ENERGY CONSERVATION

INTRODUCTION

Energy conservation is the effort made to reduce the consumption of energy by using less of an energy service. This can be achieved either by using energy more efficiently (using less energy for a constant service) or by reducing the amount of service used (for example, by driving less). Energy conservation is a part of the concept of Eco sufficiency. Energy conservation reduces the need for energy services and can result in increased environmental quality, national security, personal financial security and higher savings. It is at the top of the sustainable energy hierarchy. It also lowers energy costs by preventing future resource depletion

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Energy can be conserved by reducing wastage and losses, improving efficiency through technological upgrades and improved operation and maintenance. On a global level energy use can also be reduced by the stabilization of population growth.

Energy can only be transformed from one form to other, such as heat energy to motive power in cars, or kinetic energy of water flow to electricity in hydroelectric power plants .However machines are required to transform energy from one form to other. The wear and friction of the components of the machine while running cause losses of very high amounts of energy and very high related costs. It is possible to minimize these losses by adopting green engineering practices to improve life cycle of the components.

Energy conservation day is celebrated on December 14 every year since 1991.

We depend on energy for almost everything in our lives. We wish to make our lives comfortable, productive and enjoyable. Hence even if the outside temperature rises a little, we immediately switch on the air conditioner to keep our house cool. This is again using up of energy. Unfortunately, what we do not realize is that we have started taking things for granted and we have started wasting energy unnecessarily. Most of us forget that energy is available in abundance but it is limited and hence to maintain the quality of life, it is important that we use our energy resources wisely. "The earth provides enough to satisfy every man's needs but not every man's greed"- Gandhiji.

Hard facts on why energy conservation is a must are outlined below: We use energy faster than it can be produced – coal, oil and natural gas – the most utilised sources take thousands of years for formation. Energy resources are limited – India has approximately 1% of world's energy resources but it has 16% of world population. Most of the energy sources we use cannot be reused and renewed – Non renewable energy sources constitute 80% of the fuel use. It is said that our energy resources may last only for another 40 years or so. Energy saved is energy generated – when we save one unit of energy, it is equivalent to 2 units of energy produced.

Save energy to reduce pollution – energy production and use account to large proportion of air pollution and more than 83% of greenhouse gas emissions. "Energy conservation" and "Energy efficiency" are often used interchangeably, but there are some differences. At the most basic level, energy conservation means using less energy and is usually a behavioural change, like turning our lights off or setting our thermostat lower. Energy efficiency, however, means using energy more efficiently, and is often a technological change. Energy efficiency measures the difference between how much energy is used to provide the same level of comfort, performance or convenience by the same type of product, building or vehicle. A combination of both energy conservation and energy efficiency measures yields an ideal solution.

Energy generation is the most important deciding factor for a developing country like India. The total installed power capacity in India is around 255.012GW as of end of November 2014, being the world's largest producer of electricity in the year 2013 surpassing Japan and Russia with a global share of 4.8% in power generation. Renewable Power plants constituted 28.43% of the total installed capacity and Non-Renewable Power plants constituted the remaining 71.57%. As of March 2013, the per capital total electricity consumption in India was

917.2kWh. The 17th electric power survey of India report claims that over 2010–11, India's industrial demand accounted for 35% of electrical power requirement, domestic household use accounted for 28%, agriculture 21%, commercial 9%, public lighting and other miscellaneous

WHAT IS ENERGY?

In physics, energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat, the object.[note 1] Energy is a conserved quantity; the law of conservation of energy states that energy can be converted in form, but not created or destroyed. The SI unit of energy is the joule, which is the energy transferred to an object by the work of moving it a distance of 1 metre against a force of 1 newton.

Common forms of energy include the kinetic energy of a moving object, the potential energy stored by an object's position in a force field (gravitational, electric or magnetic), the elastic energy stored by stretching solid objects, the chemical energy released when a fuel burns, the radiant energy carried by light, and the thermal energy due to an object's temperature.

Mass and energy are closely related. Due to mass–energy equivalence, any object that has mass when stationary (called rest mass) also has an equivalent amount of energy whose form is called rest energy, and any additional energy (of any form) acquired by the object above that rest energy will increase the object's total mass just as it increases its total energy. For example, after heating an object, its increase in energy could be measured as a small increase in mass, with a sensitive enough scale.

Living organisms require energy to stay alive, such as the energy humans get from food. Human civilization requires energy to function, which it gets from energy resources such as fossil fuels, nuclear fuel, or renewable energy. The processes of Earth's climate and ecosystem are driven by the radiant energy Earth receives from the sun and the geothermal energy contained within the earth.

he total energy of a system can be subdivided and classified into potential energy, kinetic energy, or combinations of the two in various ways. Kinetic energy is determined by the movement of an object – or the composite motion of the components of an object – and potential energy reflects the potential of an object to have motion, and generally is a function of the position of an object within a field or may be stored in the field itself.

<u>TYPES OF ENERGY</u>

1. RENEWABLE ENERGY

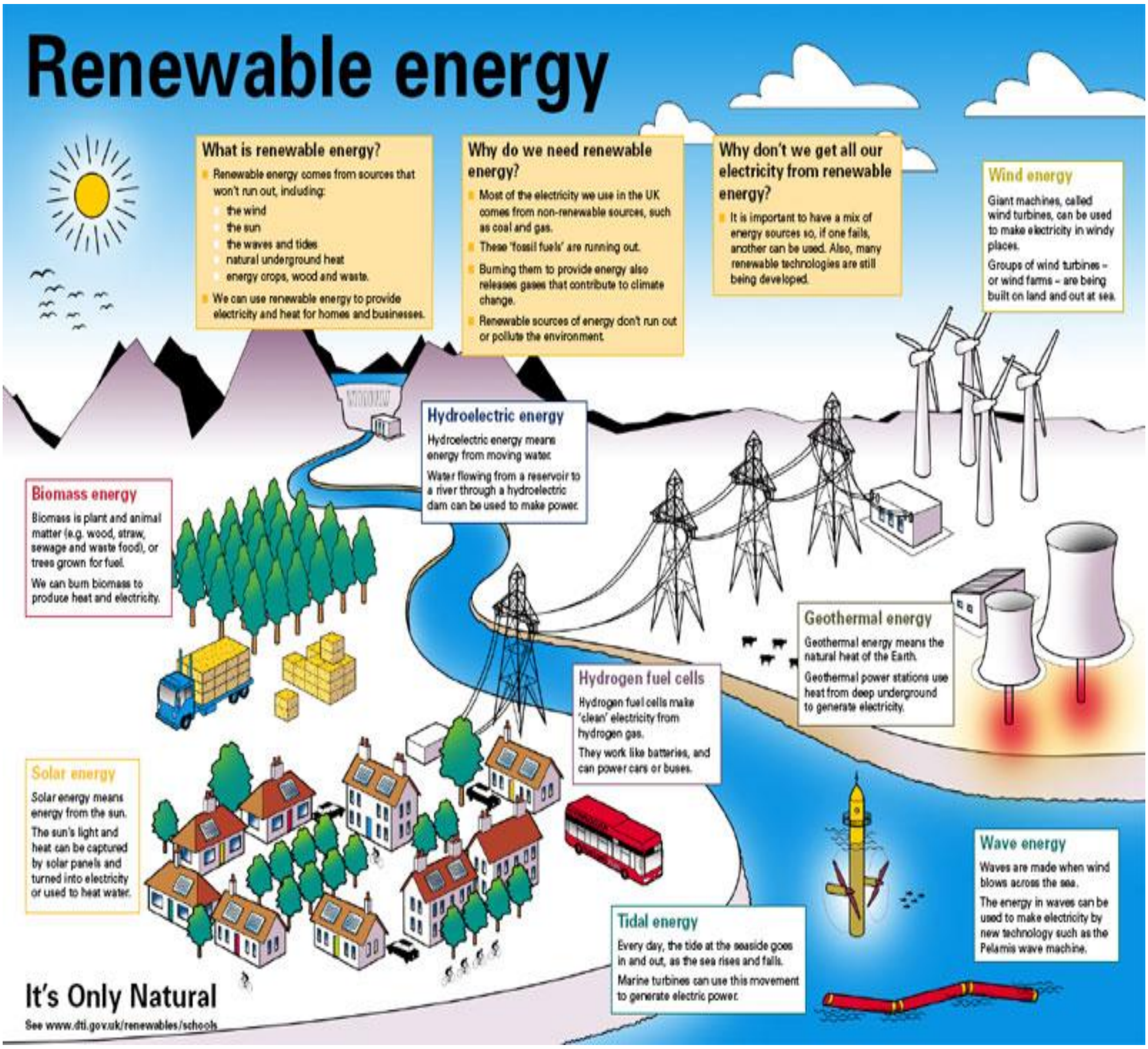
Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services.

Based on REN21's 2017 report, renewables contributed 19.3% to humans' global energy consumption and 24.5% to their generation of electricity in 2015 and 2016, respectively. This energy consumption is divided as 8.9% coming from traditional biomass, 4.2% as heat energy (modern biomass, geothermal and solar heat), 3.9% from hydroelectricity and the remaining 2.2% is electricity from wind, solar, geothermal, and other forms of biomass.

Worldwide investments in renewable technologies amounted to more than US$286 billion in 2015. In 2017, worldwide investments in renewable energy amounted to US$279.8 billion with China accounting for US$126.6 billion or 45% of the global investments, the United States for US$40.5 billion and Europe for US$40.9 billion. Globally there are an estimated 7.7 million jobs associated with the renewable energy industries, with solar photovoltaics being the largest renewable employer.

