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Principles and Practice of Energy Conservation Using Renewable Energy as Alternative Sources

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Abstract – The energy sector is faced with a lot of challenges including sustainability, availability, high cost and its subsequent effect on the environment. All these serve as a motivating factor all over the world to conserve energy and avoid wastages. Energy conservation is concerned with ways and methods of achieving the same level of output with less energy consumption. Energy efficiency embraces the idea of conserving scarce energy resources; it also includes improving the technical efficiency of energy conversion, generation, transmission and end-use devices. This paper examines some available renewable energy sources, the adaptation, utilisation and exploitation of these sources to meet energy conservation challenges.

Keywords: Energy, Energy efficiency, energy conservation, renewable energy, sustainability.

1.Introduction

Energy is a very vital and important ingredient for development of social and economic change in any community, country or region. It is at the heart of the improvement of the quality of life of a people and a critical factor that enhances infrastructural and economic development. The energy need in the contemporary world cannot but be a major source of concern; neither can it be over emphasized. It is indeed undoubtedly fundamental to the fulfillment of basic need of the individual and the pressing need of various communities in today's modern developed and developing societies. , Keeping a hospital and operational, providing heating and illumination in a building, running a factory, lighting the street and road network, provision of clean water, etc, all require energy (Akorede, Ibrahim, Amuda, Otuoze, and Olufeagbas, 2017). Global primary energy use in 1973 was 4,672 million tonnes of oil equivalent (mtoe). By 2012 this had increased to 13,361 mtoe (Fawkes, Oung, and Thorpe, 2016).

2. Energy conservation

Energy conservation is any behavior that results in the use of less energy. It is focused on ways and methods of reducing energy demand yet achieving the same objective as before. Examples include turning the lights off when leaving the room and recycling aluminum cans etc (Adeyemo S.B., and Odukwu A.O., 2008). Energy conservation is the change in the pattern of energy consumption. It is an effort pursued to reduce the increasing growth in energy consumption. It is a scientific approach towards decreasing the quantity of energy used while achieving a similar outcome or end result. Energy conservation provides the most economical solution to energy shortages. It enhances national and personal security, human comfort and environmental value. (Mallikarjun G.H, Vishwanath M.S, 2015). Energy conservation effort enhances firstly, greenhouse gas emission reduction, secondly, reduction of energy cost. A fundamental step for energy conservation in organisations is to reduce energy consumption in buildings as this reduces operating cost. While a major obstructing factor for energy conservation includes lack of ownership, use of obsolete facilities and equipment, individual controlled air-conditioning system as against a central cooling system (Dong W.K, Jae W.J, Ho T.S, Jeong H.Y, 2010)

Some of the areas or sectors energy conservation can be enhanced includes: buildings, domestic, industrial, commercial and transportation sectors (Mallikarjun and Vishwanath., 2015). Majority of world energy needs are met by fossil fuels, generally because buildings are a large energy consumer, they are also a major contributor to greenhouse gas production and global carbon emissions also. Thus addressing energy use in buildings can reduce total fossil fuel consumption and associated challenges. Buildings account for approximately 40% of the worldwide annual energy consumption (Hayter S.J., Kandt A., 2011). Some of the consideration in building design which would enhance energy conservation would include looking in to the following areas:

- construction site,
- building envelope,
- materials for windows,
- doors,
- the roof of the building,
- heating, ventilation, and air conditioning system,
- lighting system, and
- equipment control.

Mallikarjun and Vishwanath, 2015 in relation to energy conservation in homes feel that many homes are not conscious of the vital role energy conservation plays in cost reduction and environmental concern. This is possible by adopting techniques like, periodic energy audit, selecting energy efficient equipment, proper capacity, proper ambient and good operation and maintenance. The industrial sector represents all production and processing of goods, including manufacturing, construction, farming, water management and mining (Mallikarjun and Vishwanath., 2015).

