

# POWER GENERATION METHODS, TECHNIQUES AND ECONOMICAL STRATEGY

*Engr. Mansoor-ul-Hassan*  
Suadi Arabia-Pakistan

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## Abstract

The world is facing problems of power Generation shortage, operational cost and high demand in these days. The main aim of this article is to know power generation methods, techniques and economical strategy which methods are suitable for individual country on the base its own natural resources, technical expertise and economy. This article is providing and guiding a best opportunity to select the right method and technique for right and economical power generation after study power generation, methods, Techniques and economical strategy. Many countries are producing the power against its opportunities and wrong methods. Every country can produce the power depend upon its own local opportunities and resources under the guidelines of this article and its recommendations.

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**Keywords:** Guidelines & power generation

## Introduction

The power generation and energy is back bone of every country to survive in this world. **Electricity generation** is the process of generating electrical power from other sources of primary energy. The fundamental principles of electricity generation were discovered during the 1820s and early 1830s by the British scientist Michael Faraday. His basic method is still used today: electricity is generated by the movement of a loop of wire, or disc of copper between the poles of a magnet. Mankind has been generating electricity on an industrial scale since 1881. The first power plants used hydroelectric power and coal power.

**NOTE: ALTERNATOR MEANS GENERATOR'S ROTOR DRIVE & MOVE: - BY**  
(I.E. ENGINE, HYDRO, STEAM, WIND & GAS TURBINE, ETC)

An **alternator** is an electromechanical device that converts mechanical energy to electrical energy in the form of alternating current. Most alternators use a rotating magnetic field with a stationary armature but occasionally, a rotating armature is used with a stationary magnetic field; or

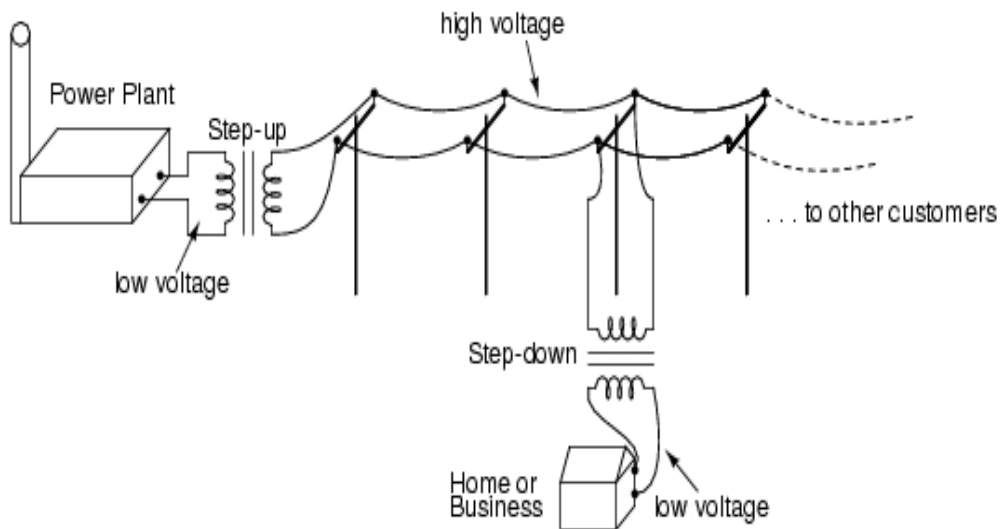
a linear alternator is used. The main aim is to move and drive the rotor by any method and techniques to produce power.

Alternators generate electricity using the same principle as DC generators, namely, when the magnetic field around a conductor changes, a current is induced in the conductor. Typically, a rotating magnet, called the rotor turns within a stationary set of conductors wound in coils on an iron core, called the stator. The field cuts across the conductors, generating an induced EMF (electromotive force), as the mechanical input causes the rotor to turn. The rotating magnetic field induces an AC voltage in the stator windings. Often there are three sets of stator windings, physically offset so that the rotating magnetic field produces a three phase current, displaced by one-third of a period with respect to each other.



Poles	RPM for 50 Hz	RPM for 60 Hz	RPM for 400 Hz
2	3,000	3,600	24,000
4	1,500	1,800	12,000
6	1,000	1,200	8,000
8	750	900	6,000
10	600	720	4,800
12	500	600	4,000
14	428.6	514.3	3,429
16	375	450	3,000
18	333.3	400	2,667
20	300	360	2,400
40	150	180	1,200





### **FUEL AND INPUT FOR POWER GENERATION**

Petrol, Diesel, HFO, Uranium, Coal, Air, Earth Heat, Sea Water Waves, Water, Solar & Sunlight, Natural Gas, Biogas etc.

### **KEY POINT TO SELECT A RIGHT METHOD OF POWER GENERATION.**

You have to select that method of power generation, when fuel and input will be local and not imported. That method will be cheap and excellence but based on your requirement of power and quality of power for industrial and domestic utilization. Solar power and wind power is not suitable for heavy load equipment and machinery. All methods have their own characteristics', quality, and quantity, merits & Demerits, fuel reliability & continuous availability, economical and utilization. The coal method is used maximum in the world for producing electricity in this time.