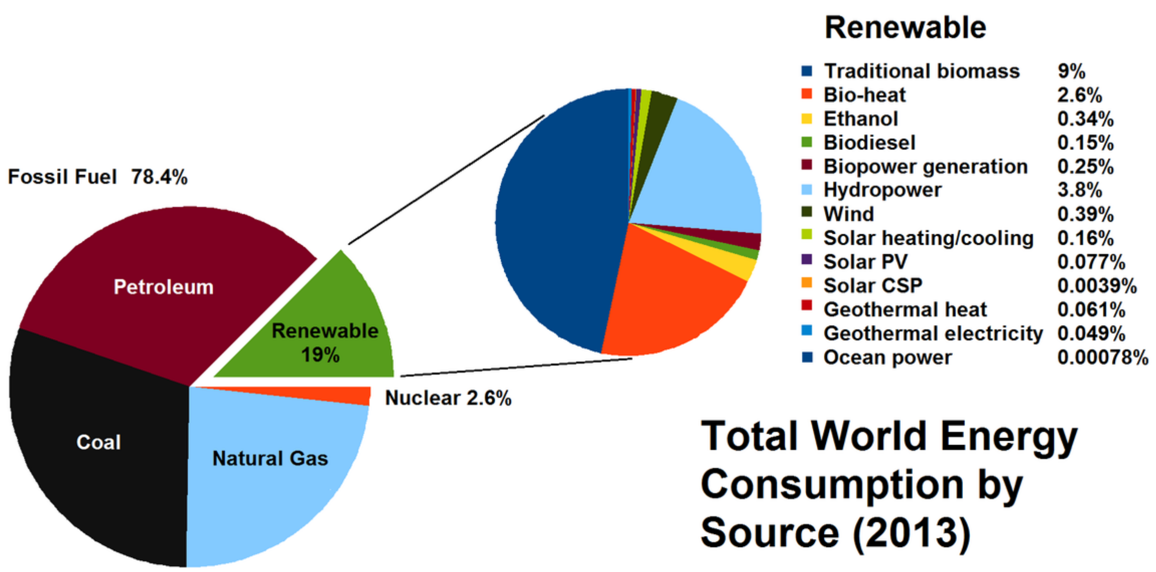
Renewable energy systems are rapidly becoming more efficient and cheaper and their share of total energy consumption is increasing. As of 2019, more than two-thirds of worldwide newly installed electricity capacity was renewable. Growth in consumption of coal and oil could end by 2020 due to increased uptake of renewables and natural gas.

At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Some places and at least two countries, Iceland and Norway, generate all their electricity using renewable energy already, and many other countries have the set a goal to reach 100% renewable energy in the future. At least 47 nations around the world already have over 50 percent of electricity from renewable resources.


Renewable energy
What is renewable energy?
Renewable energy comes from sources that won't run out, including:
the wind
the sun
the waves and tides
natural underground heat
energy crops, wood and waste.
We can use renewable energy to provide electricity and heat for homes and businesses.
Why do we need renewable energy?
Most of the electricity we use in the UK comes from non-renewable sources, such as coal and gas.
These 'fossil fuels' are running out.
Burning them to provide energy also releases gases that contribute to climate change.
Renewable sources of energy don't run out or pollute the environment.
Why don't we get all our electricity from renewable energy?
It is important to have a mix of energy sources so, if one fails, another can be used. Also, many renewable technologies are still being developed.
Wind energy
Giant machines, called wind turbines, can be used to make electricity in windy places.
Groups of wind turbines – or wind farms – are being built on land and out at sea.
Hydroelectric energy
Hydroelectric energy means energy from moving water.
Water flowing from a reservoir to a river through a hydroelectric dam can be used to make power.
Biomass energy
Biomass is plant and animal matter (e.g. wood, straw, sewage and waste food), or trees grown for fuel.
We can burn biomass to produce heat and electricity.
Geothermal energy
Geothermal energy means the natural heat of the Earth.
Geothermal power stations use heat from deep underground to generate electricity.
Hydrogen fuel cells
Hydrogen fuel cells make 'clean' electricity from hydrogen gas.
They work like batteries, and can power cars or buses.
Solar energy
Solar energy means energy from the sun.
The sun's light and heat can be captured by solar panels and turned into electricity or used to heat water.
Wave energy
Waves are made when wind blows across the sea.
The energy in waves can be used to make electricity by new technology such as the Pelamis wave machine.
Tidal energy
Every day, the tide at the seaside goes in and out, as the sea rises and falls.
Marine turbines can use this movement to generate electric power.
It's Only Natural
See www.dti.gov.uk/renewables/schools

At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Some places and at least two countries, Iceland and Norway, generate all their electricity using renewable energy already, and many other countries have the set a goal to reach 100% renewable energy in the future. At least 47 nations around the world already have over 50 percent of electricity from renewable resources. Renewable energy resources exist over wide geographical areas, in contrast to fossil fuels, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency technologies is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power.

While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas and developing countries, where energy is often crucial in human development. As most of renewable energy technologies provide electricity, renewable energy deployment is often applied in conjunction with further electrification, which has several benefits: electricity can be converted to heat (where necessary generating higher temperatures than fossil fuels), can be converted into mechanical energy with high efficiency, and is clean at the point of consumption. In addition, electrification with renewable energy is more efficient and therefore leads to significant reductions in primary energy requirements.



Renewable energy flows involve natural phenomena such as sunlight, wind, tides, plant growth, and geothermal heat, as the International Energy Agency explains

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.

Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits. It would also reduce environmental pollution such as air pollution caused by burning of fossil fuels and improve public health, reduce premature mortalities due to pollution and save associated health costs that amount to several hundred billion dollars annually only in the United States.

Renewable energy sources, that derive their energy from the sun, either directly or indirectly, such as hydro and wind, are expected to be capable of supplying humanity energy for almost another 1 billion years, at which point the predicted increase in heat from the Sun is expected to make the surface of the earth too hot for liquid water to exist.

Climate change and global warming concerns, coupled with the continuing fall in the costs of some renewable energy equipment, such as wind turbines and solar panels, are driving increased use of renewables. New government spending, regulation and policies helped the industry weather the global financial crisis better than many other sectors. As of 2019, however, according to the International Renewable Energy Agency, renewables overall share in the energy mix (including power, heat and transport) needs to grow six times faster, in order to keep the rise in average global temperatures "well below" 2.0 °C (3.6 °F) during the present century, compared to pre-industrial levels.

As of 2011, small solar PV systems provide electricity to a few million households, and micro-hydro configured into mini-grids serves many more. Over 44 million households use biogas made in household-scale digesters for lighting and/or cooking, and more than 166 million households rely on a new generation of more-efficient biomass cookstoves. [needs update]United Nations' Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20% of energy supply.

National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond, and some 120 countries have various policy targets for longer-term shares of renewable energy, including a 20% target of all electricity generated for the European Union by 2020. Some countries have much higher long-term policy targets of up to 100% renewables. Outside Europe, a diverse group of 20 or more other countries target renewable energy shares in the 2020–2030 time frame that range from 10% to 50%.

2. NON-RENEWABLE ENERGY

A non-renewable resource (also called a finite resource) is a natural resource that cannot be readily replaced by natural means at a quick enough pace to keep up with consumption . An example is carbon-based fossil fuel. The original organic matter, with the aid of heat and pressure, becomes a fuel such as oil or gas. Earth minerals and metal ores, fossil fuels (coal, petroleum, natural gas) and groundwater in certain aquifers are all considered non-renewable resources, though individual elements are always conserved (except in nuclear reactions).

Conversely, resources such as timber (when harvested sustainably) and wind (used to power energy conversion systems) are considered renewable resources, largely because their localized replenishment can occur within time frames meaningful to humans as well.

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes—or even in many, many lifetimes.

Most non-renewable energy sources are fossil fuels: coal, petroleum, and natural gas. Carbon is the main element in fossil fuels. For this reason, the time period that fossil fuels formed (about 360-300 million years ago) is called the Carboniferous Period.

All fossil fuels formed in a similar way. Hundreds of millions of years ago, even before the dinosaurs, Earth had a different landscape. It was covered with wide, shallow seas and swampy forests.

Plants, algae, and plankton grew in these ancient wetlands. They absorbed sunlight and created energy through photosynthesis. When they died, the organisms drifted to the bottom of the sea or lake. There was energy stored in the plants and animals when they died.

Over time, the dead plants were crushed under the seabed. Rocks and other sediment piled on top of them, creating high heat and pressure underground. In this environment, the plant and animal remains eventually turned into fossil fuels (coal, natural gas, and petroleum). Today, there are huge underground pockets (called reservoirs) of these non-renewable sources of energy all over the world.

Advantages and Disadvantages

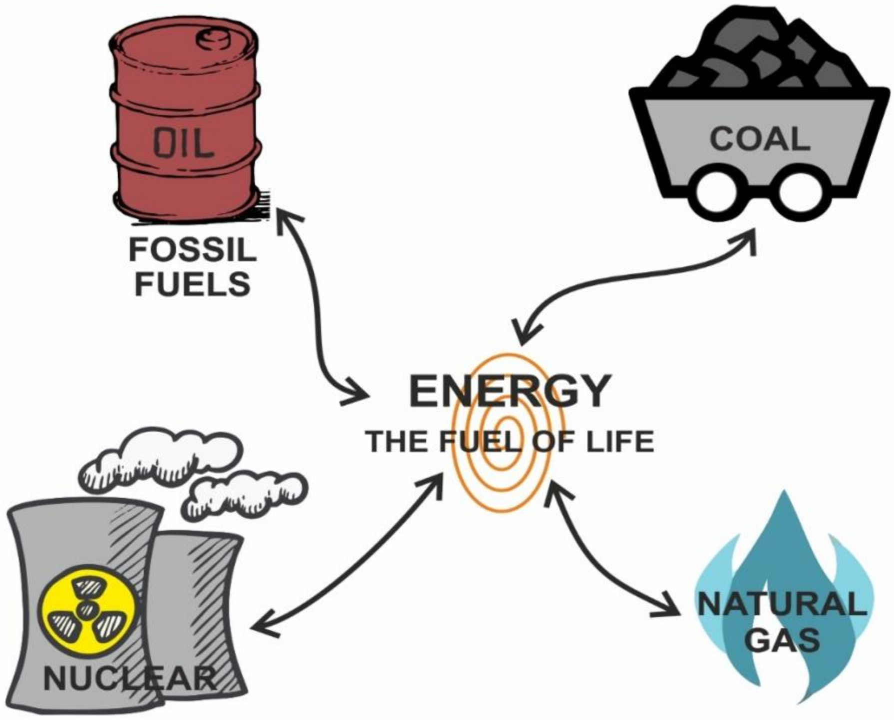
Fossil fuels are a valuable source of energy. They are relatively inexpensive to extract. They can also be stored, piped, or shipped anywhere in the world.