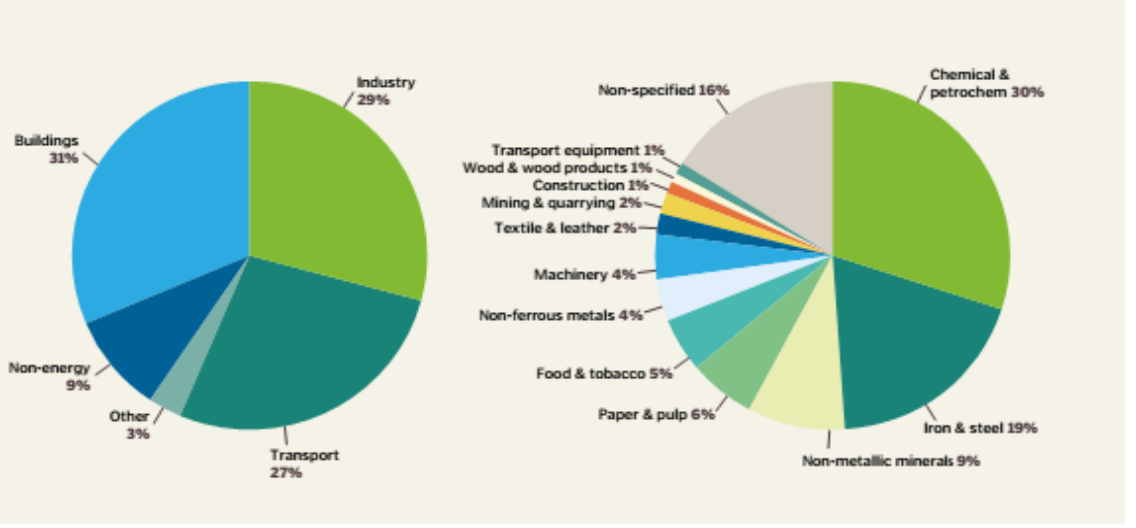

Figure 1: Showing energy consumption by various sectors (Fawkes S., Oung K., Thorpe D., 2016)

Current global breakdown of total energy consumption between sectors shows that industry consumes about 29% of final energy consumption and nearly two-thirds of industrial energy use is accounted for by chemical and petrochemical, iron and steel, non-metallic minerals and paper and pulp sectors. Fawkes et al 2016 identified the following ways of conserving energy in the industry:

Good Housekeeping

This refers to ways and means of energy conservation that cost little or nothing and it includes: implementing good maintenance, turning things off when they are not needed, reinstating and improving

insulation and air leakage, reducing waste, leaks, idle time, production rate losses, and turning off taps and hoses when not needed (Mallikarjun and Vishwanath., 2015), (Fawkes et al., 2016).

The use of control systems

This entails ensuring industrial processes operate closer to its designed control limits. It is the introduction and tightening of the control systems of existing processes. Some of these would include: introducing temperature control limits in air conditioning systems, using preventive maintenance and condition monitoring to predict and prevent equipment failures. (Fawkeset al., 2016).

Simple modifications

Another method of system optimization through simple modifications include: using compact heat exchangers, utilizing closed-loop systems, heat recovery, pipe work and pumps, waste heat recovery boilers, pre-heaters and economizers, and the use of energy efficient components in a machine such as variable speed drives to match supply with demand (Adeyemo and Odukwu, 2008), (Fawkes et al., 2016).

Process integration

Integration of energy use is a more complex form of plant modification but gives further energy savings. Some example includes: recovering heat from one process to be reused in another process, thermal pinch analysis, process intensification, de-bottlenecking and uprating, and overall plant or site-wide optimization to minimize overall energy consumption (Fawkes et al., 2016)

Alternative process

A change either in the process design and energy supply, or both gives the biggest energy savings though it is most costly and involves a high level of business risk. Examples include: combined heat and power plants, refitting the production line with a new process technology, applying dynamic simulation and predictive controls, extending the energy or waste heat into a district heating and/or cooling network. (Adeyemo and Odukwu., 2008) (Fawkes et al., 2016). Transport sector is another major energy consuming area next to industries. Road transportation in Nigeria is the major means by which people move from place to place as over 80% of transportation in Nigeria is done by road (Oni S.I.and Okanlawon K.R., 2010) Regular and periodic maintenance enhances automobile performance and saves fuel. When a vehicle is running well, it uses nine per cent less fuel and thus emits fewer toxic and noxious fumes and providing incentives to automobile manufacturers to produce energy efficient automobiles are some of the way energy can be conserved in the transport sector.it is also profitable to note that beyond one minute, it is more fuel - efficient to restart your car (Mallikarjun and Vishwanath., 2015), (Fawkes et al., 2016), (Gateway, 2017).

