JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	Jaipur Engineering college and research centre, Shri Ram ki Nangal, via Sitapura RIICO Jaipur- 302 022.	**Academic year- 2020-2021**

DEPARTMENT OF ELECTRICAL ENGINEERING

IV YEAR/VIII SEM

LECTURE NOTES ON ENERGY MANAGEMENT

(*BY:SONALI CHADHA,AP***)**

8AG6-60.1: Energy Management
Credit: 3 Max. Marks: 150(IA:30, ETE:120)

3L+0T+0P End Term Exam: 3 Hours

SYLLABUS

1 Introduction: Objective, scope and outcome of the course.
(This compulsory for all course)
2 Energy Basics; Energy Demand Management, Conservation & Resource Development, Energy for Sustainable Development.

3 Need for Energy Management by Sector- Industry, Buildings & Houses, Transport, Electric Power.

4 Need for Energy Management by Sector- Agriculture, Domestic; Energy forecasting techniques; Energy Integration, Energy Matrix.

5 Energy Auditing; Energy management for cleaner production, application of renewable energy, appropriate technologies.

COURSE OBJECTIVES

1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing.

2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing.

COURSE OUTCOMES

On completion of this course, the students will be able to exhibit

CO1. Conceptual knowledge of the technology, economics and regulation related issues associated with energy conservation and energy auditing

CO2.Acquired the expertise and skills needed for the energy monitoring, auditing and management, and for the development, implementation, maintenance and auditing of Energy Management Systems

CO3 .Become capable of analysis and design of energy conversion systems and also have acquired skills in the scientific and technological communications, and in the preparation, planning and implementation of energy projects

SCOPE OF ENERGY MANAGEMENT

The **course in Energy Management** integrates in-depth knowledge related to the field and imparts requisite skills to the individuals. It offers specialization in various domains like oil and gas, renewable energy, energy efficiency, sustainable consumption of energy resources and usage of unconventional resources. The individuals can employ their acquired knowledge in formulating appropriate tactics to manage energy efficiently. The course makes candidate eligible for the industry. One can employ the acquired knowledge in preserving the environment, for sustainable development, and for managing the energy. The successful candidates may take up positions such as Energy Auditor, Technical Consultant, Energy Manager, Energy Analyst, Oil and Gas Analyst, Project coordinator, and much more.

CONTENT: *Introduction: Objective, scope and outcome of the course.*
Energy Basics; Energy Demand Management, Conservation & Resource Development, Energy for Sustainable Development.

ENERGY BASICS

Definition
Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy.

Various Forms of Energy

There are two types of energy - stored (potential) energy and working (kinetic) energy. For example, the food we eat contains chemical energy, and our body stores this energy until we release it when we work or play.

Potential Energy: Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.
Chemical Energy: Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.
Nuclear Energy : Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.
Stored Mechanical Energy: Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.
Gravitational Energy: Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin the turbines, it becomes motion energy.

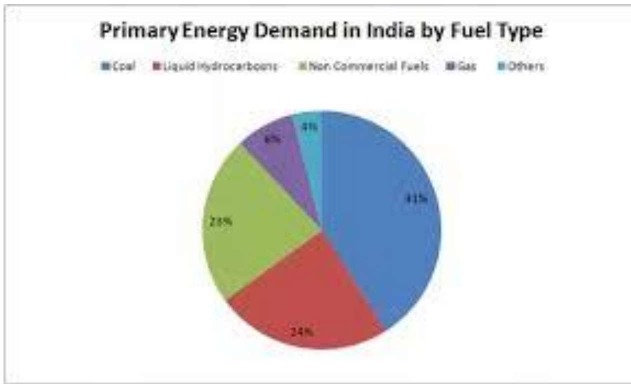
Kinetic Energy Kinetic energy is energy in motion- the motion of waves, electrons, atoms, molecules and substances. It exists in various forms.
Radiant Energy Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

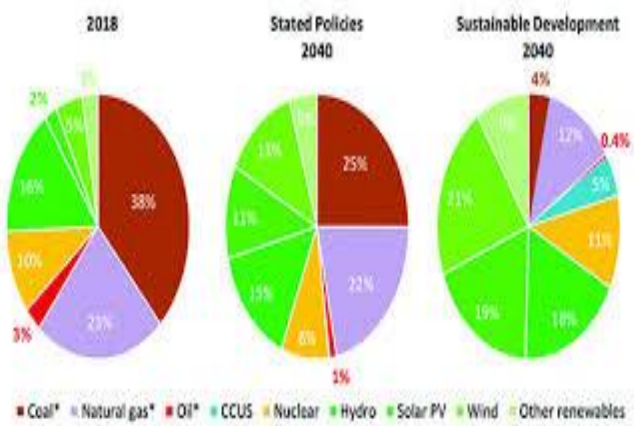
Thermal Energy Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.
Motion The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion. Sound
Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.
Electrical Energy Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

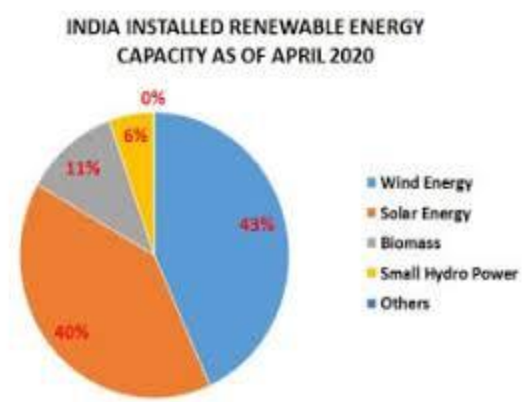
Energy Conversion Energy is defined as "the ability to do work." In this sense, examples of work include moving something, lifting something, warming something, or lighting something. The following is an example of the transformation of different types of energy into heat and power. It is difficult to imagine spending an entire day without using energy. We use energy to light our cities and homes, to power machinery in factories, cook our food, play music, and operate our TV.

Grades of Energy
High-Grade Energy Electrical and chemical energy are high-grade energy, because the energy is concentrated in a small space. Even a small amount of electrical and chemical energy can do a great amount of work. The molecules or particles that store these forms of energy are highly ordered and compact and thus considered as high grade energy.
High-grade energy like electricity is better used for high grade applications like melting of metals rather than simply heating of water.

Low-Grade Energy Heat is low-grade energy. Heat can still be used to do work (example of a heater boiling water), but it rapidly dissipates. The molecules, in which this kind of energy is stored (air and water molecules), are more randomly distributed than the molecules of carbon in a coal. This disordered state of the molecules and the dissipated energy are classified as low-grade energy.


