next few decades. Hubert (1982) did some studies in this regard. The projected annual energy growth rate ranges from 2.5-4%. World total energy growth slightly exceeds that of US with a growth rate currently over 4%. There have been projections by the International Energy Agency (IEA) and the Energy Information Administration (EIA) that world oil production will have to be increased by about 30% on the current production rate to meet rapidly rising demand (Riva, 1995). IEA further projected a rise in oil demand from 76 million b/d in year 2000 to 94 million b/d in 2010 (World Energy Outlook, 1995). If an oil production increase of this magnitude should occur and unexpected reserve are not found, the 95 million b/d rate could be sustained for only additional 20-25 years before a depleting world oil resource base would force production down.

Most projections suggest that this rate will continue. This projections for continued rapid energy growth imply some severe problems for the future-resource depletion, energy degradation, associated environmental problems, fuel shortage etc. Indeed many of these problems are already happening, thus energy conservation is concerned with ways to reduce energy demand, but yet achieve the same objective as before.

A most casual look at our civilization shows the important part played by the supply and control of energy. Many function necessary to present-day living grind to a halt when the supply of energy stops. While electric power is a common form of energy used in homes today, there are other forms used industrially and domestically. Raw energy in falling water, in deposits of coal and gas and in certain types of refuse has yielded most readily to control and is applied commercially today.

According to Mitchel (1983), energy is essential to our way of life. It provides us with comfort, transportation and the ability to produce food and material goods. Historically, energy consumption has been directly related to the gross national product (GNP), which is a measure of the market value of the total national output of goods and services (Adeyemo, 2001).

As earlier defined, the term energy conservation implies accomplishing essentially the same objective as before but with less energy e.g., lighting a space. This can be done by increasing the use of resources, settling for a slightly lowered objective or being smarter (i.e., inventing new technique/using new technology giving thoughts for energy savings.

This study will thus take a look at the various energy requirements of the various sectors vis-a-vis the energy conservation opportunities therein and also the measures to maximis these opportunities and thus conserve energy.

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The study identified about 5 major areas through which energy conservation measures can effectively cause some savings in energy and allow for energy stability. The main area of focus for application of energy conservation measures include: Manufacturing/industrial set-up; office building and residential buildings, Transportation, power generation and distribution and energy conservation through waste control. Each of these areas is being examined for possible energy savings and stability.

World energy outlook: IEA established that oil fuels account for 40% of the total primary energy demand. Oil availability in future will be a major factor in the world's economic condition.

There have been projections by the International Energy Agency IEA and the Energy Information Administration (EIA) that world oil production will have to be increased by about 33% within the next ten years to meet rapidly rising demand.

If the world's oil reserve are reported with reasonable accuracy and the undiscovered world oil resource, as assessed by the US Geological Survey, prove generally reliable, the original recoverable oil endowment of the earth may have been around 2,330 billion barrels (Master *et al*., 1994).

Nearly one third of this amount has already been produced and consumed. If unimpeded oil exploitation proceeds every where- US inclusive with the utilization of modern exploration and development technology, the remaining two-thirds of the earth's original oil could sustain world's production at about its current yearly level of 22 billion barrels for perhaps 100 years (World Energy Outlook, 1995), which means a declining resource base would force down world oil output.

Typical national energy outlook: A case study of Nigeria: Odukwe and Enibe (1988) opined that with continued rapid population growth and industrialisation in Nigeria, it has become necessary to undertake a systematic compilation of the quantitative data on known energy resources and reserves in the country in order to provide a suitable framework for national energy planning purposes and international comparisons. Estimates of coal reserves was put at 1300 million tonnes (Odukwe and Enibe, 1988) while known crude oil reserve was put at 3.42×10^9 m^3 (Onyegegebu, 2002) around year 2002 with little growth rate to date, which suggests some energy conservation measures.

It appears from experience that our utilization of energy has produced our current high standard of living. However, energy usage pattern must change as supplies become depleted and more expensive alternatives appear. Enibe and Odukwe (1990) did some studies on patterns of energy consumption in Nigeria and submitted that the forms of energy consumed in Nigeria have increased in diversity and intensity with innovations in science and technology and socio-economic changes. These authors identified the primary energy forms consumed in Nigeria to include majorly fossil fuels such as coal and lignite, petroleum products, natural gas and wood fuel while the secondary form is electricity. The sectoral energy consumption in Nigeria allocate the largest percentage to transportation 38% while, residential and commercial records 25%, industrial energy consumption in 22% and other utilities 15% (Adeyemo, 1996). The challenge to engineering profession is to increase or at least maintain our physical and economic situation at reduced levels of energy use. Hence, the need for energy conservation.