Energy sources not derived from traditional fossil fuel sources (coal, natural gas, petroleum) through conventional process are referred to as alternative energy sources. Renewable energy is one of the subsets of alternative energy. Renewable energy resources—such as wind, geo-thermal energy, wave energy, solar energy etc - are constantly replenished, and are being sustained or renewed indefinitely, because they are inexhaustible hence they do not run out (Robb, 2016). This paper examines some available renewable energy sources the adaptation, utilisation and exploitation of these sources to meet the challenge of energy conservation.

3. Renewable energy technologies

The exploitation and utilisation of conventional fossil fuel is fraught with a lot challenges which necessitate the development and utilization of renewable energy sources which should be given a high priority. Renewable energy resources and technologies should be integrated as a key component of energy conservation and sustainable development. Some of the obvious reasons are expressed as follows:

- Environmental impact: Power generation from oil, natural gas, and coal leads to greenhouse gas emissions such as carbon dioxide, oxides of nitrogen, oxides of sulfur, and particulate matters.

Renewable energy resources on the other hand have a less negative environmental impact (Oyedepo, 2012).

- Sustainable supply: Renewable energy sources are such that they can provide reliable energy almost indefinitely (Oyedepo, 2012), (Robb, 2016).
- Decentralisation and flexibility: Renewable energy provides for on-site exploitation of locally available renewable energy sources hence creating a power source independent of the national grid, thus enhancing the flexibility of the system and as a result of this economic benefits [made available and accessible to small isolated populations] (Oyedepo, 2012), (Robb, 2016).
- Security of supply: The constancy in the replenishing of renewable energy resources, they have security of supply, unlike the bottle neck attached to the supply of fossil fuels, which are subject to market forces and international competition, sometimes resulting in shortages (Oyedepo, 2012), (Akorede et al, 2017).
- Future availability: The rate at which renewable energy is being exploited does not in any way affect their future availability thus; they are inexhaustible (Oyedepo, 2012).

As a means of encouraging the use and development of renewable energy sources, industries can explore on-site renewable energy generation at their facilities. In conjunction with regulatory requirements for renewable energy, costs of fossil fuels remain rather high and costs of some renewable and alternative energy technologies are coming down (Askari, Mirzael and Mirhabib, 2014) (Fawkes et al, 2016). Some of the available renewable energy sources that can be used as alternate energy sources in relations to energy conservation include the following:

3.1 Wind energy

People in the past have harnessed energy in the wind—historically wind energy has been used to produce mechanical energy for water pumping and milling activities. Wind energy powered water pumps are still used in some areas of the world. In modern times harnessing wind energy to generate electric energy has become common (Robb, 2016). Wind energy generation is the fastest growing renewable energy market worldwide. The global cumulative installed capacity of wind power gradually increased from 6100 MW in 1996 to158, 505 MW in 2009. Eighty two (82) countries are using wind to generate energy, and 49 countries have increased their installed capacity since 2009. Middle East and African countries have also recorded a total of 230 MW of newly installed capacity; with Morocco and Tunisia recording 90% and170% growth rate respectively (Mohamed and Petirin, 2014). Modern wind turbines convert kinetic energy in the wind to rotational energy and then to electrical energy.

Trees, buildings, and topography can slow winds down tremendously hence wind generators are certainly most effective in areas with consistent, high-speed winds. Proper location of wind turbines is critical. Because there can be wide variations in wind speed over small distances (Robb, 2016).

Figure 2: Wind turbine mounted all along the top of an apartment building (Robb, 2016).

3.2 Hydrokinetic systems

The world hydropower capacity in 2004 was 2810 TWh and is projected to be 4903 TWh by the year 2030, with 1.8% growth rate per year, though the share will remain at 2% of the world energy supplied (Bada, 2011). Some of these are basically large hydropower technology plants. A modern trend is towards hydrokinetics. Hydrokinetic systems are systems which uses the natural flow of water rather than damming the water or diverting the water flow through conventional turbines for generation of electricity. There are many types of emerging hydrokinetic technologies; some are designed for rivers, some for ocean areas with strong tidal flows, and some designed to harness energy in ocean waves.