Primary Energy Demand in India by Fuel Type
Coal
Liquid Hydrocarbons
Non Commercial Fuels
Gas
Others
41%
24%
6%
4%


2018
Stated Policies 2040
Sustainable Development 2040
38%
10%
3%
2%
25%
22%
8%
1%
4%
0.4%
5%
11%
19%
Coal*
Natural gas*
Oil*
CCUS
Nuclear
Hydro
Solar PV
Wind
Other renewables


INDIA INSTALLED RENEWABLE ENERGY CAPACITY AS OF APRIL 2020
0%
6%
11%
43%
40%
Wind Energy
Solar Energy
Biomass
Small Hydro Power
Others

ENERGY DEMAND MANAGEMENT (Demand Side Management)

Demand side management (DSM) has been traditionally seen as a means of reducing peak electricity demand so that utilities can delay building further capacity. In fact, by reducing the overall load on an electricity network, DSM has various beneficial effects, including mitigating electrical system emergencies, reducing the number of blackouts and increasing system reliability. Possible benefits can also include reducing dependency on expensive imports of fuel, reducing energy prices, and reducing harmful emissions to the environment. Finally, DSM has a major role to play in deferring high investments in generation, transmission and distribution networks. Thus DSM applied to electricity systems provides significant economic, reliability and environmental benefits.

When DSM is applied to the consumption of energy in general—not just electricity but fuels of all types—it can also bring significant cost benefits to energy users (and corresponding reductions in emissions). Opportunities for reducing energy demand are numerous in all sectors and many are low-cost, or even no-cost, items that most enterprises or individuals could adopt in the short term, if good energy management is practiced.

Concept of DSM

Cost reduction – many DSM and energy efficiency efforts have been introduced in the context of integrated resource planning and aimed at reducing total costs of meeting energy demand; Environmental and social improvement - energy efficiency and DSM may be pursued to achieve environmental and/or social goals by reducing energy use, leading to reduced green house gas emissions;

Reliability and network issues – ameliorating and/or averting problems in the electricity network through reducing demand in ways which maintain system reliability in the immediate term and over the longer term defer the need for network augmentation; Improved markets - short-term responses to electricity market conditions (“demand response”), particularly by reducing load during periods of high market prices caused by reduced generation or network capacity.

Advantages to Demand Side Management

1. Better usage of existing generating and distribution infrastructure.

2. Less efficient/environmentally unfriendly generating capacity can be decommissioned.

3. Load can be matched to variable renewable energy availability.

4. Lower generating and transmission costs.

5. Lower transmission and distribution losses.

6. Reduction in “spinning reserve” costs.

7. Less intrusive load shedding.

8. More consumer growth capacity.

9. Better maintenance opportunities.

10. More availability (less black-outs).

Aims of the DSM are:

- To introduce the concept of demand-side management for residential, commercial and industrial energy users.
- To give an overview of the different types of demand-side measures.
- To show how housekeeping and preventative maintenance in commerce and industry can be used to reduce energy demand.
- To describe energy auditing and routine data collection and monitoring, and to indicate their benefits.
- To outline information dissemination on demand-side management.
- To provide an overview of the major implementation challenges for DSM Programmes.

Benefits of DSM

Demand Side Management (DSM) is a program that encourages energy users to make use of energy efficient designs. DSM presents a great chance for different power utilities to limit their GHG emissions while promoting energy conservation as well as lower emissions. This DSM approach is actually aimed at both the customers and the utility companies encouraging lower and more effective energy consumption.

1. Environmental benefits Rather than building new electrical plants for responding to the increase in customer demand for electricity, electricity producers could possibly attempt to limit the demand for power. Usually, they offer incentives of special programs having lower tariffs as well as higher efficiency appliances. This greatly assists in meeting the environment protection goals since it is going to reduce the emissions of pollutants into the atmosphere.

2. Controls load It is an undeniable fact that the demand for electricity varies from one person to the next and there is a huge difference between night and day consumption. On the other hand, utility firms prefer constant usage in order to make the most out of their investment. Such a problem is easily solved with the assistance of demand side management. In such cases, lower night tariffs are introduced or other financial incentives to ensure constant power usage.

3. Cost effective Through using the DSM approaches, you can be able to save a lot of money in electrical costs as well as maintenance costs. There is a large market nowadays of energy efficient appliances that you can use. Through using these appliances, the energy consumption will go down significantly and thus you will not require spending as much money in comparison to other firms that do not use the DSM approach.

Drawback of DSM is that DSM based resolutions usually increase the complexity of the situation and they are not competitive.

• Reducing generation margin.

• Improving efficiency of system operation•

Improving transmission and distribution grid investment and operation efficiency.

• Managing demand-supply balance in system with intermittent renewable and distributed power systems. - Reduction in customer energy bills. - Reduction in need for new power plant, transmission and distribution network. - Stimulating economic development. - Creating long term jobs due to new innovation and technologies. - Increases the competitiveness of local enterprises. - Reduction in air pollution. - Reduces dependency on foreign energy source. - Reduction in peak power prices for electricity. - reducing dependency on expensive imports of fuel, - reducing energy prices, and - reducing harmful emissions to the environment.

Different techniques of DSM

- Night-time heating with load switching.
- Direct load control: remotely controllable switch that can turn power to a load or appliance on or off.
- Load limiters: limit the power that can be taken by individual consumers.
- Commercial/industrial programs: i.e. load-interruptible programs.
- Frequency regulation: dealing with fluctuation in frequency.
- Time-of-use pricing: reflect the production and investment cost structure where rates are higher (lower) during peak (off-peak) periods.
- Demand bidding: customer reduces the consumption of electricity at a certain predetermined price.

• Smart metering: tracking amount of electricity using to manage costs and consumption. Time of day pricing It is widely recognized that the cost of producing electricity varies from hour to hour. This conclusion holds true under virtually any method of calculating costs.

In theory, marginal cost pricing can be applied with a high degree of exactness: a different price is charged every hour, depending upon the marginal costs of the system. In fact, many utilities use this type of pricing system when they interchange power with other utilities. The actual marginal costs of the selling utility are calculated for each hour when the power is interchanged; this rate is used as the price charged the purchasing utility. Realistically, such a pricing system cannot be applied to all customers, even though it is theoretically possible. When two utilities interchange power, a rather substantial amount of electricity is normally involved. Thus, the transaction cost of calculating the bill under such a complicated pricing system is small, relative to the tot al value of the transaction. But if the transaction costs per KWH are very high for small customers, a complicated pricing system would not be appropriate. Can Time- of - Day Pricing be Practically Applied to Industrial Customers For smaller industrials and large commercial customers, the situation is less clear. Although it might be impractical to implement a time- of - day pricing system where the price changed every hour, it does seem feasible to adopt a more simplified approach with two or three different price levels. If properly designed, this approach would be a major improvement over the timeless rates now used; it could be simple enough for customers to understand and modify their usage patterns, if they wished. For residential and small commercial customers, there are considerable practical difficulties with adopting a universal time- of - day pricing system. Metering costs alone are a major obstacle. Also, these customers are less likely to acquire the necessary knowledge to adapt their purchasing decisions to a time- of - day pricing system.

