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Future Energy

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ABSTRACT

The electricity requirements of the world including India are increasing at alarming rate and the power demand has been running ahead of supply. It is also now widely recognized that the fossil fuels (i.e., coal, petroleum and natural gas) and other conventional resources, presently being used for generation of electrical energy, may not be either sufficient or suitable to keep pace with ever increasing demand of the electrical energy of the world. Also generation of electrical power by cold based steam power plant or nuclear power plants causes pollution, which is likely to be more acute in future due to large generating capacity on one side and greater awareness of the people in this respect. The recent severe energy crisis has forced the world to use non conventional sources of energy for power generation, because they are free of cost and doesn't produce any pollution at all. The other non-conventional methods of power generation may be such as solar cells, fuel cells, thermo-electric generator, solar power generation, wind power generation, geo-thermal energy generation, tidal power generation etc. The path for sustainability in the next millennium is the low energy path through wise use of energy. Energy conservation and energy efficiency measures would certainly result in meeting the Energy demand with as little as half the primary supply at current levels. This requires profound structural changes in Socio-economic and institutional arrangements. Environmentally Sound, technically and economically viable energy pathways will sustain human progress in the long term future giving a fair and equitable share of the underprivileged and poor of the developing Countries. This paper elucidates about Different Energy sources, why we are going for non-conventional energy sources, Different non-conventional energy sources & comparison between them & how they can support our future.

Keywords: Biomass, fission reaction, fusion reaction, energy

INTRODUCTION

Energy plays a vital role, affecting all the activities that take place in the society. Its role in economic development of a region needs no emphasis; because of its qualitative effects, it exercises greater influence. It is the key element in the production process, and the lack or shortage of it has a serious impact on the economy. It is a Central concept in most branches of natural science, social science and engineering, since it is essential to make things happen. It plays a crucial role in diverse processes like chemical reactions, cloud formation, functioning of cells, production of goods, transportation, etc. Fossil fuels, such as, coal, oil and natural gas lay the foundation for an industrial society, but they are disappearing at an alarming rate. Present fossil fuel potential is unable to meet the growing demands of the society. There is a need to look for viable alternatives to meet this scarcity. In this regard, rational decision making is necessary to eliminate wasteful use of resources.

1. NUCLEAR ENERGY

A nuclear power plant is a thermal power station in which the heat source is one or more nuclear reactors. As in a conventional thermal power station the heat is used to generate steam which drives a steam turbine connected to a generator which produces electricity. As of February 2, 2012, there were 439 nuclear power plants in operation. Nuclear power plants are usually considered to be base load stations.

Fig. 1.1(a)- A nuclear power station.

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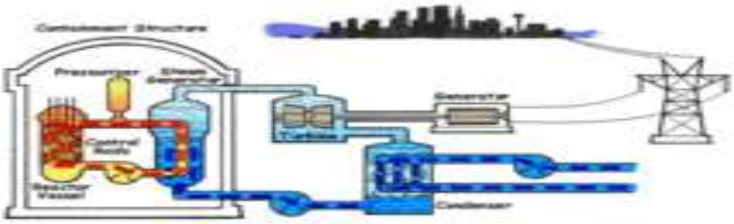
1.1 Systems

The conversion to electrical energy takes place indirectly, as in conventional thermal power plants. The heat is produced by fission in a nuclear reactor (a light water reactor). Directly or indirectly, water vapor (steam) is produced. The pressurized steam is then usually fed to a multi-stage steam turbine. Steam turbines in Western nuclear power plants are among the largest steam turbines ever. After the steam turbine has expanded and partially condensed the steam, the remaining vapor is condensed in a condenser. The condenser is a heat exchanger which is connected to secondary side such as a river or a cooling tower. The water is then pumped back into the nuclear reactor and the cycle begins again. The water-steam cycle corresponds to the Rankin cycle.