However, burning fossil fuels is harmful for the environment. When coal and oil are burned, they release particles that can pollute the air, water, and land. Some of these particles are caught and set aside, but many of them are released into the air.

Burning fossil fuels also upsets Earth's "carbon budget," which balances the carbon in the ocean, earth, and air. When fossil fuels are combusted (heated), they release carbon dioxide into the atmosphere. Carbon dioxide is a gas that keeps heat in Earth's atmosphere, a process called the "greenhouse effect." The greenhouse effect is necessary to life on Earth, but relies on a balanced carbon budget.

The carbon in fossil fuels has been sequestered, or stored, underground for millions of years. By removing this sequestered carbon from the earth and releasing it into the atmosphere, Earth's carbon budget is out of balance. This contributes to temperatures rising faster than organisms can adapt.

Non-renewable energy sources



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TYPES OF RENEWABLE ENERGY

WIND ENERGY

Wind power or wind energy is the use of wind to provide the mechanical power through wind turbines to turn electric generators and traditionally to do other work, like milling or pumping. Wind power is a sustainable and renewable energy, and has a much smaller impact on the environment compared to burning fossil fuels.

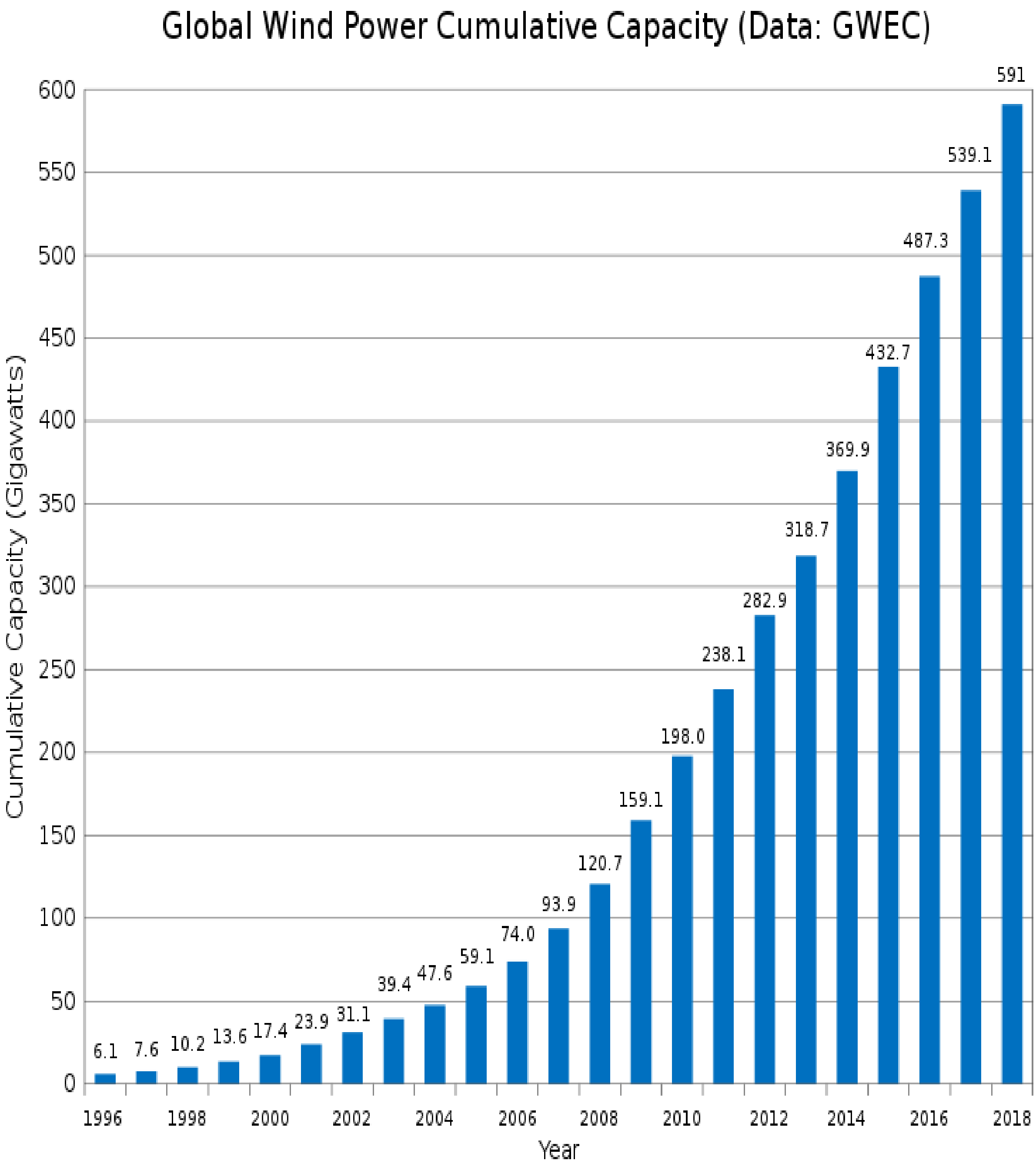
Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Onshore wind farms also have an impact on the landscape, as typically they need to be spread over more land than other power stations and need to be built in wild and rural areas, which can lead to "industrialization of the countryside" and habitat loss. Offshore wind is steadier and stronger than on land and offshore farms have less visual impact, but construction and maintenance costs are higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind is an intermittent energy source, which cannot make electricity nor be dispatched on demand It also gives variable power, which is consistent from year to year but varies greatly over shorter time scales. Therefore, it must be used together with other electric power sources or storage to give a reliable supply.

As the proportion of wind power in a region increases, more conventional power sources are needed to back it up (such as fossil fuel power and nuclear power), and the grid may need to be upgraded Power-management techniques such as having dispatchable power sources, enough hydroelectric power, excess capacity, geographically distributed turbines, exporting and importing power to neighbouring areas, energy storage, or reducing demand when wind production is low, can in many cases overcome these problems. Weather forecasting permits the electric-power network to be readied for the predictable variations in production that occur.

In 2018, global wind power capacity grew 9.6% to 591 GW and yearly wind energy production grew 10%, reaching 4.8% of worldwide electric power usage,] and providing 14% of the electricity in the European Union. Wind power supplied 15% of the electricity consumed in Europe in 2019

Denmark is the country with the highest penetration of wind power, with 43.4% of its consumed electricity from wind in 2017.[22][23] At least 83 other countries are using wind power to supply their electric power grids.



Wind energy is the kinetic energy of air in motion, also called wind. Total wind energy flowing through an imaginary surface with area A during the time t is:

$${\displaystyle E={\frac {1}{2}}mv^{2}={\frac {1}{2}}(Avt\rho)v^{2}={\frac {1}{2}}At\rho v^{3},}$$

where ρ is the density of air; v is the wind speed; Avt is the volume of air passing through A (which is considered perpendicular to the direction of the wind); Avtρ is therefore the mass m passing through "A". ½ ρv2 is the kinetic energy of the moving air per unit volume.

Power is energy per unit time, so the wind power incident on A (e.g. equal to the rotor area of a wind turbine) is:

$${\displaystyle P={\frac {E}{t}}={\frac {1}{2}}A\rho v^{3}.}$$

Wind power in an open air stream is thus proportional to the third power of the wind speed; the available power increases eightfold when the wind speed doubles. Wind turbines for grid electric power therefore need to be especially efficient at greater wind speeds.

Wind is the movement of air across the surface of the Earth, affected by areas of high pressure and of low pressure. The global wind kinetic energy averaged approximately 1.50 MJ/m2 over the period from 1979 to 2010, 1.31 MJ/m2 in the Northern Hemisphere with 1.70 MJ/m2 in the Southern Hemisphere. The atmosphere acts as a thermal engine, absorbing heat at higher temperatures, releasing heat at lower temperatures. The process is responsible for production of wind kinetic energy at a rate of 2.46 W/m2 sustaining thus the circulation of the atmosphere against frictional dissipation.

Through wind resource assessment it is possible to provide estimates of wind power potential globally, by country or region, or for a specific site. A global assessment of wind power potential is available via the Global Wind Atlas provided by the Technical University of Denmark in partnership with the World Bank. Unlike 'static' wind resource atlases which average estimates of wind speed and power density across multiple years, tools such as Renewables.

Ninja provide time-varying simulations of wind speed and power output from different wind turbine models at an hourly resolution. More detailed, site specific assessments of wind resource potential can be obtained from specialist commercial providers, and many of the larger wind developers will maintain in-house modelling capabilities.

The total amount of economically extractable power available from the wind is considerably more than present human power use from all sources. Axel Kleidon of the Max Planck Institute in Germany, carried out a "top down" calculation on how much wind energy there is, starting with the incoming solar radiation that drives the winds by creating temperature differences in the atmosphere. He concluded that somewhere between 18 TW and 68 TW could be extracted.

Cristina Archer and Mark Z. Jacobson presented a "bottom-up" estimate, which unlike Kleidon's are based on actual measurements of wind speeds, and found that there is 1700 TW of wind power at an altitude of 100 metres over land and sea. Of this, "between 72 and 170 TW could be extracted in a practical and cost-competitive manner". They later estimated 80 TW. However research at Harvard University estimates 1 watt/m2 on average and 2–10 MW/km2 capacity for large scale wind farms, suggesting that these estimates of total global wind resources are too high by a factor of about 4.

The strength of wind varies, and an average value for a given location does not alone indicate the amount of energy a wind turbine could produce there.

To assess prospective wind power sites a probability distribution function is often fit to the observed wind speed data. Different locations will have different wind speed distributions. The Weibull model closely mirrors the actual distribution of hourly/ten-minute wind speeds at many locations. The Weibull factor is often close to 2 and therefore a Rayleigh distribution can be used as a less accurate, but simpler model.