Each regional ISO operates its own power system and interacts with the RSC. When power exchanges are to be scheduled, the RSC starts aniterative procedure in which the utilities send tie-line power-flow information to the RSC Time of day models for planning Time of day modeling procedures integrated into the four-step travel demand modeling process offer a more accurate and robust mechanism for obtaining timeof-day based estimates of travel demand and link volumes. These procedures account for differences across trip purposes, modes, and origin-destination pairs.

Some of the issues that motivate the modeling of travel demand by time of day include, but are not limited to the following:

• Design hour traffic volumes for roadway design and level of service analysis

• Transit analysis

• Vehicular emissions and air quality analysis

• Assessing impact of congestion management programs

• Evaluating travel demand management strategies

• Evaluating variable (time-of-day based) pricing policies

• Analysis of peak spreading (time of day of travel choices)

• Analysis of intelligent transportation system

DEMAND SIDE MANAGEMENT – II

Load management,

Load priority technique,

Peak clipping, peak shifting,

Valley filling,

Strategic conservation,

Energy Efficient management and Organization of Energy Conservation awareness Programs.

Load management Load management is the process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load rather than the power station output. This can be achieved by direct intervention of the utility in real time, by the use of frequency sensitive relays triggering circuit breakers (ripple control), by time clocks, or by using special tariffs to influence consumer behavior. Load management allows utilities to reduce demand for electricity during peak usage times, which can, in turn, reduce costs by eliminating the need for peaking power plants. In addition, peaking power plants also often require hours to bring on-line, presenting challenges should a plant go off-line unexpectedly. Load management can also help reduce harmful emission, since peaking plants or backup generators are often dirtier and less efficient than base load power plants. New load-management technologies are constantly under development — both by private industry and public entities.

Load Priority Technique Load Priority Technique Works on individual loads priority for operation (in service and out of service). This is mainly influenced by the production schedule. The load priority could also be connected directly with the rate communication system (i.e., differential tariff system). However in the present work, while deciding priorities of various loads for operation, only production schedule is considered in consultation with the concerned section superintendents. In developing load priority technique, non-interruptible loads are classified as high priority loads (to remain in ON condition) and the interruptible loads are classified as low priority loads. Two priority lists are prepared in consultation with the various section superintendents namely:- 1. Priority for switching OFF 2. Priority for switching ONThe load demand on the industry is continuously monitored at acceptable time intervals. If the demand exceeds beyond the permitted limit then the "Low Priority Loads" to the extent of exceeded value of load are cut-off. If the load demand is less than the permitted limit then the loads which were interrupted in the previous time slots were switched on based on the "priority for switching ON". The success of load priority technique is totally dependent upon the development of various load priorities for operation which will not disturb the production schedule and gives enough scope for reduction of load demand. This DSM alternative creates possibilities for the consumers to reduce peaks and fill out valleys in their load curves. Thus resulting in an almost flat load curve. It also helps to maintain consumer lifestyle by reducing the unscheduled outages. As there is a strict control over the maximum demand penalty for the consumer.

Peak Clipping Clipping is a form of waveform distortion that occurs when an amplifier is overdriven and attempts to deliver an output voltage or current beyond its maximum capability. Driving an amplifier into clipping may cause it to output power in excess of its published ratings. Reduction of the maximum demand for electric power from an electrical utility, often achieved by direct control of customer loads by signals directed to customer appliances. A common form of distortion in telephones and other auditory transmission systems in which the peaks of the waveform are flattened off—to only one or two per cent of their original height in severe peak clipping—transforming the waveform into a sequence of rectangular pulses. When applied to speech it has surprisingly little effect on its intelligibility, 80 or 90 per cent of words still being correctly interpreted by listeners when the clipping is severe. The DISTORTION caused when the GAIN of an amplifier is increased to a point where the high points, or peaks, of the SIGNAL or WAVEFORM are cut off at a level where the amplifying circuits are driven beyond their overload point. Also called over-MODULATION.

Peak clipping—where the demand peaks (high demand periods) are "clipped" and the load is reduced at peak times. This form of load management has little overall effect of the demand but focuses on reducing peak demand. Peak Clipping - Or the reduction of the system peak loads, embodies one of the classic forms of load management. Peak clipping is generally considered as the reduction of peak load by using direct load control. Direct load control is most commonly practiced by direct utility control of either service to customer facilities or of customers' appliances. While many utilities consider this as means to reduce peaking capacity or capacity purchases and consider control only during the most probable days of system peak, direct load control can be used to reduce operating cost and dependence on critical fuels by economic dispatch.