Figure 3: A hydrokinetic device

3.3 Solar energy

The sun is a vast reservoir of energy. Energy radiated from the sun is about 3.8×10^{23} kW, which is 1.082 million ton of oil equivalent (mtoe) per day (Sambo, 2005). The total amount of energy that the earth receives daily is 1353W/m^2 (Hoff and Chiney, 2000).The sun is the most readily and widely available renewable energy source capable of meeting the energy needs of whole world. It can provide more power than any fossil fuel on the planet (Oji, Idusuyi, Aliu, Petinrin, Odejobi, and Adetunji, 2012). The goal of all solar technology is to capture the radiation generated by the sun and convert it into usable energy. Solar energy can be efficiently harnessed either as passive solar energy or as active solar energy.

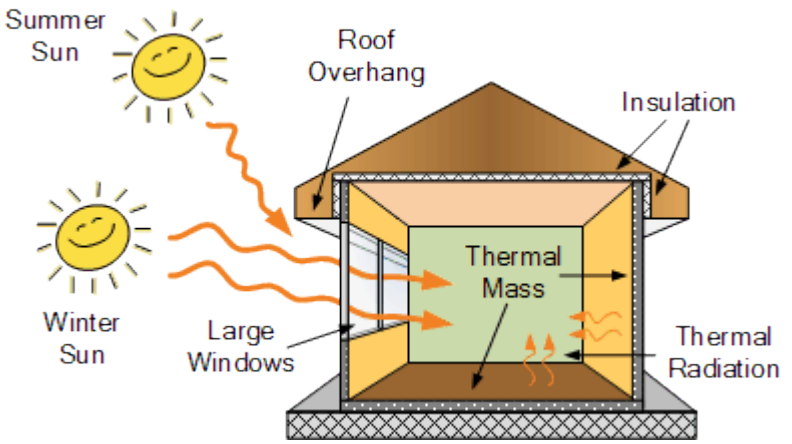

Figure 4: Passive solar energy design considerations (Alternate energy tutorials).

Passive solar technology does not require the use of specialized devices or equipment to convert the sun's energy to power. Passive solar energy designs use the energy from the sun to heat, cool, and illuminate our buildings - homes, offices and industrial buildings can be designed with passive solar systems in mind as this may reduce the need for lighting and heating in cold regions (Alternate energy tutorials). Active

solar energy systems use various electrical and mechanical components to capture and convert the sun's energy. These systems typically would include photovoltaic panels, collectors, voltage controllers, blowers and pumps that work together to process the sun's usable heat. An active solar system may also have batteries that store the collected energy for later use.

The heart of PV technology is in the semi-conductors (mostly silicon-based) used in the PV modules themselves. The modules convert sunlight to direct current (DC) energy; the DC energy is then converted to alternating current (AC) energy via inverters. From the inverters, energy is fed into a building's electric system or exported to the utility grid.

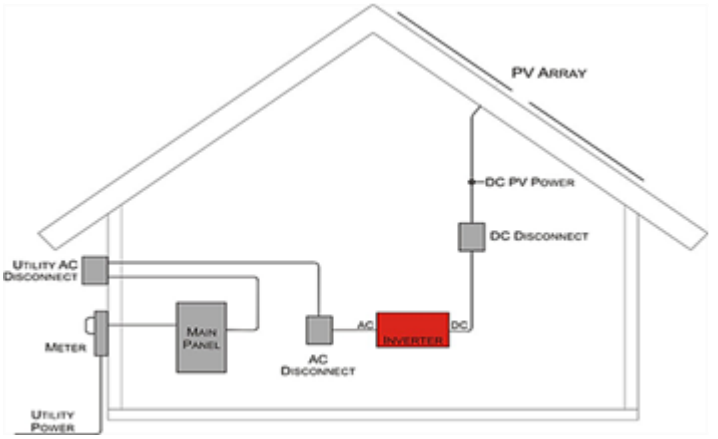

Figure 5: Simple schematic diagram showing PV system incorporated to a home (Robb, 2016).