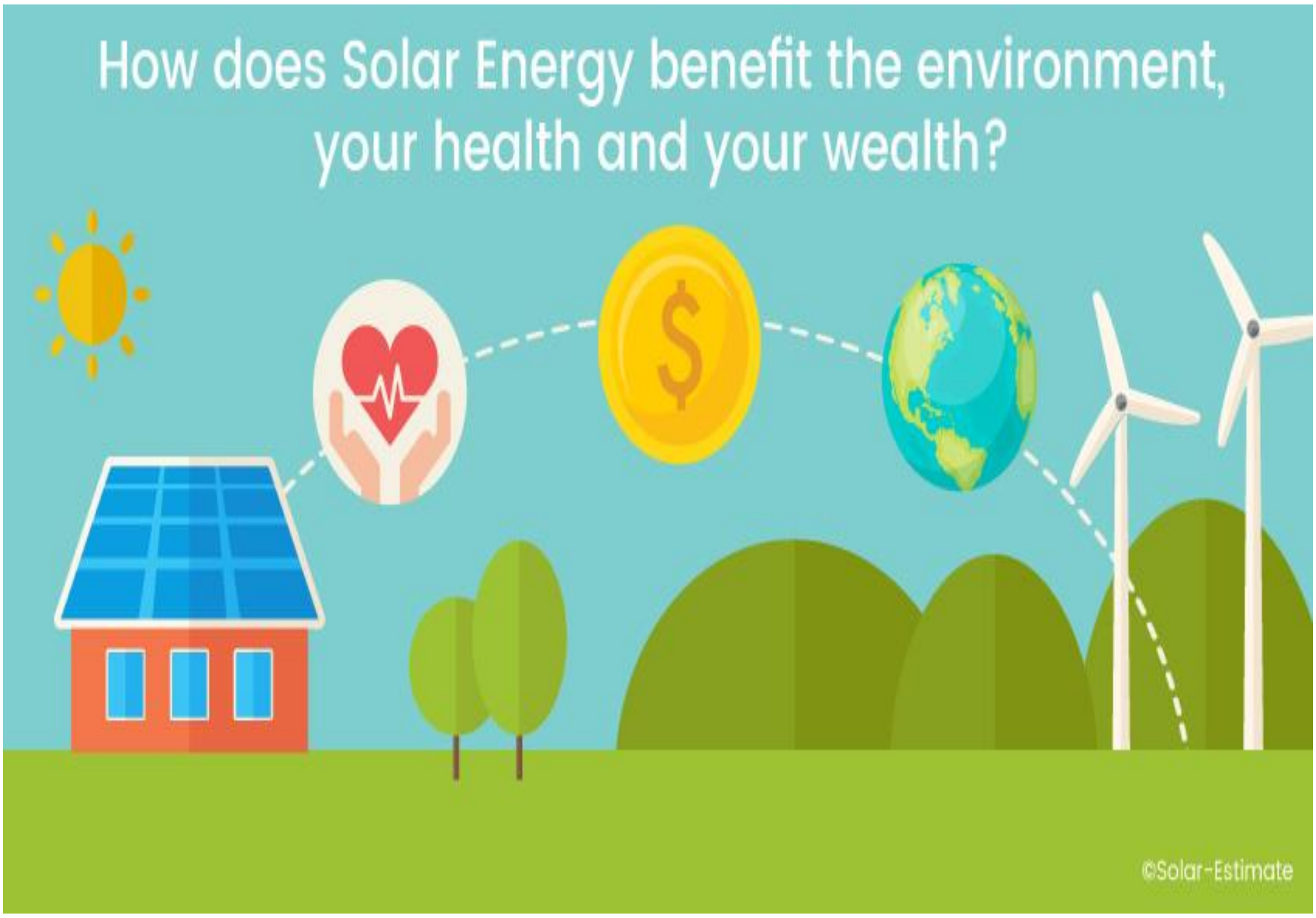
SOLAR ENERGY

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

The large magnitude of solar energy available makes it a highly appealing source of electricity. The United Nations Development Programme in its 2000 World Energy Assessment found that the annual potential of solar energy was 1,575–49,837 exajoules (EJ). This is several times larger than the total world energy consumption, which was 559.8 EJ in 2012.

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries’ energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared".



The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Most of the world's population live In areas with insolation levels of 150–300 watts/m², or 3.5–7.0 kWh/m² per day.[citation needed

Solar radiation is absorbed by the Earth's land surface, oceans – which cover about 71% of the globe – and atmosphere. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti-cyclones. Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of

14 °C. By photosynthesis, green plants convert solar energy into chemically stored energy, which produces food, wood and the biomass from which fossil fuels are derived.

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. In 2002, this was more energy in one hour than the world used in one-year Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined

Yearly solar fluxes & human consumption1		
Solar	*3,850,000*	*[10]*
Wind	*2,250*	*[15]*
Biomass potential	*~200*	*[16]*
Primary energy use2	*539*	*[17]*
Electricity2	*~67*	*[18]*
1 Energy given in Exajoule (EJ) = 1018 J = 278 TWh *2 Consumption as of year 2010*		

The potential solar energy that could be used by humans differs from the amount of solar energy present near the surface of the planet because factors such as geography, time variation, cloud cover, and the land available to humans limit the amount of solar energy that we can acquire.

Geography affects solar energy potential because areas that are closer to the equator have a greater amount of solar radiation. However, the use of photovoltaics that can follow the position of the Sun can significantly increase the solar energy potential in areas that are farther from the equator. Time variation effects the potential of solar energy because during the night-time there is little solar radiation on the surface of the Earth for solar panels to absorb. This limits the amount of energy that solar panels can absorb in one day. Cloud cover can affect the potential of solar panels because clouds block incoming light from the Sun and reduce the light available for solar cells.

In addition, land availability has a large effect on the available solar energy because solar panels can only be set up on land that is otherwise unused and suitable for solar panels. Roofs have been found to be a suitable place for solar cells, as many people have discovered that they can collect energy directly from their homes this way. Other areas that are suitable for solar cells are lands that are not being used for businesses where solar plants can be established.

Solar technologies are characterized as either passive or active depending on the way they capture, convert and distribute sunlight and enable solar energy to be harnessed at different levels around the world, mostly depending on distance from the equator. Although solar energy refers primarily to the use of solar radiation for practical ends, all renewable energies, other than Geothermal power and Tidal power, derive their energy either directly or indirectly from the Sun.

Active solar techniques use photovoltaics, concentrated solar power, solar thermal collectors, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favourable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

In 2000, the United Nations Development Programme, UN Department of Economic and Social Affairs, and World Energy Council published an estimate of the potential solar energy that could be used by humans each year that took into account factors such as insolation, cloud cover, and the land that is usable by humans. The estimate found that solar energy has a global potential of 1,600 to 49,800 exajoules (4.4×1014 to 1.4×1016 kWh) per year.

Annual solar energy potential by region (Exajoules)											
Region	*North America*	*Latin America and Caribbean*	*Western Europe*	*Central and Eastern Europe*	*Former Soviet Union*	*Middle East and North Africa*	*Sub-Saharan Africa*	*Pacific Asia*	*South Asia*	*Centrally planned Asia*	*Pacific OECD*
Minimum	*181.1*	*112.6*	*25.1*	*4.5*	*199.3*	*412.4*	*371.9*	*41.0*	*38.8*	*115.5*	*72.6*
Maximum	*7,410*	*3,385*	*914*	*154*	*8,655*	*11,060*	*9,528*	*994*	*1,339*	*4,135*	*2,2*

GEOTHERMAL ENERGY

Global geothermal capacity in 2017 was 12.9 GW.

High Temperature Geothermal energy is from thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet and from radioactive decay of minerals (in currently uncertain but possibly roughly equal proportions).

The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. The adjective geothermal originates from the Greek root’s geo, meaning earth, and thermos, meaning heat.

The heat that is used for geothermal energy can be from deep within the Earth, all the way down to Earth's core – 4,000 miles (6,400 km) down. At the core, temperatures may reach over 9,000 °F (5,000 °C). Heat conducts from the core to surrounding rock. Extremely high temperature and pressure cause some rock to melt, which is commonly known as magma.

Magma convicts upward since it is lighter than the solid rock. This magma then heats rock and water in the crust, sometimes up to 700 °F (371 °C).

Low Temperature Geothermal refers to the use of the outer crust of the earth as a Thermal Battery to facilitate Renewable thermal energy for heating and cooling buildings, and other refrigeration and industrial uses. In this form of Geothermal, a Geothermal Heat Pump and Ground-coupled heat exchanger are used together to move heat energy into the earth (for cooling) and out of the earth (for heating) on a varying seasonal basis.

Low temperature Geothermal (generally referred to as "GHP") is an increasingly important renewable technology because it both reduces total annual energy loads associated with heating and cooling, and it also flattens the electric demand curve eliminating the extreme summer and winter peak electric supply requirements. Thus, Low Temperature Geothermal/GHP is becoming an increasing national priority with multiple tax credit support and focus as part of the ongoing movement toward Net Zero Energy.

BIOENERGY

Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-derived materials which are specifically called lignocellulosic biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel.

Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods. Wood remains the largest biomass energy source today; examples include forest residues – such as dead trees, branches and tree stumps –, yard clippings, wood chips and even municipal solid waste. In the second sense, biomass includes plant or animal matter that can be converted into fibres or other industrial chemicals, including biofuels. Industrial biomass can be grown from numerous types plants,
including miscanthus, switchgrass, hemp, corn, poplar, willow, sorghum, sugarcane, bamboo, and a variety of tree species, ranging from eucalyptus to oil palm (palm oil).

Plant energy is produced by crops specifically grown for use as fuel that offer high biomass output per hectare with low input energy. The grain can be used for liquid transportation fuels while the straw can be burned to produce heat or electricity. Plant biomass can also be degraded from cellulose to glucose through a series of chemical treatments, and the resulting sugar can then be used as a first generation biofuel.