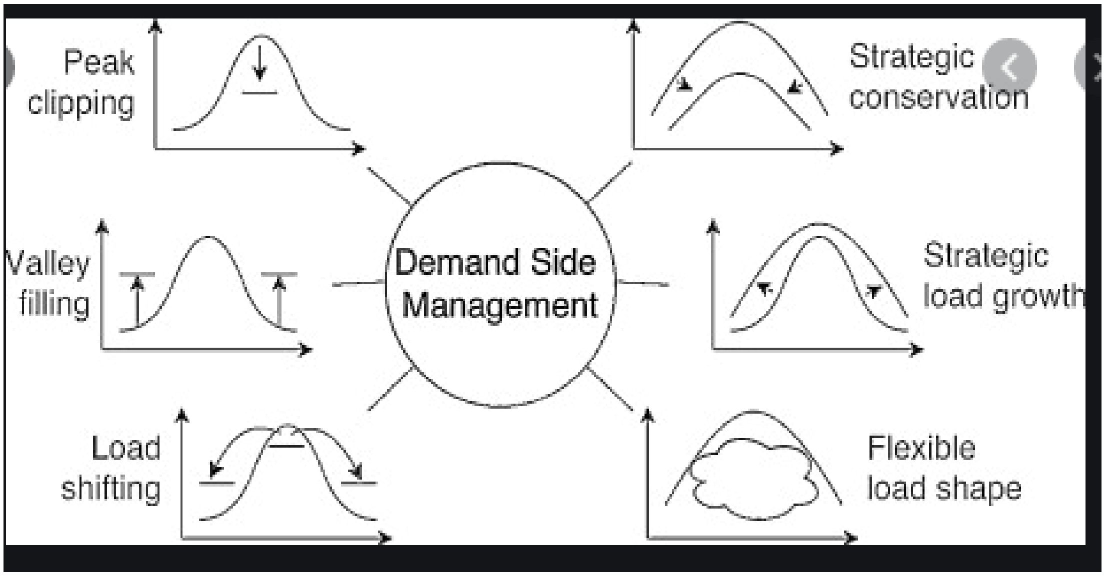
Peak Shifting Peak Shifting is a highly cost-effective method of reducing electric utility expenses. When electric utility commercial or industrial customers use electricity can make a big difference on their monthly electric bills. By shifting the time of day that electric power is used, a commercial or industrial customer can reduce their "demand charge" portion of their electric bill during peak times of the day. This reduces the overall cost of power each month for the customer. Unlike most products, electricity can't be stored after it's generated. Electricity must be generated - and consumed - at the time of demand by a utility's customer. Electricity usage continuously varies throughout the day, and varies from month to month and season-to-season. Each day, there are "peak" demand periods of usage during which time the electric utilities must generate additional amounts of electricity to meet these peak demands for all of their customers. To meet this additional peak demand for electricity utilities use "peaking generators" also called "peaking plants" or simply "peakers." These peaking plants are the least efficient methods of generating power, meaning they generate less power with more fuel (and their associated greenhouse gas emissions) compared with the utility's base-load generators. These peaking plants typically burn oil or natural gas to produce the electricity and are brought on line only during "peak periods" of the day and run for short periods. While peaking generators generally cost less to build than other types of generators, they also have relatively high fuel costs because they are typically much less efficient in the use of fuel. Therefore, "Peak Shifting" is a method that addresses shifts the time of day when electricity is used; reducing the need for peaking plants and can reduce a commercial or industrial customer's electric bills, if correctly implemented. Because the vast majority of electricity is generated in direct, instantaneous response to demand, costs of electricity differ dramatically between high demand ("on peak") and low demand ("off peak") periods. By installing energy storage on the grid, both utilities and consumers are able to shift their demand out of on-peak periods and into off peak periods, flattening their energy consumption profile: This reduces energy costs for the average user on the system, regardless of whether or not they are the user of time-shifted electricity. Commercial electric customers on time-of-use rate schedules have a compelling financial opportunity in the form of energy arbitrage. Peak shifting also lessens the total effect of electric vehicle charging on the grid, and makes electric vehicles less expensive per mile.

Valley Filling The process of making an energy production and delivery system more efficient by encouraging additional energy use during periods of lowest system demand. Valley filling programs are usually accompanied by load shifting programs, often with the aim of shifting peak demand usage to low demand periods, but the term can refer to any program or strategy aimed at filling the valley. An essential component of nearly all demand-side management programs.

Valley Filling - Is the second classic form of load management and applies to both gas and electric systems. Valley filling encompasses building off-peak loads. This may be particularly desirable where the long-run incremental cost is less than the average price of energy. Adding properly priced off-peak load under those circumstances decreases the average price. Valley filling can be accomplished in several ways, one of the most popular of which is new thermal energy storage (water heating and/or space heating) that displaces loads served by fossil fuels. Valley filling—where the demand valleys (low demand periods) are "filled" by building off-peak capacities. This form of load management can be achieved by thermal energy storage (water heating or space heating) that displaces fossil fuel loads. Strategic Conservation Strategic Conservation - Is the load shape change that results from programs directed at end use consumption. Not normally considered load management, the change reflects a modification of the load shape involving a reduction in consumption as well as a change in the pattern of use. In employing energy conservation, the planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended programs to accelerate or stimulate those actions. Examples include weatherization and appliance efficiency improvement. Strategic conservation is the load shape change that results from utility-stimulated programmes directed at end use consumption.

Strategic load conservation Not normally considered load management, the change reflects a modification of the load shape involving a reduction in sales as well as a change in the pattern of use. In employing energy conservation, the utility planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended utility programmes to accelerate or stimulate those actions. An example is appliance efficiency improvement. Strategic Conservation is a process that produces tools to aid decision makers in identifying, prioritizing, pursuing, and protecting those specific tracts of land that will most effectively and efficiently achieve the land trust's mission.

Energy Efficient Equipment Energy consumed by appliances and equipment is a major source of greenhouse gas emissions in Australia. Improving the energy efficiency of appliances is a key objective for all Australian Governments. Load Management Options Direct Load Control (DLC) – Utility has control of directly switching off customer loads Interruptible Load Control (ILC) - Utility provides advance notice to customers to switch off loads Time of Use (TOU) Tariffs – price signal provided – customer decides response Load management programmes—changing the load pattern and encouraging less demand at peak times and peak rates: - Load leveling - Load control Tariff incentives and penalties Load leveling Load levelling helps to optimize the current generating base-load without the need for reserve capacity to meet the periods of high demand.



Energy Conservation

It is the term used for reducing the consumption through using less energy service. Energy conservation is not about making limited resources last longer, but it is a process of doing nothing more than delaying a crisis until we finally run out of all our energy resources. Conservation is the process of reducing demand on a limited supply (for example natural gas) and ensuring that the demand is met by alternative means of supply. Most of the times the best way to do this is to replace the existing energy used with an alternate one. Energy Conservation is all about using energy only when it is required and using it as much as needed for the job and not wasting any amount of it. It requires a conscious effort from the user of energy to make sure that there is no wastage on a regular basis.

Some of the practical methods and technologies for energy conservation and energy management are:

1. **Using Smart Grids:** these grids improve efficiency by using technology to optimize the production and distribution. Through a combination of distributed resources, interactive technologies, renewable energy, two-way communications, and dynamic utilization, they provide businesses and consumers with information that allows them to alter their consumption based on supply, demand, and pricing. That improves the reliability and flexibility of energy use.
2. **Installing CFL lights:** trying to replace the incandescent bulbs with CFL lights. CFL bulbs cost more upfront but last 12 times longer than the regular bulbs and will not only save energy but over time it is cost effective.
3. **Using maximum daylight:** turning off the lights during the day and using daylight as much as possible will reduce the burden on the local power grid and will save a good amount of money in the long run.
4. **Getting the energy audit done:** one of the primary ways to reduce energy usage is to conduct an energy audit. It is mostly done by a panel of trained professionals for analyzing the energy use and

flow for energy in a building, process or systems to reduce the amount of energy input into the system without affecting the output. The recent development of smartphone apps will help the consumers to get their energy audit done at home.

5. Building technologies and smart meters allow the energy users, both business and residential to see graphically the impact their energy use can have in their workplace. Advance real time metering allows people to save and conserve energy by their actions.
6. **Energy Tax:** Some countries employ energy or carbon taxes to motivate the energy users to reduce their consumption. Carbon taxes allows consumptions to alter. Nuclear and other alternative methods of energy can help reduce environmental impacts. Taxes on all energy consumption helps reduce energy use across the board, while reducing the environmental consequences arising from energy production.
7. **Switching off the electric appliances when not in use.**
8. **Drive less, walk more and carpooling:** is yet another way of conserving energy. This will not only reduce the carbon footprint but will also keep us healthy.