1.2 Nuclear reactors

Nuclear reactor is a device to initiate and control a sustained nuclear chain reaction. The most common use of nuclear reactors is for the generation of electric energy and for the propulsion of ships.
The nuclear reactor is the heart of the plant. In its central part, the reactor core's heat is generated by controlled nuclear fission. With this heat, a coolant is heated as it is pumped through the reactor and thereby removes the energy from the reactor. Heat from nuclear fission is used to raise steam, which runs through turbines, which in turn powers either ship's propellers or electrical generators.



Pressurized water reactor

Since nuclear fission creates radioactivity, the reactor core is surrounded by a protective shield. This containment absorbs radiation and prevents radioactive material from being released into the environment. In addition, many reactors are equipped with a dome of concrete to protect the reactor against external impacts.

1.3 Steam turbine

The object of the steam turbine is to convert the heat contained in steam into mechanical energy. The engine house with the steam turbine is usually structurally separated from the main reactor building. It is aligned to prevent debris from the destruction of a turbine in operation from flying towards the reactor.

In the case of a pressurized water reactor, the steam turbine is separated from the nuclear system. To detect a leak in the steam generator and thus the passage of radioactive water at an early stage is the outlet steam of the steam generator mounted an activity meter. In contrast, boiling water reactors and the steam turbine with radioactive water applied and therefore part of the control area of the nuclear power plant.

1.4 Generator

The generator converts kinetic energy supplied by the turbine into electrical energy. Low-pole AC synchronous generators of high rated power are used.

1.5 Cooling system

A cooling system removes heat from the reactor core and transports it to another area of the plant, where the thermal energy can be harnessed to produce electricity or to do other useful work. Typically the hot coolant is used as a heat source for a boiler, and the pressurized steam from that boiler powers one or more steam turbine driven electrical generators.

1.6 Safety valves

In the event of an emergency, two independent safety valves can be used to prevent pipes from bursting or the reactor from exploding. The valves are designed so that they can derive all of the supplied flow rates with little increase in pressure. In the case of the BWR, the steam is directed into the condensate chamber and condenses there. The chambers on a heat exchanger are connected to the intermediate cooling circuit.

1.7 Feed water pump

The water level in the steam generator and nuclear reactor is controlled using the feed water system. The feed water pump has the task of taking the water from the condensate system, increasing the pressure and forcing it into either the Steam Generators (Pressurized Water Reactor) or directly into the reactor vessel (Boiling Water Reactor).

1.8 Emergency power supply

The emergency power supplies of a nuclear power plant are built up by several layers of redundancy, such as diesel generators, gas turbine generators and battery buffers. The battery backup provides uninterrupted coupling of the diesel/gas turbine units to the power supply network. If necessary, the emergency power supply allows the safe shut down of the nuclear reactor. Less important auxiliary systems such as, for example, heat tracing of pipelines are not supplied by these backups. The majority of the required power is used to supply the feed pumps in order to cool the reactor and remove the decay heat after shut down.

1.9 Advantages

- Almost 0 emissions (very low greenhouse gas emissions).
- They can be sited almost anywhere unlike oil which is mostly imported.
- The plants almost never experience problems if not from human error, which almost never happens anyway because the plant only needs like 10 people to operate it.
- A small amount of matter creates a large amount of energy.
- A lot of energy is generated from a single power plant.
- Current nuclear waste in the US is over 90% Uranium. If reprocessing were made legal again in the US we would have enough nuclear material to last hundreds of years.
- A truckload of Uranium is equivalent in energy to 10,000+ truckloads of coal. (Assuming the Uranium is fully utilized.)
- A nuclear aircraft carrier can circle the globe continuously for 30 years on its original fuel while a diesel fueled carrier has a range of only about 3000 miles before having to refuel.
- Modern reactors have two to ten times more efficiency than the old generation reactors currently in use around the US.
- New reactor types have been designed to make it physically impossible to melt down. As the core gets hotter the reaction gets slower, hence a run-away reaction leading to a melt-down is not possible.
- Theoretical reactors (traveling wave) are proposed to completely eliminate any long-lived nuclear waste created from the process.