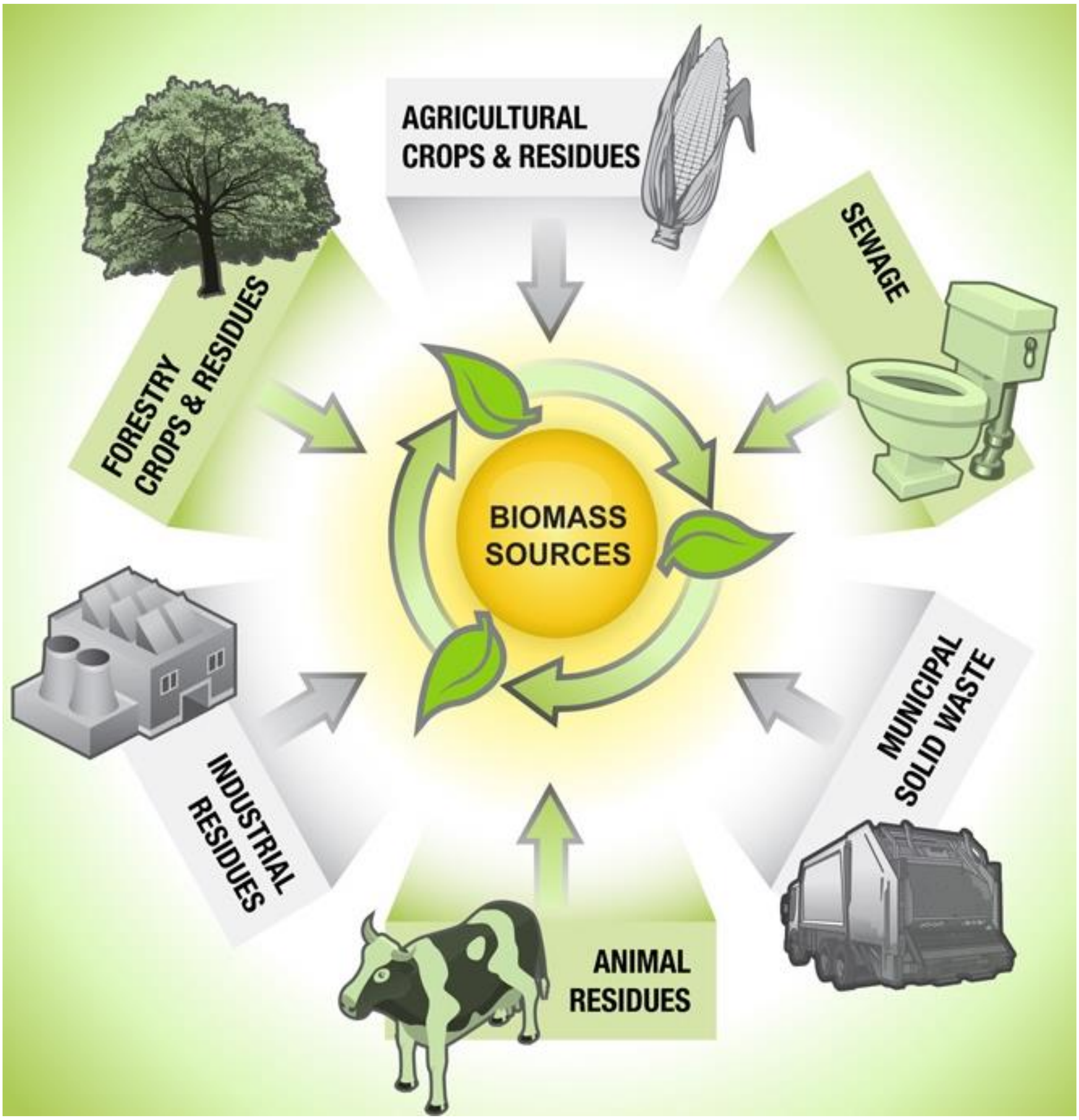
Biomass can be converted to other usable forms of energy such as methane gas or transportation fuels such as ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas – also called landfill gas or biogas. Crops, such as corn and sugarcane, can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products such as vegetable oils and animal fats. Also, biomass to liquids (BTLs) and cellulosic ethanol are still under research. There is a great deal of research involving algal fuel or algae-derived biomass due to the fact that it is a non-food resource and can be produced at rates 5 to 10 times those of other types of land-based agriculture, such as corn and soy. Once harvested, it can be fermented to produce biofuels such as ethanol, butanol, and methane, as well as biodiesel and hydrogen. The biomass used for electricity generation varies by region. Forest by-products, such as wood residues, are common in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks). Animal husbandry residues, such as poultry litter, are common in the United Kingdom.

Biofuels include a wide range of fuels which are derived from biomass. The term covers solid, liquid, and gaseous fuels. Liquid biofuels include bio alcohols, such as bioethanol, and oils, such as biodiesel. Gaseous biofuels include biogas, landfill gas and synthetic gas. Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. These include maize, sugarcane and, more recently, sweet sorghum. The latter crop is particularly suitable for growing in dryland conditions, and is being investigated by International Crops Research Institute for the Semi-Arid Tropics for its potential to provide fuel, along with food and animal feed, in arid parts of Asia and Africa.

With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstock's for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the United States and in Brazil. The energy costs for producing bio-ethanol are almost equal to, the energy yields from bio-ethanol. However, according to the European Environment Agency, biofuels do not address global warming concerns.

Biodiesel is made from vegetable oils, animal fats or recycled greases. It can be used as a fuel for vehicles in its pure form, or more commonly as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe. Biofuels provided 2.7% of the world's transport fuel in 2010.

Biomass, biogas and biofuels are burned to produce heat/power and in doing so harm the environment. Pollutants such as sulphurous oxides (Sox), nitrous oxides (NOx), and particulate matter (PM) are produced from the combustion of biomass; the World Health Organisation estimates that 7 million premature deaths are caused each year by air pollution. Biomass combustion is a major contributor



TYPES OF NON-RENEWABLE RESOURCES

Earth minerals and metal ores

Earth minerals and metal ores are examples of non-renewable resources. The metals themselves are present in vast amounts in Earth's crust, and their extraction by humans only occurs where they are concentrated by natural geological processes (such as heat, pressure, organic activity, weathering and other processes) enough to become economically viable to extract. These processes generally take from tens of thousands to millions of years, through plate tectonics, tectonic subsidence and crustal recycling.

The localized deposits of metal ores near the surface which can be extracted economically by humans are non-renewable in human time-frames. There are certain rare earth minerals and elements that are more scarce and exhaustible than others. These are in high demand in manufacturing, particularly for the electronics industry.

FOSSIL FUEL

In 1987, the World Commission on Environment and Development (WCED) classified fission reactors that produce more fissile nuclear fuel than they consume (i.e. breeder reactors) among conventional renewable energy sources, such as solar and falling water. The American Petroleum Institute likewise does not consider conventional nuclear fission as renewable, but rather that breeder reactor nuclear power fuel is considered renewable and sustainable, noting that radioactive waste from used spent fuel rods remains radioactive and so has to be very carefully stored for up to a thousand years. With the careful monitoring of radioactive waste products also being required upon the use of other renewable energy sources, such as geothermal energy.

The use of nuclear technology relying on fission requires Naturally occurring radioactive material as fuel. Uranium, the most common fission fuel, is present in the ground at relatively low concentrations and mined in 19 countries. This mined uranium is used to fuel energy-generating nuclear reactors with fissionable uranium-235 which generates heat that is ultimately used to power turbines to generate electricity.

As of 2013 only a few kilograms (picture available) of uranium have been extracted from the ocean in pilot programs and it is also believed that the uranium extracted on an industrial scale from the seawater would constantly be replenished from uranium leached from the ocean floor, maintaining the seawater concentration at a stable level. In 2014, with the advances made in the efficiency of seawater uranium extraction, a paper in the journal of Marine Science &

Engineering suggests that with, light water reactors as its target, the process would be economically competitive if implemented on a large scale.

Nuclear power provides about 6% of the world's energy and 13–14% of the world's electricity. Nuclear energy production is associated with potentially dangerous radioactive contamination as it relies upon unstable elements. In particular, nuclear power facilities produce about 200,000 metric tons of low and intermediate level waste (LILW) and 10,000 metric tons of high level waste (HLW) (including spent fuel designated as waste) each year worldwide.

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Issues entirely separate from the question of the sustainability of nuclear fuel, relate to the use of nuclear fuel and the high-level radioactive waste the nuclear industry generates that if not properly contained, is highly hazardous to people and wildlife. The United Nations (UNSCEAR) estimated in 2008 that average annual human radiation exposure includes 0.01 Millis evert (mSv) from the legacy of past atmospheric nuclear testing plus the Chernobyl disaster and the nuclear fuel cycle, along with 2.0 mSv from natural radioisotopes and 0.4 mSv from cosmic rays; all exposures vary by location.

natural uranium in some inefficient reactor nuclear fuel cycles, becomes part of the nuclear waste "once through" stream, and in a similar manner to the scenario were this uranium remained naturally in the ground, this uranium emits various forms of radiation in a decay chain that has a half-life of about 4.5 billion years the storage of this unused uranium and the accompanying fission reaction products have raised public concerns about risks of leaks and containment, however the knowledge gained from studying the Natural nuclear fission reactor in Okolo Gabon, has informed geologists on the proven processes that kept the waste from this 2 billion year old natural nuclear reactor that operated for hundreds of thousands of years.

REVIEW OF LITERATURE

- **ENERGY CONSERVATION ACT 2001**

The Bureau of Energy Efficiency is an agency of the Government of India, under the Ministry of Power created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act. The agency's function is to develop programs which will increase the conservation and efficient use of energy in India. The government has proposed to make it mandatory for certain appliances in India to have ratings by the BEE starting in January 2010.

The mission of Bureau of Energy Efficiency is to "institutionalise" energy efficiency services, enable delivery mechanisms in the country and provide leadership to energy efficiency in all sectors of the country. The primary objective would be to reduce energy intensity in the economy.

The broad objectives of BEE are as under:

- . To exert leadership and provide policy recommendation and direction to national energy conservation and efficiency efforts and programs.
- To coordinate energy efficiency and conservation policies and programs and take it to the stakeholders
- To establish systems and procedures to measure, monitor and verify energy efficiency results in individual sectors as well as at a macro level.
- To leverage multi-lateral and bi-lateral and private sector support in implementation of Energy Conservation Act and efficient use of energy and its conservation programs.
- To demonstrate delivery of energy efficiency services as mandated in the EC bill through private-public partnerships.
- To interpret, plan and manage energy conservation programs as envisaged in the Energy Conservation Act

Objectives

- Provide a policy recommendation and direction to national energy conservation activities
- Coordinate policies and programmes on efficient use of energy with shareholders
- Establish systems and procedures to verify, measure and monitor Energy Efficiency (EE) improvements
- Leverage multilateral, bilateral and private sector support to implement the EC Act '01
- Demonstrate EE delivery systems through public-private partnerships

- **BEE operationalized from 1st march 2002s**

- **Standards and labelling program**

- Evolve minimum energy consumption and performance standards for notified equipment and appliances
- Prohibit manufacture and sale of equipment and appliances not conforming standards
- Introduce mandatory labelling to enable consumers to make informed choices
- Work started on agricultural pump sets, Distribution transformer, Motors, lighting products and refrigerators.