Emerging Technologies in Energy Management:

- **Smart and Wireless systems**: Networking and communications technologies help reduce waste, improve efficiency and enable changes in behavior. The simplest example is lighting fixtures with integrated occupancy and/or daylight sensors. More advanced examples are lighting ballasts that can connect and talk to each other and to a central control system through a wireless mesh network. This type of system provides true plug-and-play capabilities, where luminaires can simply be installed or relocated and they will determine for themselves where they are and how they should function in relation to that location.
- **Net zero energy buildings.** The movement now is beyond simply reducing energy use in buildings to having buildings that produce energy and contribute it back to the grid. Renewable energy sources and on-site generation will contribute to a more distributed energy model, where individual buildings and sites are more active participants in the energy system. The development of energy storage capabilities will enable this type of interaction so that individual customers can decide when to buy from the grid, when to store energy and when to supply it back to the grid based not just on the load but also on price, the availability of renewable sources or even the carbon content of grid energy.
- **Focusing more on renewable energy:** to deal with the environmental issues. Countries should invest substantially in using renewable energy in their day to day life such as use of solar panels to supply their daily energy requirements.
- **Using autonomous vehicles technology** will help reduce the traffic congestion and will improve the fuel economy by 4-10 % by accelerating and decelerating more smoothly than a human driver. As we know that smog in industrial areas is linked to the number of vehicles, having autonomous cars will help reduce the air pollution. A shared autonomous vehicle system also offers benefits in terms of emissions and energy.

Basic principles for effective energy management:

Because of the rising energy costs, energy management has again become a priority for facilities managers. Many new energy saving technologies are available, such as automated management systems, but they do not support or guarantee a successful energy program. Facility managers should keep the following principles in mind, while considering innovative approaches to energy management:

1. Without knowing how, when and where energy is used, there is no way to gauge the relative importance of energy management projects. Identifying and tracking energy use patterns is the first step in any energy program.
2. Good maintenance practices and good energy management go hand in hand. Some of the highest rates of return on energy conservation are generated simply by performing maintenance. Preventive maintenance is still critical, and reactive maintenance (waiting for a crisis to occur) is still foolish, despite funding limitations. It is easy to ignore preventive maintenance when systems are new, calibrations are precise, seals are tight, and heat-exchanger surfaces are clean.
3. Maintenance and energy management serve different purposes. One cannot be substituted for the other. For example, cleaning light-fixture lenses and re lamping them is good maintenance; installing more efficient lamps and ballasts is good energy management.

Importance of Energy Conservation

Energy conservation plays a significant role of lessening climate change. It helps the replacement of non-renewable resources with renewable energy. Energy conservation is often the most inexpensive solution to energy shortages, and it is more environmentally kind alternative to increased energy production.

Since, we have limited quantity of non-renewable energy resources available on earth, it is very important to preserve energy from our current supply or to utilize renewable resources so that it is also available to our future generations.

Energy conservation plays a very important role because utilization of non-renewable resources also impacts our environment. Specially, usage of fossil fuels supplies to air and water pollution such as carbon dioxide is produced when oil, coal and gas combust in power stations, heating systems, and engines of car.

As we all aware of that carbon dioxide works as a transparent layer in the atmosphere that is part of the cause to the global warming of the earth, or we can also name it as greenhouse effect. Global warming has its own consequences in our atmosphere. It has its deadly effects like spreading of different diseases, warmer waters and more chances of hurricanes, financial costs, polar ice melting, increased chances and intensity of heat waves. Ozone depletion is the reduction of the protection layer of ozone in the uppermost atmosphere by chemical pollution. Ozone layer is the protection line between earth and the ultraviolet rays emitted by the sun. People who have more exposure to UV radiation can have some health problems like DNA damage, skin cancer, aging and other problems related to skin.

There could be some possible issues that include a danger to human body health, impact on environment like rising sea levels, and major changes in vegetation growth methods. When coal is burned, it realises sulphur dioxide into the air and therefore, it reacts with water and oxygen in the clouds and forms acid rain. Acid rain kills fish and trees and also damage limestone buildings and statutes. These types of global problems can be resolved. As per the data of United States calculated per year, we found that the average family's energy uses produces over 11,200 pounds of air pollutants. Therefore, every unit of kilowatt of electricity preserved diminishes the natural environment impact of energy use.

Energy Resource Development

The recent sharp increases in the prices of oil, natural gas, uranium and coal underline the importance for all countries to focus on development of alternative energy resources. For developing countries, these price increases can have ruinous economic consequences; for many countries already plagued by poverty this means a choice between fuel and food, health care, education and other essentials. Renewable energy resources need priority because: 1) the overwhelming scientific evidence that anthropological emissions of greenhouse gases from carbon combustion threaten catastrophic results from rapid climate change; 2) the severe health and environmental consequences from fossil fuel combustion being experienced in every major developing country city; and 3) the high cost, environmental damages and security threats of nuclear power.

Renewable resources covered here include: electricity produced from the light of the sun via photovoltaic cells on individual buildings or for communities of buildings, or for the production of central station power in vast arrays; from the heat of the sun, again for localized tasks like providing homes and businesses with hot water or space heating, or providing central station power using fields of parabolic collectors focused on a fixed hot water source or solar ponds; from the power of the wind; from the heat below the earth through various geothermal applications; from the power of ocean tides and waves; from the temperature variations between ocean surfaces and depths; from small hydroelectric installations; from agricultural wastes through biomethanation; and from biomass crops grown for energy use or from crop waste cellulose; the biomass can be refined to produce ethanol or gasified for heat, electric and transportation applications.

Traditional biomass in the form of firewood is not covered as a renewable resource, however, because it most often involves the cutting down of ecologically valuable forests that act as protection against floods and erosion and as sinks for carbon dioxide and because the gathering of firewood is so debilitating to women and children who also suffer serious health hazards when the firewood is burned in enclosed spaces for heating and cooking. The same is true of burning animal dung for heating and cooking. However, so-called modern biomass consisting of crops to ethanol and gasified wood and crop wastes is included.

Nuclear energy is excluded from this analysis as a development option because of its high capital and operating costs, complex technical requirements for operation and maintenance, and its unresolved problems of proliferation and waste disposal. After the attacks on the World Trade Center in New York of September 11, 2001, an over-riding problem with nuclear plants is their great vulnerability to terrorist attack, particularly on the control rooms and spent fuel pools that are located outside the containment vessels.