1.10 Disadvantages

- Nuclear plants are more expensive to build and maintain.
- Proliferation concerns - breeder reactors yield products that could potentially be stolen and turned into an atomic weapon.
- Waste products are dangerous and need to be carefully stored for long periods of time. The spent fuel is highly radioactive and has to be carefully stored for many years or decades after use. This adds to the costs. There is presently no adequate safe long-term storage for radioactive and chemical waste produced from early reactors, such as those in Hanford, Washington, some of which will need to be safely sealed and stored for thousands of years.
- Early nuclear research and experimentation has created massive contamination problems that are still uncontained. Recently, for instance, underground contamination emanating from the Hanford Nuclear Reservation in Washington State in the U.S. was discovered and threatens to contaminate the Columbia River (the largest river in North America west of the continental divide).
- Lot of waste from early reactors was stored in containers meant for only a few decades, but is well past expiration and, resultantly, leaks are furthering contamination.

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- Nuclear power plants can be dangerous to its surroundings and employees. It would cost a lot to clean in case of spillages.
- There exist safety concerns if the plant is not operated correctly or conditions arise that were unforeseen when the plant was developed, as happened at the Fukushima plant in Japan; the core melted down following an earthquake and tsunami the plant was not designed to handle despite the world's strongest earthquake codes.
- Many plants, including in the U.S., were designed with the assumption that "rare" events never actually occur, such as strong earthquakes on the east coast (the New Madrid quakes of the 1800s were much stronger than any east coast earthquake codes for nuclear reactors; a repeat of the New Madrid quakes would exceed the designed earthquake resiliency for nuclear reactors over a huge area due to how wide-spread rare but dangerous eastern North American earthquake effects spread), Atlantic tsunami (such as the 1755 Lisbon quake event, which sent significant tsunami that caused damage from Europe to the Caribbean) and strong hurricanes which could affect areas such as New York that are unaccustomed to them (rare, but possibly more likely with global warming)

1.11 Location of nuclear power plant in India

There are a total number of four nuclear power stations in India at present. These are:

(a) Tarapur nuclear power station at Tarapur in Maharashtra.
(b) Rajasthan nuclear power at Rana Partab Sagar near kota in Rajasthan.
(c) Madras nuclear power station at kalpakkam on Tamil nadu.
(d) Narora nuclear power station in Uttar Pradesh

2 SOLAR ENERGY

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar energy technologies include solar heating, solar photovoltaic's, solar thermal electricity and solar architecture, which can make considerable contributions to solving some of the most urgent problems the world now faces.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

TABLE 2(a)

Yearly Solar Fluxes and Human Energy Consumption

Solar	3,850,000 EJ
Wind	2,250 EJ
Biomass	3,000 EJ
Primary energy use (2005)	487 EJ
Electricity (2005)	56.7 EJ

2.1 SOLAR POWER

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect.

Fig.2.1 (a) SOLAR CONCENTRATOR

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2.2 SPACE BASED SOLAR POWER

Space-based solar power (SBSP) is the concept of collecting solar power in space for use on Earth. It has been in research since the early 1970s.
SBSP would differ from current solar collection methods in that the means used to collect energy would reside on an orbiting satellite instead of on Earth's surface. Some projected benefits of such a system are:

- Higher collection rate: In space, transmission of solar energy is unaffected by the filtering effects of atmospheric gases. Consequently, collection in orbit is approximately 144% of the maximum attainable on Earth's surface.
- Longer collection period: Orbiting satellites can be exposed to a consistently high degree of solar radiation, generally for 24 hours per day, whereas surface panels can collect for 12 hours per day at most.
- Elimination of weather concerns, since the collecting satellite would reside well outside of any atmospheric gasses, cloud cover, wind, and other weather events.
- Elimination of plant and wildlife interference.
- Redirect able power transmission: A collecting satellite could possibly direct power on demand to different surface locations based on geographical base load or peak load power needs.
- Besides the cost of implementing such a system, SBSP also introduces several new hurdles, primarily the problem of transmitting energy from orbit to Earth's surface for use. Since wires extending from Earth's surface to an orbiting satellite are neither practical nor feasible with current technology, SBSP designs generally include the use of some manner of wireless power transmission. The collecting satellite would convert solar energy into electrical energy on board, powering a microwave transmitter or laser emitter, and focus its beam toward a collector (retina) on the Earth's surface. Radiation and micrometeoroid damage could also become concerns for SBSP.