ENERGY CONSERVATION OPPORTUNITIES (ECOS)

The prominent areas of opportunities for energy conservation generally and particularly in office and residential buildings, industrial set-up/manufacturing processes are facilities such as: Ventilating air-conditioning equipment for space cooling, (HVAC); Lighting and illuminating devices; Power generating machines for electrically operated equipment, such as Pumps, Fans and Domestic water heating appliances etc.

Energy Conservation Opportunities (ECOS) in Heating Ventilating and Airconditioning equipment (HVAC): For convenience and clarity, energy conservation in design will be divided into 4 categories: building construction, design criteria, system design and controls. Methods of achieving conservation in design usually are considered in the planning of new buildings. Some of the methods may be applicable to existing buildings through retrofitting-changes to the existing system. Whether or not a specific method is practiced in existing buildings depends on the nature of each case. In some cases, the decision is obvious (an existing building could not be turned round to reduce solar heat gain).

Building construction: Reduced HVAC energy consumption in building construction is a direct result of minimizing heat gains and losses. ASHRAE Book of Fundamentals (1997) gave some guide lines as regards the ECOS in HVAC. The use of exterior walls and roof materials with high thermal resistance is recommended. Avoid excessive use of exterior glass which has a low thermal resistance value and high solar heat gain.

Building sites are often planned for reduced gains or losses. Trees maybe planted for structures erected to reduce solar heat gains or infiltration. Buildings may be oriented to minimize solar heat gains during summer and maximize it in winter time. The use of internal shading devices and external shading overhangs could save much heat gains into the interiors (Duffie and Long, 1980). It is often recommended to avoid excessive lighting to conserve energy.

Design criteria: HVAC system design values used in the past have often resulted in systems that consume excessive amounts of energy. ASHRAE (1997) standards had advocated for design temperatures that will ensure minimum energy consumption by the HVAC equipment. The use of minimum recommended design ventilation rates consistent with ASHRAE standard codes should be encouraged. Efforts should be geared to using cooling load calculation procedures and data that account for the building thermal storage. Proper duct and piping friction loss calculation are essential features that will really reduce energy consumption.

System design: The type of HVAC system and equipment affects the consumption of energy. Several suggestions have been put forward to conserve energy through system design. Examination of the possibility of the use of total energy system compared with conventional system seems positive. The use of refrigeration condenser water for heating is considered positive, use of variable air volume type airconditioning systems are considered generally the most energy efficient system, but the reduction in air quantity directly lowers the power use.

Controls: Considerable energy conservation can be achieved through selection of proper automatic controls as recommended by Dubin and Long (1980). The use of automatic time switching to start and stop equipment according to need is a good energy saving device. Use of night and week-end automatic temperature set-back for unoccupied spaces does a lot in energy savings. Use of a central computerized control system designed to provide the most efficient operations at all times has always been encouraged and proved effective.

Energy Conservation Opportunities (ECOS) in lighting: Lighting systems provide sources of illumination to an enclosure, room, hall, space. Generally, a good standard of illumination requires the adherence to the minimum lighting requirement for a space in term of foot candles (one lumen of illumination energy incident on one square foot of area produces an illumination of one footcandle (fc). The lumen is the unit of light quantity and in terms of power is equal to 0.0015W.

The British IES gives the minimum illumination in footcandle/lux of various workspace as tabulated by McGuinness *et al.* (1981). For best savings in lighting, strict adherence to these standards has been recommended.

Dubin and Long (1980) gave some guidelines to conserve energy in lighting. Such guidelines include: reduction in illumination levels; improving lighting system operations, use of day light, improving space condition for lighting, improving lamp and fixture efficacy.

- Reducing illumination levels requires that: Incandescent lighting be turned off where day lighting can give adequate illumination; turning off flood lighting when not required.
- Improving lighting system operation may require the following guidelines: Provision of manual switches to switch of lights when available day light is adequate; install additional switches to permit shutting off lights in unoccupied areas of the building, installation of master switching system etc.
- Use of daylight involves that windows and sky lights must be clean; and that where practicable, schedule period of occupancy, cleaning, meeting to maximum use of day light. Locate tasks that need the best illumination close to windows. Refinish interior room surfaces with lighter colours that are more reflective to increase the efficacy of all light sources.
- Improving space condition for lighting to conserve energy requires the following measures: clean and wash walls, ceilings and floors, when re-carpeting or retiling, use lighter-coloured carpets or tiles, paint light coloured reflective finishes on interior room surfaces to increase inter-reflectance and to improve the efficacy of both natural and artificial illumination.