Nuclear energy at any rate is not renewable because of the limits on supply of uranium unless reprocessing of spent fuel is utilized, an even more prohibitively expensive and technologically challenging option for developing countries. Reprocessing is a technology that is particularly vulnerable to proliferation because of its resulting plutonium that can readily be used in weapons and is virtually detection-proof. Waste-to-energy power from trash incineration is excluded because it is so highly polluting and because recycling options for wastes are so much cleaner and more economic. Large hydroelectric dams also are excluded because of their expense, their unreliability because of vulnerability to droughts as recently demonstrated in Brazil and the west coast of the United States, because of their potential hazard in breaching, and because of their environmental damages both from flooding large areas of productive and often populated lands and their carbon dioxide releases from decaying vegetation in their reservoirs, particularly in shallow reservoirs

SOLAR Solar energy presents great development opportunities in developing countries, particularly since most of them are in the Sun Belt. Solar photovoltaic energy is uniquely useful in rural areas unserved by electric grids to provide basic services such as refrigeration, irrigation, communications and lighting. An estimated 1.1 million solar photovoltaic home systems and solar lanterns existed in rural areas of developing countries as of 2000. Solar thermal energy is particularly suited to the large demand for heat and hot water in the domestic, agricultural, industrial and commercial sectors of the economy. It is applied successfully for water heating, industrial process heating, drying, refrigeration and air conditioning, cooking, water desalination and purification (through use of solar ponds), pumping and power generation.“Hot water for residential and commercial uses, both in rural and urban areas, can be provided cost-effectively by solar hot water heaters in many regions. An estimated 15 million domestic solar hot water collectors are installed worldwide, about two thirds of them in developing countries. China’s solar hot water industry has mushroomed in the 1990s, with growth rates of 10%–20% and up to 10 million households now served with solar hot water. Markets with hundreds of thousands of households served include Egypt, Israel, India, and Turkey.”Solar energy often is far more efficient than existing energy uses. For lighting, a photovoltaic compact fluorescent light system is 100 times more efficient than kerosene, used in the rural areas of many developing countries to provide night lighting.18 Photovoltaic systems also avoid the high costs and pollution problems of standard fossilfueled power plants.

BIOMASS Utilization of biomass is a very attractive energy resource, particularly for developing countries since biomass uses local feedstocks and labor. Crop wastes, cellulosic biomass and crops raised to provide energy feedstocks on otherwise barren lands are good energy sources for industry, electricity production and home heating and cooking if used in efficient modern stoves or gasified. Technologies for efficient biomass cookstoves in developing countries have developed rapidly, with close to 220 million improved biomass stoves in use in 2000. The largest program is in China, where between 1982 and 1999, the Chinese National Improved Stoves Program disseminated 180 million improved biomass stoves. This program established local energy offices to provide training, service, installation support, and program monitoring. It also fostered selfsustaining rural energy enterprises that manufacture, install, and service the stoves. Users pay the full direct costs of the stoves (about $10), and government subsidies are limited to the indirect costs of supporting the enterprises. In Africa in the 1990s, over 3 million improved biomass stoves were disseminated.Brazil supplies 60% of its primary energy requirements from renewable energy sources, most of which comes from hydropower and biomass. The biomass produced in Brazil largely results from an ethanol fuel production program started in 1975 from sugar cane crops grown specifically for fuel use, presently occupying 2.7 million hectares of land and employing about 350 distilleries. Ethanol currently provides over 40% of the fuel consumed by cars and light trucks.It is estimated to have saved Brazil over $40 billion in oil imports, excluding the costs of the program. Ethanol was heavily subsidized by the government until 1998 when it was deregulated and taxes from gasoline sales were substituted to subsidize its costs. To get the program started, the state-owned oil company guaranteed ethanol purchases on a cost plus basis and tax incentives were provided for the purchase of neat ethanol-using vehicles. The subsidies have now been phased out and the program thrives on its own. In 1999, almost thirteen mega-tonnes of carbon emissions were reduced as a result of the program, and local emissions of lead, sulfur and carbon monoxide have been greatly reduced. In addition, the ethanol production supports about 700,000 rural jobs.In 1985, Brazil established a very successful national electricity conservation and renewable energy program, known as PROCEL, housed at the national electricity utility. PROCEL funds energy efficiency and renewable projects carried out by state and local utilities, state agencies, private companies, universities and research institutes. In Africa, ethanol is produced in Kenya, Malawi and Zimbabwe for blending with gasoline, but Zimbabwe is the only one to mandate blending of ethanol with all gasoline sold.

GEOTHERMAL Geothermal power is a relatively pollution-free energy resource derived from naturally occurring reservoirs of hot water or steam that occur below the earth's surface and is tapped to drive a turbine to create electricity. It is an established and economic energy source used in many parts of the world. Its use is expanding in Indonesia, the Philippines, Mexico, Kenya and Central America. Global electricity generating capacity is about 8,500 MW as of 2000, about 45% of it in developing countries. A more experimental pollution-free geothermal energy resource, requiring further research to become economic, hot rock energy is obtained by drilling intersecting holes deep into the center of the earth, pouring water down one of the holes and obtaining steam to drive a turbine up the other hole.

HYDROELECTRICITY Hydroelectricity is the largest renewable resource in use today, but mostly utilizing large dams with their environmental problems described above. Adding power to existing dams, however, does not create these problems. Also, the placement of generating equipment at existing dams has great worldwide potential and no environmental consequences. Run of the river hydro systems are technologically more complex but also have minimal environmental consequences. Lastly, small dams can reduce the environmental harms of large dam hydroelectric power production. Small hydropower uses the flow of water in small rivers and streams to run electricity-producing turbines. Plants classified as small hydropower generally produced less than 10MW.World-wide small hydropower production is about 43,000 MW as of 2000, about 60% in developing countries. China alone accounted for 21,000 MW of that capacity.

HYDROGEN Hydrogen, while not an energy resource in itself, is the most promising alternative fuel for the future. It currently is produced from natural gas in a process less polluting than oil or coal-fired power plants. With improved and more economic technology, hydrogen can be produced from photovoltaic or wind-powered electrolysis, separating hydrogen from water – the focus of current EU research. Most hydrogen utilization research in the U.S. is centered on fuel cells that are pollution-free, involving no combustion. Fuel cells can power vehicles or stationary electric generators, but they still require substantial research to bring down their costs and are not expected to be available commercially for approximately twenty years. However, hydrogen can be used directly in today’s motor vehicles without further research. Hydrogen combustion is virtually pollution free with a byproduct primarily of pure water. The principal challenge for its widespread adoption is to create an infrastructure to transport the hydrogen to wholesale markets -- although existing natural gas pipelines can be used if treated or lined – and a retail infrastructure for fueling vehicles at service stations. This infrastructure work will involve very large initial capital expenses. There is a circular problem in accomplishing this infrastructure investment since hydrogen manufacturers don’t want to invest in production without a transportation and distribution system and established market, while pipeline manufacturers and utilities don’t want to invest in pipelines without an assured supply and distribution system in place. Hydrogen is sufficiently developed today so that a number of major vehicle manufacturers are planning to market fuel cell vehicles in the next few years and it is beginning to be used as an electric power source, but virtually no attention has been devoted to use of hydrogen in existing vehicle engines.