- **List of designated consumer designated consumers have to:**

- Get energy audit done by accredited energy audit firms
- Implement cost effective recommendations
- Appoint or designated energy manager
- Comply with energy consumption norms and standards

- **By regulations BEE to prescribe**

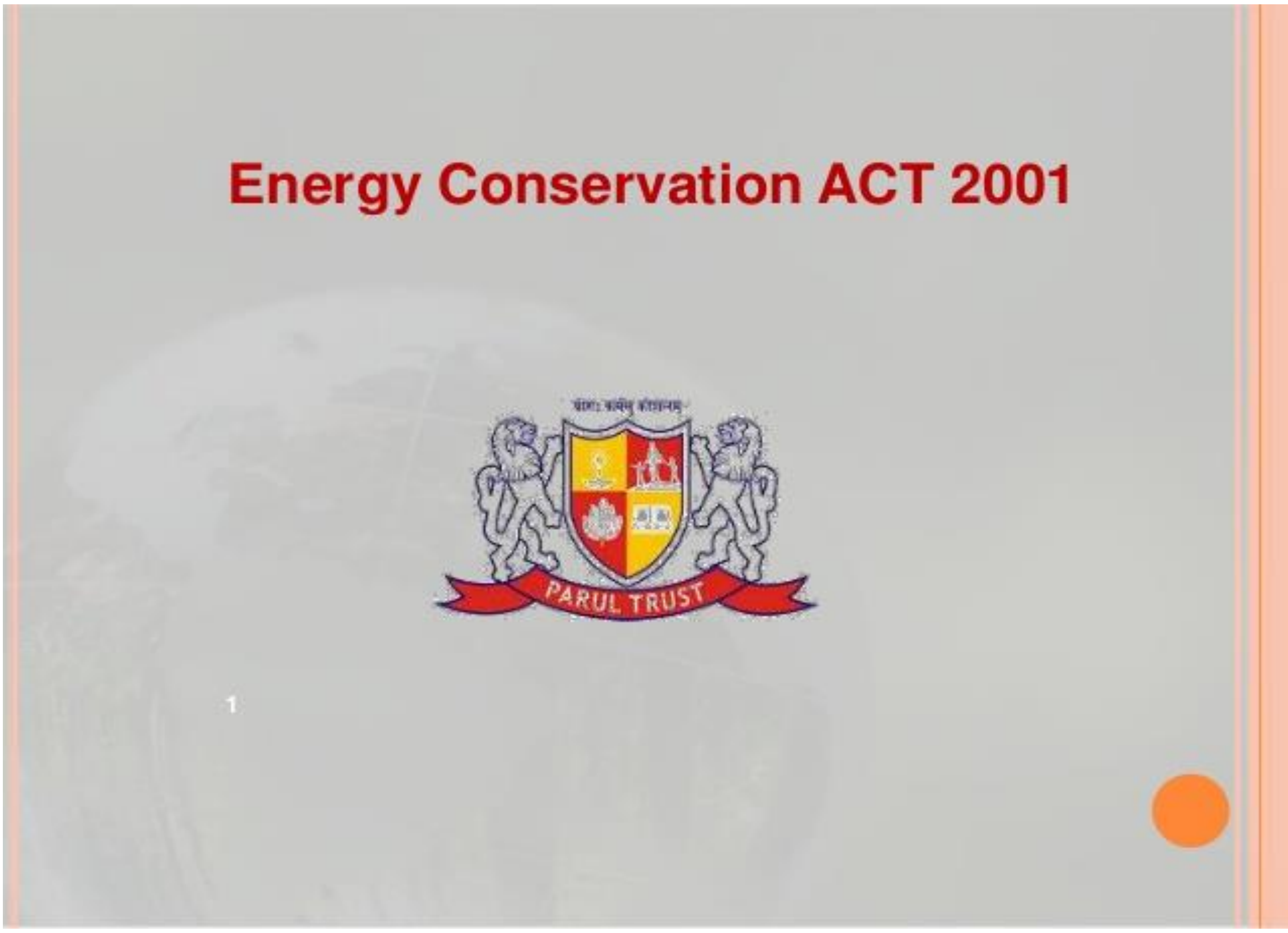
- Qualification and certification procedure for energy manager and energy auditors
- Accreditation procedure for Energy audit to firms

- **Energy conservation building codes**

- To prepare guidelines on codes
- To be modified by states to suit local climatic conditions
- To be applicable to new buildings having connected load of 500 kW and above

- **To set up Energy Conservation Fund to provide**

- Awareness creation
- Innovative financing
- Promotion of ESCOs
- R&D, testing facilities and Demonstration



The Energy Conservation (EC) Act, 2001, provides for the efficient use of energy and its conservation in India. The Government of India set up a Bureau of Energy Efficiency (BEE) under the provisions of the EC Act. The mission of the BEE is to assist in developing policies and strategies—with a thrust on self-regulation and market principles—within the overall framework of the EC Act with the primary objective of reducing the energy intensity of the Indian economy.

The BEE coordinates with designated consumers (DCs), designated agencies, and other organizations and recognizes, identifies, and utilizes the existing resources and infrastructure, in performing the functions assigned to it under the EC Act. In addition to providing regulatory and promotional functions of the Bureau, the act also provides a list of energy-intensive industries and other establishments specified as DCs. One of the flagship programmes of Bureau of Energy Efficiency is Perform, Achieve and Trade (PAT) scheme aimed towards enhancing energy efficiency in Indian industrial sector in general and Designated Consumers (DCs) in particular. The PAT scheme was formed under the National Mission for Enhanced Energy Efficiency (NMEEE).

The NMEEE is one of the eight national missions under the National Action Plan on Climate Change (NAPCC) launched by the Government of India in the year 2008. The Bureau has envisaged that the smooth implementation of PAT scheme can be enhanced and strengthened by formulating and making available a suitable ‘Energy Conservation Guidelines’ (EC Guidelines) for the targeted industry sub-sectors.

Japan is one of the pioneers in implementing energy efficiency at the global level. As part of their energy efficiency efforts, the Government of Japan had introduced EC guidelines to support industries to improve energy performance. Looking at their success, the Government of India, on similar lines, has also prepared EC Guidelines for different categories of industries operating in India

METHODOLOGY

WHY TO CONSERVE ENERGY?

Energy conservation is an evergreen topic since we all use energy in our daily lives. Energy conservation is simply the act of cutting back on energy use by utilizing less of the energy service provided. Energy conservation should not be confused with ‘’efficient energy use,” which implies using less energy for a continuous service. A classic example of energy conservation is driving less. In the same vein, energy efficiency is utilizing the same amount of fuel with a higher mileage car.

With the recent shift to green living, especially with the introduction of hybrid cars and people increasingly using alternative sources of energy, it’s easy to understand why society wants to change up to a more earth-conscious world rapidly. While most recognize that saving energy is a path they should be pursuing, not everyone understands its importance. Naturally, it’s always easier to do something when you perfectly understand why you’re doing it. This is why getting to know the reasons accompanying the need to conserve energy is critical.

Drawing from the research study undertaken by the American Energy Information Administration and the International Energy Agency, the universe is projected to continue the consumption of 2% more energy each year than it consumed the past year unless some countermeasures are drawn up and put into practice. In fact, we consume way more energy than we discover the oil resource to bridge the energy gap, which simply means oil reserves are declining every single day.

The largest sources of oil are located in nations that experience political turmoil, meaning they are unsafe. This brings about conflict with high energy consumers like the U.S., China and other nations including over-dependence on them. This explains why energy must be conserved at all costs to shield the population in case of any emergency.

Keeps your purse string closed

In life, there are far bigger motivations than money. Energy conservation is a plus for Mother Nature, but it’s equality good for your bottom-line. Conserving energy saves you money by peeling back on your overall energy bills. Also, installing alternative energy equipment such as solar in your residence and buying energy saving appliances can enable you to qualify for tax incentives and rebates.

Construction of fewer power plants

Although most view construction of power plants as a bright prospect, they greatly impact the environment. Firstly, they are unsightly, which means they interfere with the natural aesthetic value of the scenery. Secondly, they pollute the sound since they generate a lot of noise during electricity production. Thirdly, they are hazardous since the fumes produced by the power plant can cause respiratory diseases if inhaled over time. Also, installation of wind energy systems like turbines is disadvantageous as they kill local bird species that fly into them. Conservation of energy will mean adequate supply, alleviating the need to construct new power plants or install new turbines.

Boosts human health

Pollution from energy resources like coal, natural gas, and oil can cause a huge range of severe medical complications like asthma and lung cancer. This brings about unnecessary suffering and extraordinary medical costs. Conservation of energy ensures less carbon footprint, hence, fewer cases of respiratory diseases.

Mitigates global warming

A big percentage of the energy we consume today emanates from fossil fuels. Refining these fossil fuels into useful energy like gasoline for cars or electricity for home applications involves emission of vast amounts of carbon dioxide into the atmosphere. Carbon dioxide is the chief contributor to the greenhouse effect and global warming. The impacts of global warming are apparent these days including changing weather patterns, increase in atmospheric temperature, rising sea levels, which threaten to submerge some islands and proliferation of deadly diseases like cancer. Energy conservation minimizes the emission of carbon dioxide into the atmosphere thereby lowering the possibility of global warming.

To ensure constant safe water supply

Water conservation is critical to the future sustenance of life. Water is a vital element and makes up two-thirds of the surface of the earth. Water should not only be conserved, but also needs to be clean and free from pollution for the Biosystems to work properly. It requires massive amounts of water for hydropower plants to generate energy. The more energy is conserved, the less amount of water is needed for this process.

Social responsibility

In a country like America, a bigger part of the energy is generated by burning coal. While this provides the needed electricity to meet the needs of the population, miners are putting their lives and health in grave danger each day by going deep in the coal mines. Individuals working in gas and oil mines are also endangering their lives each day considering the explosive nature of these energy resources. On top of the potential dangers, health complications may manifest through long-term inhalation of these fossil fuels.