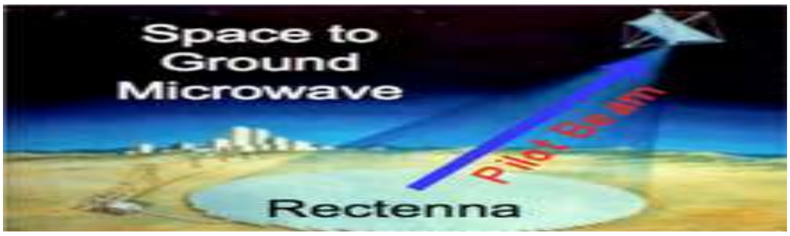

Fig.2.2 (a) A laser pilot beam guide the microwave power transmission to a retina.

3 FUEL CELL

The basic concept involved in any modern fuel cell for electric power generation is the electrochemical reaction between hydrogen and oxygen in the presence of catalysts, which produces electrical energy in the form of a DC current. The by-products are heat and water. Since hydrogen has one of the highest chemical reactivity's, it is commonly used as either pure hydrogen or hydrogen rich fuel in most modern fuel cells. The fuel is supplied on the anode side. The anode reaction in fuel cells is either direct oxidation of hydrogen or methanol or indirect oxidation via a reforming process for hydrocarbon fuels. The cathode reaction is oxygen reduction from air in most fuel cells. Since the electricity in a fuel cell is not produced through the use of thermal energy, fuel cell efficiency is not limited by the Carnot efficiency.

The basic components of a fuel cell are the electrodes (anode and cathode), the electrolyte and the catalyst. The anode consists of a porous gas diffusion layer as an electrode and an anodic catalyst layer. It conducts electrons generated at the catalyst/anode/electrolyte interface to the external electrical circuit, which eventually returns to the cathode An electrolyte is formed by an ionic bond, conducts protons or ions to the opposite electrode internally, thus completing the electric circuit. The electrolyte is considered the heart of the fuel cell. It consists of a solid membrane having a proton-conducting medium (e.g., moistened with water for PEMFC or DMFC), and a solid matrix with a liquid ion-conducting electrolyte (e.g., PAFC, MCFC), or a solid matrix having ion-conducting characteristics (e.g., SOFC). The cathode consists of a porous gas diffusion layer as an electrode and a cathode catalyst layer. It conducts electrons returning from the external electric circuit to the catholic catalyst layer. Catalysts speed up the reaction without actually participating in the reaction. The highest oxidation rates and hence current densities are found at sites having significant catalyst activity.

3.1 BRIEF THEORY AND OPERATION

For the hydrogen/oxygen (air) fuel cell, the overall reaction is: $H_2 + \frac{1}{2} O_2 = H_2O$. The product of this reaction is water released at the cathode or anode depending on the type of fuel cell. For PEM fuel cell, hydrogen is oxidized at the anode as given by the reaction, $H_2 = 2 H^+ + 2 e^-$. Electrons generated at the anode are flown through external load to the cathode. Protons (H^+) are migrated through the proton exchange membrane to the cathode. The protons and electrons reached at the cathode react with oxygen from air as given by the reaction, $2 H^+ + 2 e^- + \frac{1}{2} O_2 = H_2O$.