Drivers for Renewable Energy Policies

Environmental Drivers The extraction, transport, refining and use of fossil and nuclear fuels result in a host of significant environmental impacts, including damage to land from mining; pollution of air and water; consumption of vast amounts of fresh water, particularly for cooling at power plants; loss of biodiversity; risk of nuclear accidents; global climate change; and associated impacts on human health Health problems, biodiversity loss, and other environmental challenges will only be exacerbated by climate change. Renewable energy deployment has become an integral part of government strategies around the world to address these many challenges. Examples include: Reduce pollution and improve public health. Around the world, governments at all levels have enacted policies to support renewables in order to reduce health impacts associated with energy production and use. In China, for example, the quest for cleaner air and water has become an important driver of renewable energy targets and policies, alongside carbon dioxide (CO_2) emissions reductions, job creation and economic development. Concerns about the impacts of traditional use of biomass, and burning of kerosene and other fossil fuels for cooking and heating on indoor air quality, as well as the need to reduce local deforestation, also have driven policies to promote modern renewables. Reduce fresh water use. Many governments are turning to renewable energy to reduce water consumption associated with energy production. For example, Georgetown, Texas, a US city of more than 50,000 inhabitants, aims to achieve 100% renewables in the electricity sector by 2017, in part to reduce water consumption in the sector; other drivers include opportunities for local economic development and protection against volatile fossil fuel prices.Reduce reliance on nuclear power. In the wake of the 2011 Fukushima Daiichi nuclear disaster, several Japanese cities and regions – including Hokkaido, Kyoto, and Osaka – have set targets and enacted policies to promote renewables and energy efficiency in order to reduce their reliance on nuclear power. Germany reacted to the disaster in Japan by planning to phase out its own nuclear power facilities, to be replaced over time with renewable energy

Mitigate climate change. Climate change mitigation is becoming increasingly the key environmental driver of renewable energy; in combination with energy efficiency improvements, renewables now represent a key pillar in many governments' efforts to decarbonize their energy sectors.

Economic Drivers Renewable energy technologies can provide a number of economic benefits, particularly for energy importers. This is becoming increasingly true as renewable energy costs (especially costs of solar PV and wind power) continue their rapid decline. In addition, the use of renewable energy helps to avoid a number of indirect economic costs associated with fossil energy production and use, such as health care expenses. It also can help reduce the longer term costs associated with global climate change, such as the potential for sudden disruption and displacement of people and their economic activity (e.g., spread of disease, forced migration). Thus, investments in renewable energy systems and associated infrastructure can result in sustainable development in every sense of the term – sustained economic growth that is environmentally sustainable.Economic benefits associated with renewable energy that drive the adoption of support policies include:

Improve balance of trade and reduce price volatility. The majority of countries, states or communities must import most if not all of the fossil or nuclear fuels that they consume. Investment in renewables can improve a country's or region's trade balance and can reduce fuel price volatility and supply risk. Reduction of fossil fuel imports, and the associated economic savings (for consumers and for government budgets for related subsidies, etc.), is one of the key drivers for renewable energy policies, including 100% renewables targets.

Create jobs and develop new industries and skills. Studies suggest that while the renewable energy transition shifts jobs by sector and location, the net impact on job creation will be positive.

Skills required for manufacturing, selling, installing and maintaining renewable energy systems and associated infrastructure vary significantly, with a variety of medium- and high-skilled opportunities. Job creation has been a driver of renewable energy policies that aim to help strengthen local economies, and to stem or reverse depopulation and brain drain

Meet rapidly rising energy demand. The modularity of many renewable technologies and relative speed with which they can be implemented, alongside their rapidly falling costs (particularly for solar PV and wind power), have made them technologies of choice for meeting ever-growing demand for energy services across the Global South

Provide access to energy and alleviate poverty in the Global South. More than a billion people still lack access to electricity while more than two in five people around the world depend on traditional biomass for heating and cooking. In remote areas, electricity generated with renewable technologies is generally less costly than the alternatives, including imported diesel fuel and grid extension. Indeed, in many areas it may be the only viable option, economically or otherwise, within any reasonable timeframe. Renewables also can provide heating, cooling, and mechanical energy for crop irrigation and other productive services. The modularity of many renewable technologies means that they can be installed rapidly and scaled up as needed. Many countries have established targets and enacted support policies to scale up renewable energy to provide access to modern energy services for people living in remote and rural areas.

Alleviate fuel poverty and advance rural economic development in industrialized countries. In industrialized countries, where the vast majority of people have access to modern energy services, renewables can reduce fuel poverty and improve quality of life. The aforementioned community project in Tipperary, Ireland, was established to invest in renewable energy combined with energy efficiency retrofits in order to reduce fuel poverty. Policies in the United Kingdom also have aimed at reducing fuel poverty by supporting domestic renewable heat.

Keep energy revenue local. When fuel imports are displaced with local renewables, whether at the national or sub-national level, energy expenditures can spur further economic activity in the local economy

Increase tax revenue. Local governments collect income and property tax payments from renewable energy project owners; the additional revenue enables governments to reduce tax rates for inhabitants, such as low-income residents, or to support additional public services. Renewable energy projects may also reduce government expenditures.

Reduce public health costs. The burning of fossil fuels for energy production results in high economic costs for societies, in addition to tremendous physical suffering.

Political and Security Drivers

Energy is critical to a healthy economy and energy services can sustain or improve people's quality of life. Therefore, the uninterrupted physical availability of highly reliable and reasonably affordable energy products and services is critically important to economic and political security. By the same token, conditions of economic stability and political security are the necessary foundation for the healthy development of energy infrastructure and reliable delivery of energy services. Increasing the share of energy from indigenous renewables offers the potential to reduce dependence on imported fuels, improving security of supply. Renewables can increase the diversity of energy supply, and contribute to flexibility and resilience of the energy system through local, distributed generation, both of which reduce the risk of disruption of energy services. The risk of widespread technical failure of the energy system (system component malfunction) and risk of external physical disruption (natural disasters, terrorism and sabotage, and piracy) are potentially lessened by the use of distributed renewables. This is because each individual system component, (e.g., a wind turbine) becomes less critical to total system integrity. Political and security drivers of renewable energy policies and targets include the following

Improve energy security. Many countries import fossil (and nuclear) fuels, often from regions that are politically unstable or that might stop the flow of supply at any time. By contrast, renewable energy resources are diverse, they rely on natural flows (rather than exhaustible stock), are available locally (with type and amount of resource differing by location), and the technologies required for capturing and converting these resources into useful energy are available in the global market place.