Mitigates habitat destruction

Conserving energy, without a doubt, will assist to mitigate habitat destruction. The fossil fuels extracted to produce power originate from somewhere, and that somewhere is a home to certain animal and plant species. Mining in these habits leads to transfer of wildlife and human populations. Some mines even involve clearing large chunks of forests, which is a natural home for wildlife.

Personal benefits

The personal benefits of conserving energy involve your own body. You can reduce the use of fossil fuels by cycling instead of driving your car or reducing the use of energy-intensive cleaning appliances. Cycling means exercising more and this enhances your fitness level, hence, keeping cardiovascular diseases at bay. Exercising also makes you feel and look better.

To maintain steady prices of energy

Conserving energy means the possibility of shortages will be eliminated. Abundant energy supply means steady prices throughout the year, or better still reduction in prices. Steady prices will keep your budget stable each month.

Positive impact in society

You may think that conserving energy will go unnoticed. The truth is when your neighbour realizes your low monthly utility bills, they will be curious to know the steps you are taking. They will want to reduce their overall utility bills as well, so that they will follow your example. When this chain continues, more people in the community will be involved in energy conservation, which is good for the future of the community.

Accords researchers more time to formulate solutions and alternatives

Energy conservation accords researchers more time to go into deep research (which takes years) to establish solutions and alternatives to energy sources that are projected to deplete. While fossil fuels are projected to deplete, prudent use of energy will allow fossil fuels to last long enough for tangible solutions to be discovered.

Transportation and commerce may grind to a halt

Most vehicles on the road today run on gasoline. Gasoline is derived from fossil fuels. Depletion of fossil fuels will mean no gasoline to power the vehicles. This can practically bring the transportation sector to a halt and affect commerce. The solution lies in the conservation of energy to ensure fossil fuel resources meet our needs to the end of time

.

Normal functioning of the country would be affected

Although steps are being taken to ramp up renewable energy resources, the bitter truth is that fossil fuels are still the most depended source of energy in the world. If fossil fuels were to deplete today, the whole world would come to a standstill. Energy conservation is the only way to prevent such a thing from happening.

Enhances the value of your home

Most people buy homes in anticipation of selling later at a profit. One way of beefing up the value of your home is installing water conservation systems like solar panels, rainwater harvesting systems, and installing water saving toilet and shower. Aside from saving you money at the end of the month, it will be attractive to prospective home buyers, leading to quick sale when you decide to put it on the market.

A clean future for your kids

We all want our children and grandchildren to grow up healthy. This is only possible with a clean environment. If we want a better environment for our children and children’s children, then minimizing global warming by conserving energy is the sure fire way.

HOW TO CONSERVE ENERGY IN INDUSTRIES?

Silicon
... beyond teaching

Energy Conservation in Indian Industries

Industry	Absolute energy consumption (million G Cal)	Scope of energy conservation in the sector (%)	Energy cost as Percentage of mfg cost (%)
Fertilizers & Pesticides	112	10	60
Sugar	100	20	12
Cement	67	10	40
Textile	52.5	20-25	13
Aluminum	30.1	15-20	40
Paper	26	20	25
Glass	15	15	30

SOME ENERGY CONSERVATION DEVICES

THERMAL UTILITIES

Boilers

- Preheat combustion air with waste heat
- (22 ^{0}C reduction in flue gas temperature increases boiler efficiency by 1%).
- Use variable speed drives on large boiler combustion air fans with variable flows.
- Burn wastes if permitted.
- Insulate exposed heated oil tanks.
- Clean burners, nozzles, strainers, etc.
- Inspect oil heaters for proper oil temperature.
- Close burner air and/or stack dampers when the burner is off to minimize heat loss up the stack.
- Improve oxygen trim control (e.g. -- limit excess air to less than 10% on clean fuels). (5% reduction in excess air increases boiler efficiency by 1% or: 1% reduction of residual oxygen in stack gas increases boiler efficiency by 1%.) • Automate/optimize boiler blowdown. Recovery boiler blowdown heat.
- Use boiler blowdown to help warm the back-up boiler.
- Optimize deaerator venting.
- Inspect door gaskets.
- Inspect for scale and sediment on the water side
- 1 mm thick scale (deposit) on the water side could increase fuel consumption by 5 to 8%).
- Inspect for soot, flash, and slag on the fire side
- Optimize boiler water treatment.
- Add an economizer to preheat boiler feedwater using exhaust heat.
- Recycle steam condensate.

- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple boilers.

Steam System

- Fix steam leaks and condensate leaks
- Accumulate work orders for repair of steam leaks that can't be fixed during the heating season due to system shutdown requirements. Tag each such leak with a durable tag with a good description.
- Use back pressure steam turbines to produce lower steam pressures.
- Use more-efficient steam DE superheating methods.
- Ensure process temperatures are correctly controlled.
- Maintain lowest acceptable process steam pressures.
- Reduce hot water wastage to drain.
- Remove or blank off all redundant steam piping.
- Ensure condensate is returned or re-used in the process
- Preheat boiler feed-water.
- Recovery boiler blowdown.
- Check operation of steam traps.
- Remove air from indirect steam using equipment

(0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall.)

- Inspect steam traps regularly and repair malfunctioning traps promptly.
- Consider recovery of vent steam (e.g. -- on large flash tanks).
- Use waste steam for water heating.
- Use an absorption chiller to condense exhaust steam before returning the condensate to the boiler.
- Use electric pumps instead of steam ejectors when cost benefits permit.

Furnaces

- Check against infiltration of air: Use doors or air curtains.
- Monitor O_2 /CO_2/CO and control excess air to the optimum level.
- Improve burner design, combustion control and instrumentation.
- Ensure that the furnace combustion chamber is under slight positive pressure.
- Use ceramic fibres in the case of batch operations.
- Match the load to the furnace capacity.
- Retrofit with heat recovery device.
- Investigate cycle times and reduce.
- Provide temperature controllers.
- Ensure that flame does not touch the stock.

Insulation

- Repair damaged insulation
- Insulate any hot or cold metal or insulation.
- Replace wet insulation.
- Use an infrared gun to check for cold wall areas during cold weather or hot wall areas during hot weather.
- Ensure that all insulated surfaces are cladded with aluminium
- Insulate all flanges, valves and couplings
- Insulate open tanks

Waste heat recovery

- Recover heat from flue gas, engine cooling water, engine exhaust, low pressure waste steam, drying oven exhaust, boiler blowdown, etc.
- Recover heat from incinerator off-gas.
- Use waste heat for fuel oil heating, boiler feedwater heating, outside air heating, etc.
- Use chiller waste heat to preheat hot water.
- Use heat pumps.
- Use absorption refrigeration.
- Use thermal wheels, run-around systems, heat pipe systems, and air-to-air exchangers.

ELECTRICAL UTILITIES

- Electricity Distribution System
- Optimise the tariff structure with utility supplier
- Schedule your operations to maintain a high load factor
- Shift loads to off-peak times if possible.
- Minimise maximum demand by tripping loads through a demand controller
- Stagger start-up times for equipment with large starting currents to minimize load peaking.
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.90 under rated load conditions.
- Relocate transformers close to main loads.
- Set transformer taps to optimum settings.
- Disconnect primary power to transformers that do not serve any active loads

- Consider on-site electric generation or cogeneration.
- Export power to grid if you have any surplus in your captive generation
- Check utility electric meter with your own meter.
- Shut off unnecessary computers, printers, and copiers at night.

Motors

- Properly size to the load for optimum efficiency.
- Use energy-efficient motors where economical.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation
- *(For every 10 ^{o}c increase in motor operating temperature over recommended peak, the motor life is estimated to be halved)*
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.

(An imbalanced voltage can reduce 3 – 5% in motor input power)

- Demand efficiency restoration after motor rewinding.

(If rewinding is not done properly, the efficiency can be reduced by 5 – 8%)

Drives

- Use variable-speed drives for large variable loads.
- Use high-efficiency gear sets.
- Use precision alignment.
- Check belt tension regularly.
- Eliminate variable-pitch pulleys.
- Use flat belts as alternatives to v-belts.
- Use synthetic lubricants for large gearboxes.

- Eliminate eddy current couplings.
- Shut them off when not needed.

Fans

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation • Eliminate leaks in ductwork.
- Minimise bends in ductwork
- Turn fans off when not needed.

Blowers

- Use smooth, well-rounded air inlet ducts or cones for air intakes.
- Minimize blower inlet and outlet obstructions.
- Clean screens and filters regularly.
- Minimize blower speed.
- Use low-slip or no-slip belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable blower loads.
- Use energy-efficient motors for continuous or near-continuous operation.
- Eliminate ductwork leaks.

Pumps

- Operate pumping near best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an on-line spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.

Compressors

- Consider variable speed drive for variable load on positive displacement compressors.
- Use a synthetic lubricant if the compressor manufacturer permits it.
- Be sure lubricating oil temperature is not too high (oil degradation and lowered viscosity) and not too low (condensation contamination).
- Change the oil filter regularly.
- Periodically inspect compressor intercoolers for proper functioning.
- Use waste heat from a very large compressor to power an absorption chiller or preheat process or utility feeds.
- Establish a compressor efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressor efficiency-maintenance program a part of your continuous energy management program.

Compressed air

- Install a control system to coordinate multiple air compressors.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple air compressors.
- Avoid over sizing -- match the connected load.
- Load up modulation-controlled air compressors. (They use almost as much power at partial load as at full load.)
- Turn off the back-up air compressor until it is needed.
- Reduce air compressor discharge pressure to the lowest acceptable setting. (Reduction of 1 kg/cm^2 air pressure (8 kg/cm^2 to 7 kg/cm^2) would result in 9% input power savings. This will also reduce compressed air leakage rates by 10%)

- Use the highest reasonable dryer dew point settings.
- Turn off refrigerated and heated air dryers when the air compressors are off.
- Use a control system to minimize heatless desiccant dryer purging.