Energy Conservation Opportunities (ECOS) in the use of power for electrically operated machines: Dubin and Long (1980) enumerated some guidelines to be followed to achieve energy savings in the use of power for electrically operated machines. Such guide-lines include: turning off equipment/machines when not in use e.g., coffee pots, kettle heaters, fans, etc. Reduction of peak loads is another measure to conserve energy. This can be achieved through electric load controls for load shedding. Other measures include reduction in transformer losses, improving the efficiency of motors, reducing the resistance to flow in piping system for pumps, reducing the volume of flow in water distribution systems.

Reduction in energy consumption in elevators can be achieved through measures such as: increasing the interval during non-peak hours; reducing the number of elevators in service during off-peak hours; turning off motor-generating sets in machine room when not in use; e.t.c.

Several measures have been highlighted as regards energy conservation in domestic hot water heating. Reduction in domestic water temperature (Dubin and Long, 1980) is a measure to cause energy savings. Also, where possible use cold water alone for hand washing; do not maintain an entire hot water system at the same temperature required for most critical work; take some measures to control the use of hot water; install self closing faucets on hot water taps etc. Reduction of domestic hot water losses has been described as a cut in energy cost, Dick-Larkam (1977) reported. Repair of insulation of hot water piping and tanks or its installation where missing are measures to conserve energy. Where forced circulation of hot water is used, shut off the pump when the building is unoccupied. When hot water usage is light, consider using gravity circulation without the pump. Repair pump packing glands of recirculation hot water heaters to reduce leaking of hot water. Insulate hot water storage tank to reduce losses.

ENERGY CONSERVATION MEASURES

Office and residential buildings: Energy conservation in office and residential buildings actually entails ways of minimising energy usage in these buildings, this could only be achieved through some measures to be applied to the functional energy usage system such as air-conditioning - space cooling/heating, lighting, electrically operated machines such as motors, pumps, elevators, duplicating machines, water heaters etc.

Santamouris *et al*. (1994) conducted a research study on the energy characteristics and savings potentials in office buildings. Their report gave the findings of a monitoring campaign in 186 office building in Greece. The specific energy consumption of the buildings for heating, cooling and lighting purposes, as well as the consumption of the office equipment was reported. The impact of the used system, techniques and components was investigated. The potential and limitations of various energy conservation system and alternative techniques was assessed. The study provided useful information for efficient energy planning, as well as appropriate design and equipment selection in office buildings.

Up to 50% of the energy used up in the office building and residential buildings could be recovered through such measures as optimum building design (O'callaghan, 1980), more efficient and water distribution systems, improved heating efficiencies for various heating purposes-domestic water heating etc, improved lighting design, energy auditing and integrated design procedures, ventures for alternative energy sources (Onyegegbu, 2002; Adeymo, 2006) Solar, biomass, wind etc.

Lighting: Replace incandescent bulbs with screw-in fluorescent bulbs, which use 75% less electricity and last at least 8 times longer; turn lights off when not needed; install light dimmers or photoelectric switches that automatically turn off lights during daylight or install timers to control use of lights; for lights used for home security, install motion detectors so lights come on only when motion is detected.

Manufacturing and industrial processes: Three prominent broad areas had been identified for energy conservation measures in manufacturing and industrial processes. Dubin and Long (1980) itemized these as improved house keeping, recovery of wastes and technological innovations.

Improved housekeeping: Improved house keeping with such factors as furnace maintenance, adjustment of lighting system operations, use of daylight, improving space conditions for lighting and improving lamp and fixture efficiency are quantifiable measures of energy conservation.

Recovery of waste: This forms a significant savings in energy through recovery of waste heat - flue gas, exhaust steam, co-generation of electricity etc. Heat reclamation is the recovery and utilization of energy that is otherwise wasted, which can be a substitute for a portion of the new energy that would normally be required for heating cooling and domestic hot water system. Heat recovery conserves fuels, reduces operating costs and reduces peak loads.

Technological innovation: This borders on major redesign of processes and products to yield greater efficiency of cycle operations.

Reduction of greenhouse gas emission: The developed countries are all working to reduce greenhouse emissions (Adeyemo, 2006). Several European countries impose heavy taxes on energy usage, designed partly to curb such emissions. Norway taxes industries according to the amount of carbon dioxide they emit. In the Netherlands, government and industry have negotiated agreements

aimed at increasing energy efficiency, promoting alternative energy (Adeyemo, 2001; O'callaghan, 1980) sources and cutting down greenhouse gas output.