Increase reliability and resilience. At the state and local levels, concerns about risk associated with fuel transport (e.g., rail or pipeline accidents), power outages, supply bottle-necks, and other factors are driving renewable energy policies. Distributed renewable energy systems are less prone to large-scale failure; can make the power grid and other energy systems more resilient to a variety of threats, including weather-related impacts of global climate change; and distributed power can be available locally (on rooftops, or from wind power projects in a city's harbor), so there is less concern about transporting power to demand areas.

Ensure energy democracy.) The desire for energy democracy, including local control over energy production and distribution, is playing an increasingly important role in driving local targets and policies to support renewable energy, often in combination with energy efficiency improvements, particularly at the local level.

Energy for Sustainable Development

Energy sustainability is becoming a global necessity, given the pervasive use energy resources globally, the impacts on the environment of energy processes and their reach beyond local to regional and global domains, and the increasing globalization of the world's economy. Energy is directly linked to the broader concept of sustainability and affects most of civilization. That is particularly evident since energy resources drive much if not most of the world's economic activity, in virtually all economic sectors, e.g., industry, transportation, residential, commercial. Also, energy resources, whether carbon-based or renewable, are obtained from the environment, and wastes from energy processes (production, transport, storage, utilization) are typically released to the environment. Finally, the services provided by energy allow for good living standards, and often support social stability as well as cultural and social development. Given the intimate ties between energy and the key components of sustainable development, the attainment of energy sustainability is being increasingly recognized as a critical aspect of achieving sustainable development.

Energy sustainability is taken here not just to be concerned with sustainable energy sources, but rather to be much more comprehensive. That is, energy sustainability is taken to involve the sustainable use of energy in the overall energy system. This system includes processes and technologies for the harvesting of energy sources, their conversion to useful energy forms, energy transport and storage, and the utilization of energy to provide energy services such as operating communications systems, lighting buildings and warming people in winter. Thus, energy sustainability goes beyond the search for sustainable energy sources, and implies sustainable energy systems, i.e.systems that use sustainable energy resources, and that process, store, transport and utilize those resources sustainably.

Sustainable development is increasingly becoming a goal to which countries aspire. Overall sustainability has been defined in many ways, and is often considered to have three distinct components: environmental, economic and social. These three factors when considered separately usually pull society in different directions (e.g., economic sustainability may be achieved at the expense of environmental and social sustainability). Overall sustainable development in general requires the simultaneous achievement of environmental, economic and social sustainability. Achieving this balance is challenging, and energy factors into each component.

the concept of energy sustainability is simply the application of the general definitions of sustainability to energy. In other ways, energy sustainability is more complex and involved. Energy sustainability involves the provision of energy services in a sustainable manner,which in turn necessitates that energy services be provided for all people in ways that, now and in thefuture, are sufficient to provide basic necessities, affordable, not detrimental to the environment, andacceptable to communities and people.

The connection between energy, the environment and sustainable development is worth highlighting. Energy supply and use are related to climate change as well as such environmental

concerns as air pollution, ozone depletion, forest destruction, and emissions of radioactive substances.
These issues must be addressed if society is to develop while maintaining a healthy and clean environment, especially since the future will be negatively impacted if people and societies continue to degrade the environment.

Approach to Energy Sustainability
There are several distinct components to the manner in which energy resources can be used sustainably in society, each of which is a requirement for energy sustainability. In the following sections, each of these aspects of energy sustainability is described and examined.

Harness Sustainable Energy Sources
The requirements for energy services need to be satisfied, and sustainable energy sources need to be utilized for that objective. This will be a particularly challenging task as the use of energy resources increases with increasing populations and living standards, especially as developing countries become more industrialized and affluent. Renewable energy includes solar radiation incident on the earth, and energy forms that result from that radiation, as well as energy from such other natural forces as gravitation and the rotation of the earth. Solar radiation, which is incident on the Earth at 20,000 times the global energy-use rate, can be collected as heat or concentrated to high-temperature heat or converted directly to electricity in photovoltaic devices. Several other renewable energy types stem from solar radiation. Hydraulic energy, which includes falling and running water, ranges in size from large complexes like at Niagara Falls to much smaller systems like microhydro. Ocean thermal energy is based on the temperature difference between surface and deep waters, which can be exploited to generate electricity. There are two distinct types of geothermal energy: hot, which utilizes the internal heat of the Earth, and ambient (i.e., natural ground temperature), which can be used by ground-source energy systems like heat pumps. Tidal energy exploits the motion with tides caused by gravitational forces of the sun and moon and the rotation of the earth, while wave energy is based on the motion of waves. Biomass energy includes wood (e.g., fast-growing trees or forestry wastes), plants and other organic matter, which can be combusted or converted to other fuels. Biomass energy is only a

renewable resource when the rate at which it is used does not exceed the rate at which it is replenished.

Wastes (material and heat) can be considered either renewable or non-renewable energy, and can be
used to produce heat or to generate electricity via waste-to-energy incineration. Non-fossil fuel energy options reduce or eliminate greenhouse gas emissions and thus often facilitate sustainable energy solutions, although some like biomass can lead to net emissions if not managed carefully. Although non-renewable, nuclear energy avoids greenhouse gas emissions. Non fossil fuel energy options are diverse in their characteristics and types, ranging from renewables to nuclear energy.

Utilize Sustainable Energy Carriers

Utilizing sustainable energy carriers usually implies the conversion of sustainable energy sources into appropriate energy carriers. The range of energy carriers is diverse. Material energy carriers include secondary chemical fuels, ranging from such conventional ones as oil products(e.g., gasoline, diesel fuel, naphtha), coal products (e.g., coke) and synthetic gaseous fuels (e.g., coal gasification products), to non-conventional chemical fuels like hydrogen, methanol and ammonia. Thermal energy can be either heat (or a heated medium such as hot air, steam and exhaust gases) or cold (or a cooled medium such as cold brine and ice), and can be transported via district energy systems. For example, buildings in some cities are connected by pipes through which hot water or steam flows to provide space and water heating, while district cooling uses a piping network to provide cooling. Energy carriers in general are an important consideration in energy sustainability because conventional and non-fossil fuel energy options are not sufficient for avoiding environmental issues such as climate change, in that they are not necessarily readily utilizable in their natural forms. Conversion systems are often needed to render non-fossil energy more conveniently utilizable.