Minimize purges, leaks, excessive pressure drops, and condensation accumulation. (Compressed air leak from 1 mm hole size at 7 kg/cm^2 pressure would mean power loss equivalent to 0.5 kW)

- Use drain controls instead of continuous air bleeds through the drains.
- Consider engine-driven or steam-driven air compression to reduce electrical demand charges.
- Replace standard v-belts with high-efficiency flat belts as the old v-belts wear out.
- Use a small air compressor when major production load is off.
- Take air compressor intake air from the coolest (but not air conditioned) location. *(Every 5^0C reduction in intake air temperature would result in 1% reduction in compressor power consumption)*
- Use an air-cooled aftercooler to heat building makeup air in winter.
- Be sure that heat exchangers are not fouled (e.g. -- with oil).
- Be sure that air/oil separators are not fouled.
- Monitor pressure drops across suction and discharge filters and clean or replace filters promptly upon alarm.
- Use a properly sized compressed air storage receiver. Minimize disposal costs by using lubricant that is fully demisable and an effective oil-water separator.
- Consider alternatives to compressed air such as blowers for cooling, hydraulic rather than air cylinders, electric rather than air actuators, and electronic rather than pneumatic controls.
- Use nozzles or venturi-type devices rather than blowing with open compressed air lines.
- Check for leaking drain valves on compressed air filter/regulator sets. Certain rubber type valves may leak continuously after they age and crack.
- In dusty environments, control packaging lines with high-intensity photocell units instead of standard units with continuous air purging of lenses and reflectors.

- Establish a compressed air efficiency-maintenance program. Start with an energy audit and follow-up, then make a compressed air efficiency-maintenance program a part of your continuous energy management program.

Chillers

- Increase the chilled water temperature set point if possible.
- Use the lowest temperature condenser water available that the chiller can handle.
- *(*Reducing condensing temperature by 5.5 ^{0}C, results in a 20 -
- 25% decrease in compressor power consumption)
- Increase the evaporator temperature
- *(5.5^{0}C increase in evaporator temperature reduces compressor power consumption by 20 - 25%)*
- Clean heat exchangers when fouled.
- (1 mm scale build-up on condenser tubes can increase energy consumption by 40%)
- Optimize condenser water flow rate and refrigerated water flow rate.
- Replace old chillers or compressors with new higher-efficiency models.
- Use water-cooled rather than air-cooled chiller condensers.
- Use energy-efficient motors for continuous or near-continuous operation.
- Specify appropriate fouling factors for condensers.
- Do not overcharge oil.
- Install a control system to coordinate multiple chillers.
- Study part-load characteristics and cycling costs to determine the most-efficient mode for operating multiple chillers.
- Run the chillers with the lowest energy consumption. It saves energy cost, fuels a base load.
- Avoid oversizing -- match the connected load.
- Isolate off-line chillers and cooling towers.

- Establish a chiller efficiency-maintenance program. Start with an energy audit and follow-up, then make a chiller efficiency-maintenance program a part of your continuous energy management program

HVAC (Heating / Ventilation / Air Conditioning)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use morning pre-cooling in summer and pre-heating in winter (i.e. -- before electrical peak hours).
- Use building thermal lag to minimize HVAC equipment operating time.
- In winter during unoccupied periods, allow temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allow temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Reduce HVAC system operating hours (e.g. -- night, weekend).
- Optimize ventilation.
- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. -- computer rooms).

- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Reduce humidification or dehumidification during unoccupied periods.
- Use atomization rather than steam for humidification where possible.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic controls air compressors for proper operation, cycling, and maintenance.
- Isolate air-conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally-designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC window units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short cycle" which results in poor humidity control.)
- Install multi-fuelling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.
- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Consider ground source heat pumps.

- Seal leaky HVAC ductwork.
- Seal all leaks around coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.

Refrigeration

- Use water-cooled condensers rather than air-cooled condensers.
- Challenge the need for refrigeration, particularly for old batch processes.
- Avoid oversizing -- match the connected load.
- Consider gas-powered refrigeration equipment to minimize electrical demand charges.
- Use "free cooling" to allow chiller shutdown in cold weather.
- Use refrigerated water loads in series if possible.
- Convert firewater or other tanks to thermal storage.
- Don't assume that the old way is still the best -- particularly for energy-intensive low temperature systems.
- Correct inappropriate brine or glycol concentration that adversely affects heat transfer and/or pumping energy.
- If it sweats, insulate it, but if it is corroding, replace it first.
- Make adjustments to minimize hot gas bypass operation.
- Inspect moisture/liquid indicators.
- Consider change of refrigerant type if it will improve efficiency.
- Check for correct refrigerant charge level.
- Inspect the purge for air and water leaks.
- Establish a refrigeration efficiency-maintenance program. Start with an energy audit and follow-up, then make a refrigeration efficiency-maintenance program a part of your continuous energy management program.

Cooling towers

- Control cooling tower fans based on leaving water temperatures.
- Control to the optimum water temperature as determined from cooling tower and chiller performance data.
- Use two-speed or variable-speed drives for cooling tower fan control if the fans are few. Stage the cooling tower fans with on-off control if there are many.
- Turn off unnecessary cooling tower fans when loads are reduced.
- Cover hot water basins (to minimize algae growth that contributes to fouling).
- Balance flow to cooling tower hot water basins.
- Periodically clean plugged cooling tower water distribution nozzles.
- Install new nozzles to obtain a more-uniform water pattern.
- Replace splash bars with self-extinguishing PVC cellular-film fill.
- On old counterflow cooling towers, replace old spray-type nozzles with new square spray ABS practically-non-clogging nozzles.
- Replace slat-type drift eliminators with high-efficiency, low-pressure-drop, self-extinguishing, PVC cellular units.
- If possible, follow manufacturer's recommended clearances around cooling towers and relocate or modify structures, signs, fences, dumpsters, etc. that interfere with air intake or exhaust.
- Optimize cooling tower fan blade angle on a seasonal and/or load basis.
- Correct excessive and/or uneven fan blade tip clearance and poor fan balance.
- Use a velocity pressure recovery fan ring.

- Divert clean air-conditioned building exhaust to the cooling tower during hot weather.
- Re-line leaking cooling tower cold water basins.
- Check water overflow pipes for proper operating level.
- Optimize chemical use.
- Consider side stream water treatment.
- Restrict flows through large loads to design values.
- Shut off loads that are not in service.
- Take blowdown water from the return water header.

Lighting

- Reduce excessive illumination levels to standard levels using switching, decamping, etc. (Know the electrical effects before doing decamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts
- Consider daylighting, skylights, etc.
- Consider painting the walls a lighter colour and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

DG sets

- Optimise loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly
- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

FINDINGS

PHILOSOPHY OF ENERGY AUDIT

- Through energy audit we optimize the consumption of fuel i.e. coal, electricity, petroleum products etc.
- To spread the benefits obtained through Energy Audit in any one industry to entire cluster.
- To replicate the benefits obtained through Energy Audit in other industries through Education Campaign and ITPs

Energy Audits in Clusters(2001-02 to 2003-04)

Silicon ... beyond teaching

Sl no	Name of the cluster industry	No . Of industries Audited	Annual energy consumption (KLOE)	Saving potential indentified (KLOE)
1	Aluminium	5	13570	936
2	Iron & steel	62	133677	16276
3	cement	2	37786	722
4	Pulp & paper	11	58297	3561
5	sugar	1	1490	290
6	textile	49	153770	6749
7	chemical	30	56642	3366
8	Process industries	131	290718	16882
9	Thermal power plant	1	1800	257

- Sponsor R&D projects identified from Energy Audit.

MAJOR ENERGY AUDITS (since 2001)

Silicon ... beyond teaching

Sl no	Name of Industry	Type	Audit Type**	City	*EYC KLOE	Savings Identified (SI) KLOE
1	ONGC	Natural Gas	p	Uran, Mumbai	128891	20834
2	IOC Blending Ltd.	LO Blending	p	Vashi, Mumbai	1750	205
3	IOC LPG Bottling	LPG Bottling	p	Bhopal	1000	200
4	Star Wire India Ltd	Steel	E	Ballabhargh	1247	61
5	India Habitat Centre	Office	m	Delhi	1338	96

**P = Process; E=Engg; M=Miscellaneous
*EYC indicates Estimate l Yearly Consumption of audited industrioes

DISSCUSSION

INDUSTRIES TOWARDS ENERGY CONSERVATION

ALUMINIUM-

- Energy consumption varies from plant to plants as their smelters are based on different design parameters
- NALCO has adopted the latest energy efficient systems au-MI has the lowest specific heat consumption of 13,500 kwh per tonne of aluminium production
- Potential energy saving up to 15-20% by energy saving projects.

CEMENT –

- India is the 4^{th} largest producer of cement in the world
- Energy costs making up as much as 40% of the total cost of manufacturing.
- According to CII potential energy saving up to 10% by energy saving projects.
- Particulate emission that has a significant influence on the environment

BUILDING DESIGN

One of the primary ways to improve energy conservation in buildings is to perform an energy audit. An energy audit is an inspection and analysis of energy use and flows for energy conservation in a building, process or system with an eye toward reducing energy input without negatively affecting output. This is normally accomplished by trained professionals and can be part of some of the national programs discussed above. Recent development of smartphone apps enables homeowners to complete relatively sophisticated energy audits themselves

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Building technologies and smart meters can allow energy users, both commercial and residential, to visualize the impact their energy use can have in their workplace or homes. Advanced real-time energy metering can help people save energy by their actions.

In passive solar building design, windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design because, unlike active solar heating systems, it does not involve the use of mechanical and electrical devices.

The key to designing a passive solar building is to best take advantage of the local climate. Elements to be considered include window placement and glazing type, thermal insulation, thermal mass, and shading. Passive solar design techniques can be applied most easily to new buildings, but existing buildings can be retrofitted.

CONCLUSION

By now, we are all experts in identifying how energy is converted between different forms and conserved through any process. We can convincingly describe the nature of these transfers... but what if we want to perform calculations involving energy? How does the conservation of energy relate the speed of a falling object to its height? How can we use calculations of energy to predict the motion of a pendulum? If we can't create or destroy energy, where did all this energy come from in the first place?

Luckily, we still have many weeks ahead of us to investigate these questions. Keep your energy reference sheets handy as we continue investigating as a class. Hopefully you will show up tomorrow excited to learn and feeling... *energetic!*

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