Solar-thermal involves the use of heat to heat up fluids to produce steam in order to drive turbines which in turn generate electricity exported to the utility grid. Solar thermal systems are also called concentrated solar power (CSP). Solar thermal systems normally make use a solar collector (reflective mirrored surface) to focus sunlight on a receiver which in turn heats up liquid. The super-heated liquid is used to produce steam to generate electricity (Oji et al, 2012).

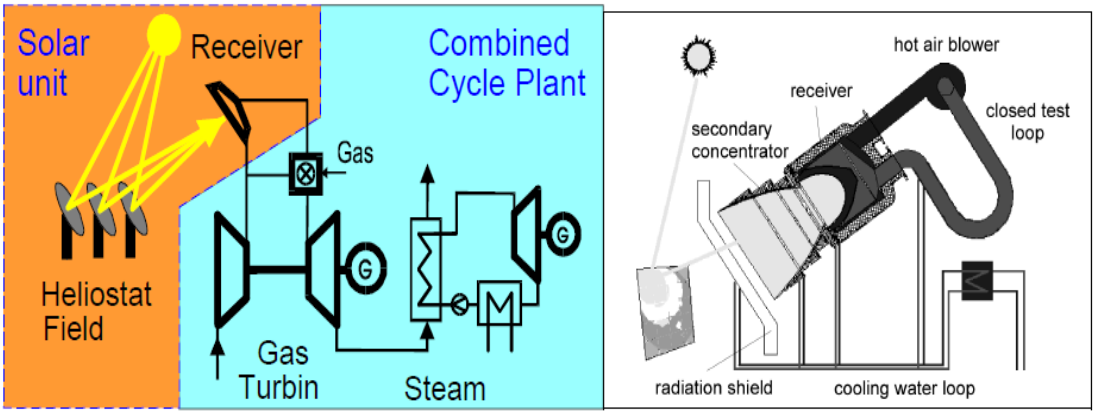

Figure 6: Schematic diagram of solar thermal conversion plant

3.4 Biomass

Biomass is an indirect form of solar energy because it arises due to photosynthesis. Fuel wood is the most common form of biomass energy. Biomass resources include wood, forage grasses and shrubs, wastes arising from forestry, agricultural, municipal and industrial activities, as well as aquatic biomass

(Mohamed and Petirin, 2014). Plant biomass can be used as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a very versatile and cheap biogas (Garba and Bashir, 2002). Biomass can also be used for power to power turbines which—in turn—generate electricity. The term biofuel generally refers to a fuel derived from plant material (biomass) that can be used in lieu of conventional fossil fuels.

The oldest use of biomass energy is burning wood to keep warm. This is still quite common in homes today, and there are also more advanced boiler systems that burn wood to heat water for use in homes or larger buildings. Some of these devices are designed to burn wood pellets rather than larger pieces of wood. Wood pellets are small (less than one inch) pieces of processed biomass from a variety of sources (wood chips, sawdust, waste from wood processing, etc.). Pellet-burning appliances typically have hoppers that feed the fuel to the firebox at a controlled rate—making pellet burning easier to control than some other types of biomass appliances.

On larger scales, many timber and agricultural industries burn wood and agricultural waste to obtain useful heat—the heat can be used directly or used to power turbines to generate electricity. When the biomass fuel is inexpensive—especially when it is a waste product—such power generation can be very cost-effective. Estimates show that 200 million ton of dry biomass can be obtained from forage grasses and shrubs, releasing about 2.28 ×106 MJ of energy (Oyedepo, 2012).