The reversible open circuit voltage E0 for hydrogen/oxygen fuel cells at standard conditions of 25°C and 1 BAR pressure is 1.23 V. This voltage level is too low to be useful. Most of electronic products require a power source with much higher voltage. Many cells are connected in series called a cell stack to produce useful voltages (which is the sum of individual cell voltages).The cell current depends on the area (the size) of a cell. In general, the larger the cell area, higher will be current generated. Hence, the cell current is usually presented in terms of the current density, mA/cm2 or A/cm2. Cells are connected by the bipolar plates or interconnect. They serve as the current pathway from cell to cell in a stack. Besides collecting current, bipolar plates also have gas flow channels on each side through which the gases [fuel (hydrogen) and oxidant (air)] evenly distribute through the entire cell. Bipolar plates may have cooling channels depending on the stack-cooling requirement. The reversible open circuit voltage E for given operating conditions depends on the operating temperature T, partial pressures (P with appropriate subscripts) of the reactants and products in the fuel cell, and the number of electrons generated for each molecule of the fuel, and are given by the Nernst equation. Actual voltages generated in a fuel cell are always less than the Nernstian voltage due to various losses associated with a fuel cell and the fuel cell system. These voltage losses for a fuel cell are due to activation over potential, ohmic over potential and concentration over potential. Activation over potential is the voltage loss to overcome the electrochemical barrier of the electrochemical reaction occurring in the fuel cell. Ohmic over potential loss is the voltage loss due to internal electrical resistance of the cell. Concentration over potential is the voltage loss attributes to the depletion of reacting species on the electrode.

3.2 MERITS

- The unit is lighter and smaller and requires little maintenance because of absence of mechanical parts
- They cause little pollution and little noise.
- No overhead line is required.
- Fuel can be used more effectively than in a central power plant.
- They can become remarkable home units.
- High efficiency of about 50% compared to 30% of conventional power systems.
- Fast startup and fast load response.
- A fuel cell gives a few times more electrical energy per unit weight as compared to a turbo generator or a storage battery.
- A variety of fuels such as methane, ethane, ethylene, acetylene, propane, butane, benzene, methanol, ammonia, hydrazine, LPG, biogas or coal gas can be used.

4 WIND ENERGY

Windmills have been used for centuries to grind grain and pump water in rural areas. Winds are caused by rotation of the earth and heating of the atmosphere by the sun, and have global patterns of a semi-continuous nature. It is affected by by topography, and weather, with seasonal, daily and hourly variations. The total annual kinetic energy of air movement in the atmosphere is estimated to be about 3 x 1015 kWh or about 0.2% of the solar energy reaching the earth. The maximum technically usable potential is theoretically estimated to be 30 trillion kWh per year, or about 35% of current world total energy consumption. The power in the wind blowing at 25.6 km/h is about 200 W/m2 of the area swept by the windmill. Approximately 35% of this power can be captured by the windmill and converted to electricity. However, it is important to note that the power output from the windmill varies with the cube of the wind speed. Consequently, only windy locations on mountains and coasts are suitable for the economic Generation of electricity by wind power. Harnessing of wind energy could play a significant role in the energy mix of a region. Wind energy is renewable source of energy. It has the advantage of being harnessed locally for applications in rural and remote areas. Pumping of water for agriculture and plantations is probably the most important application that contributes to rural development through multiple cropping. Wind driven electric generators could be utilized as an independent power source, and for purposes of augmenting the electricity supply from grids.

Fig.3 (a) wind mill

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5 Biomass

Biomass refers to solid carbonaceous material derived from plants and animals. These include the residues of agriculture and forestry, animal wastes and wastes from food processing operations. A small amount of solar energy is used by plants in the process of photosynthesis and this trapped energy can be used in various ways. Wood and grass can be dried and then burnt to release heat. Plant material, particularly those rich in starches and sugars such as sugar-cane, wheat, and etc. is fermented to produce ethanol. Alternately, methanol can be produced by the distillation of biomass which contains considerable amount of cellulose such as wood and biogases (residue from sugar-cane). Both these alcohols can be used to fuel vehicles and machinery, and can be mixed with petrol to make a petrol / alcohol blend. Although biomass energy is predominantly used in rural areas, it provides an important fuel source for the urban poor and many rural small and medium scale industries. In order to meet the growing demand for energy, it is imperative to focus on efficient production and use of biomass energy to meet both traditional (as a heat supplier) and modern fuel requirements (like electricity and liquid fuels). This production of biomass, in all its forms for fuel, food and fodder, demands environmentally sustainable Land use and integrated planning approaches.