Energy conservation measures in transportation: These include increasing the efficiency of the vehicle system, proper vehicle maintenance for better engine performance, use of alternative energy source e.g., fuel- cells etc.

Rationing: Techniques used in rationing include restricting the uses of an item-for example, forbidding the use of gasoline to power pleasure boats; limiting the quantity available to any consumer; curtailing the hours when an item may be sold; setting a maximum amount a person can spend for an item; and employing a point system, which assigns a point value to a number of articles and permits customers to "spend" a certain number of total points.

Improved technology through electric cars: These are automobiles propelled by one or more electric motors, drawing power from an onboard source of electricity (Wikipedia). Electric cars are mechanically simpler and more durable than gasoline-powered cars, stores its energy on board-typically in batteries, but alternatively with capacitors or flywheel storage devices. Or it may generate energy using a fuel cell or generator, They produce less pollution than do gasoline-powered cars. Energy conservation in electric cars, however, is so important that engineers found a way to recover the heat and use it for other heating purposes.

Energy conservation in power for electrically operated machines: Conserving electricity has become increasingly important as energy rates and shortages have increased. Consumers can find a number of ways to cut back on their electrical use, especially with appliances commonly found in the offices and homes.

Conserving electricity through appliances

Air conditioners: Check and clean the air conditioner's filter once a month; make sure the air conditioning unit is the proper size for the room it is cooling; locate the air conditioner on the north or east side of a house in a shady area; ventilate the house's attic to reduce heat buildup; install ceiling fans to improve air circulation.

Refrigerators: Check door seals to make sure there are no air leaks; clean condenser coils on the back of the refrigerator; keep refrigerator away from oven or dishwasher and give the unit breathing room; turn thermostat down to 37 degrees Fahrenheit; turn on energy saver switch.

Water heater: Lower the heater setting to 120-130°F; insulate the water heater and any exposed hot water pipes; use low-flow shower heads.

Appliances: Replace aging appliances with new, more energy-efficient models when possible; look for Energy Star label designating an energy-efficient appliance.

Computers: Turn off computers when not in use or set the computer to energy-saving mode.

Dishwashers: Wash only a full load; turn off drying cycle, open door to air dry dishes.

Cloth washers and dryers: Use only with a full load; use warm or cold water, reserving hot water use only for heavily soiled clothes; use only full loads for the dryer and if a second load is necessary, dry that load immediately after the first to retain as much heat as possible; clean lint filter before each load.

Ovens and stove: Use microwave instead of oven where possible; food in glass dishes can be cooked at lower temperature; preheating oven is usually unnecessary; on the stove top cook with covered pans and match pan size to the size of the burner.

Energy conservation in power generation and distribution: This involves improvement in energy conversion technology for better efficiency (McGuinnes *et al*., 1981), use of thermionic, thermoelectric in, magneto-hydrodynamic generators for better fuel saving.

Energy conservation through research and development: The Department of Energy has responsibility for energy research. These programs, now distributed among a number of departments within the DOE, are concerned mainly with scientific and engineering research. They aim to develop better and cleaner methods for extracting and burning traditional fuels, such as coal and oil and also to develop new sources of energy, such as solar power, liquid fuels from biomass and nuclear fusion.

Demonstration plants have been funded for technologies such as coal liquefaction and coal gasification, fluidized-bed combustion of coal (Adeyemo, 2001; Onyegeggbu, 2002) and improvement of methods for extracting oil from shale. Other concepts being explored are the conversion of solid waste into methane gas, the extraction of natural gas from coal seams, the use of fuel cells, magneto-hydrodynamics, wind energy and ocean thermal energy.

Solar power research is being pursued in connection with efforts to design residential and commercial buildings

that will use energy more efficiently. Some of the most promising devices are solar collectors (which employ water heated by the sun), solar mirrors and photovoltaic cells capable of directly converting the energy of sunlight into electricity (Onyegeggbu, 2002; Adeyemo, 2006).

CONCLUSION

The foregoing has been a presentation on the opportunities that are available in conserving energy in our various sectors-office building and residential areas, manufacturing industries, transportation, electricity for equipment and appliances. The various areas where savings in energy can be made have been identified-they include energy use in heating and ventilating equipments, lighting, electrically operated machines such as pumps, motors, fans, hot water heating e.t.c. Several guidelines and measures have been suggested to conserve energy in these areas and if the guidelines and measures are strictly adhered to, substantive savings in energy will be made. This may likely give room for better efficient management of the energy distribution and stability.

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