3.5 Geothermal energy

Geothermal energy is heat energy generated and stored in the earth; it is generated from the radioactivity decay and continual heat loss from the earth's formation. This energy can be used for direct heating, space heating, industrial processes, desalination, agricultural applications and most importantly to generate electricity (Tunde Olaoye, Titilayo Ajilore, Kunle Akinluwade, Femi Omole and Adelana Adetunji, 2016). To generate electricity using geothermal energy, a hole is dug into the ground or rock to depths of about 4 – 10 Km and water is allowed to flow into this hole and back to the surface. The water reaching the hotter earth crust is heated up and the steam travelling, back up to the surface is used to drive turbines which in turn drive generators that produce electricity (Askari M.B, Mirzael V., Mirhabib M.,, 2014), (Olaoye et al 2016). Geothermal power supplied less than 1% of the world's energy in 2009 but by 2050 it is expected to supply between 10 to 20% of world's energy requirement. Geothermal power plants are operating in about 20 countries (Askari et al., 2014). Building applications for geothermal technologies include geothermal heat pumps which are able to heat, cool and supply homes and buildings with hot water. A geothermal heat pump system basically consists of a heat pump, an air delivery system (ductwork), and a heat exchanger—a system of pipes buried in shallow ground (Hayter S.J., Kandt A., 2011).

Using emerging technology known as Enhanced Geothermal Systems (EGS) the heat in the earth's crust can be harnessed for electricity generation on a large scale. Geothermal power is reliable and sustainable, as the earth's internal heat content is 100 billon times current worldwide energy consumption (Tunde et al, 2016). The creation of power using geothermal energy does not produce pollution. Geothermal power requires no fuel; it is therefore immune to fuel cost fluctuations (Askariet al., 2014). However, capital costs tend to be high. Drilling accounts for over half the costs, and exploration of deep resources entails significant risks. Geothermal power is highly scalable: a small power station can supply a rural village, though initial capital costs can be high (Askari et al., 2014).

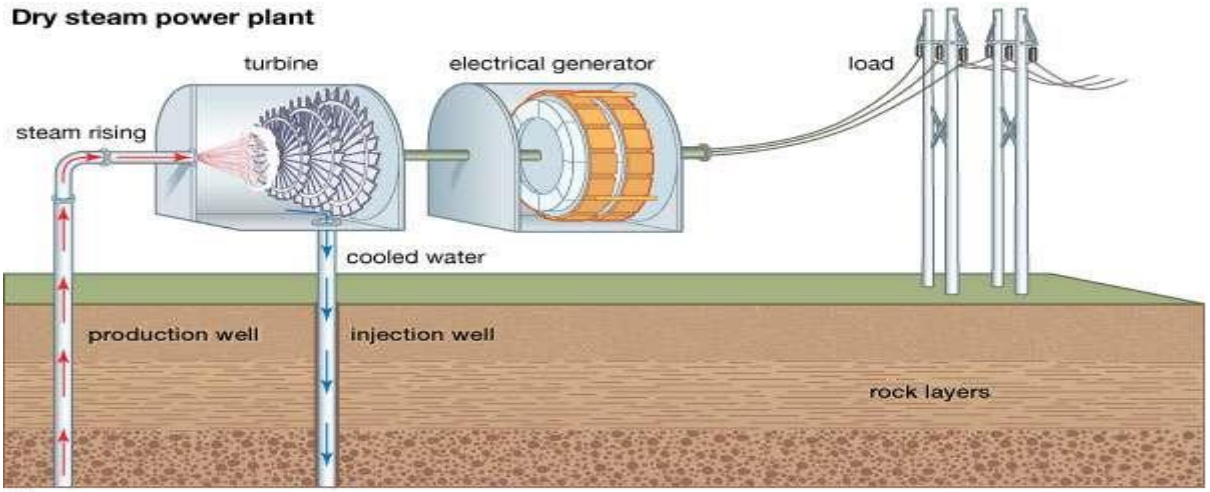

Figure 7: Geothermal plant

4. Conclusion

Conclusively, renewable energy resource is a viable option for reducing dependence on fossil fuels and enhancing energy conservation. Energy efficiency embraces the idea of conserving scarce energy resources; it also includes improving the technical efficiency of energy conversion, generation, transmission and end-use devices. Energy conservation can further be enhanced by substituting more expensive fuels with cheaper ones and reducing or reversing the negative impact of energy production and consumption activities on the environment. When an organisation or nation focuses on energy efficiency and conservation it enhances its competitiveness, energy security, environmental quality and reduces cost of production. Optimization of the use production resources is achieved. Energy conservation demands a collective effort with everyone who consumes energy in one form or the other contributing (Mohamed and Petirin, 2014), (Akorede et all., 2017).

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