Detailed planning would be required from National to State, District, and Taluk and Village levels. The inappropriate selection and site matching of species or management strategies can have adverse effects and lead to degradation and abandonment of land. However, the correct selection of plant species can allow the economic production of energy crops in areas. Such selection strategy allows synergistic increases in food crop yield and decreases fertilizer applications, while providing local source of energy and employment.

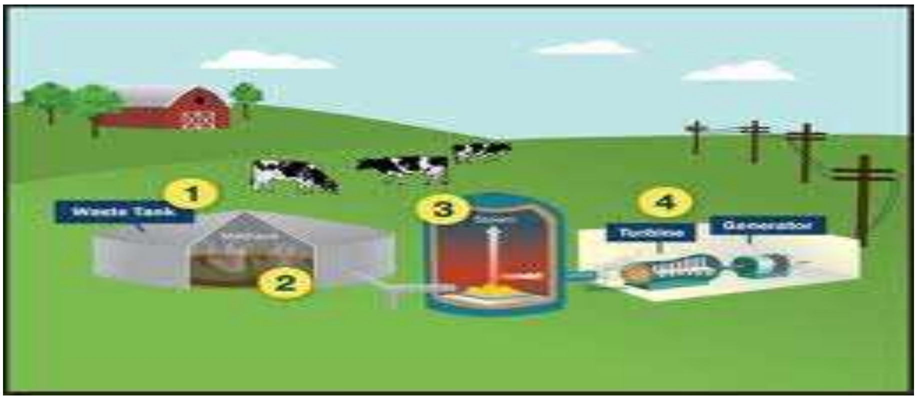

Fig.4 (a) biomass plant

6 Peltier Plate

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice-versa. A thermoelectric device creates a voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side.

This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices are efficient temperature controllers.

The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect and Thomson effect. Textbooks may refer to it as the Peltier–Seebeck effect. This separation derives from the independent discoveries of French physicist Jean Charles Athanase Peltier and Estonian-German physicist Thomas Johann Seebeck. Joule heating, the heat that is generated whenever a voltage is applied across a resistive material, is related though it is not generally termed a thermoelectric effect.

Fig.5 (a) Peltier Plate

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7 Piezoelectric material

Piezoelectricity is the charge that accumulates in certain solid materials (notably crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. It is derived from the Greek piezo or piezei, which means to squeeze or press, and electric or electron, which stands for amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie.The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in that materials exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force) also exhibit the reverse piezoelectric effect (the internal generation of a mechanical strain resulting from an applied electrical field). For example, lead zirconate titanate crystals will generate measurable piezoelectricity when their static structure is deformed by about 0.1% of the original dimension. Conversely, those same crystals will change about 0.1% of their static dimension when an external electric field is applied to the material. The inverse piezoelectric effect is used in production of ultrasonic sound waves.

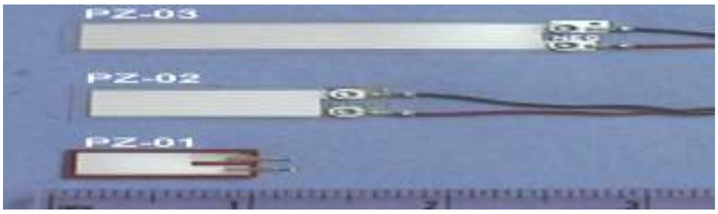

Fig.7 (a) piezoelectric plate

Conclusion

To make sure we have plenty of energy in the future, it's up to all of us to use energy wisely. We must all conserve energy and use it efficiently. It's also up to those who will create the new energy technologies of the future. All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as solar, wind, geothermal, wave power and hydrogen. But we'll need to continue to use fossil fuels and nuclear energy until new, cleaner technologies can replace them. One of you who is reading this might be another Albert Einstein or Marie Curie and find a new source of energy. Until then, it's up to all of us. The future is ours, but we need energy to get there.

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