### **MOST IMPORT AND RELIABLY METHODS**

These are very important, quality, high quantity, economical, industrial power insensitivity for heavy load and suitable methods of power generation i.e. Hydro-power, Coal Power, Nuclear, Thermal Power which are depend upon of the characteristic , economy and natural resources of every country. Hydro- and Coal power is very suitable, reliable and economical for Pakistan, China, India etc but worse for Saudi Arabia and Middle East etc. Whenever thermal power method is very economical, suitable and reliable for Saudi Arabia, Iran and Middle East etc but worse for Pakistan, India, and China etc.

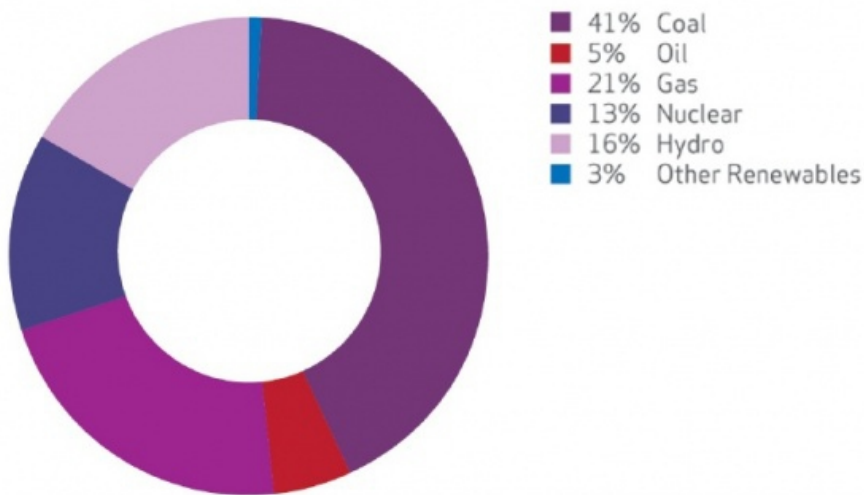
## **WORLD POWER GENERATION MACHINERY AND EQUIPMENT**

**BRAND:** FG Wilson, AKSA- Turkey, Listterpetter-uk, Cummins-UK, VISA-Italy, Ottomotor- Mexico, GE-USA, GE-Jenbacher-Gas –Austria, Siemens- Germany, Caterpillar, Waukesha, Wartsila, Weichai & Sida, Dongfong-China. Mitsubishi-Japan, Jinko Solar, Hitachi, Toshiba, Man & Duetz-Germany, Toshiba-Japan etc.

**I.C.Engine:-** Weichai, Cummins, John Deere, Perkins, Volvo, Listerpitter, Chinese, Yuchai & Sida , MAN, Duetz etc,

**Alternator** :- Stamford, Leroy Somer, MECC, Sincro etc.

**Factors Consider:** - Economically, Quantity & quality, fuel-365, application, Capital investment etc.

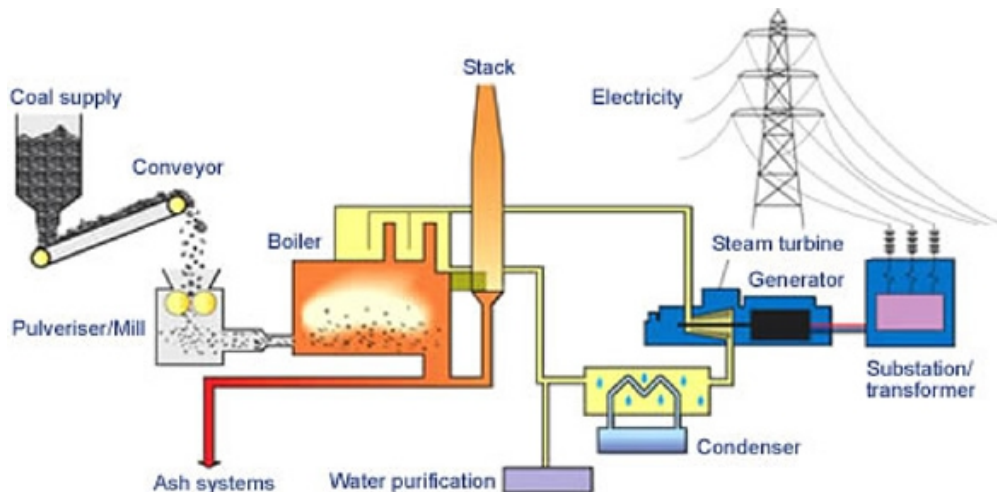


## **POPULAR WORLD POWER GENERATION FUEL & METHODS** **METHODS AND TECHNIQUES OF POWER GENERATION**

There are different methods and techniques to generate the power and Electricity in the world with help of machinery and equipment as below.

### **1. COAL POWER GENERATION**

Steam coal, also known as thermal coal, is used in power stations to generate electricity. Coal is first milled to a fine powder, which increases the surface area and allows it to burn more quickly. In these pulverized coal combustion (PCC) systems, the powdered coal is blown into the combustion chamber of a boiler where it is burnt at high temperature (see diagram below). The hot gases and heat energy produced converts water – in tubes lining the boiler – into steam.

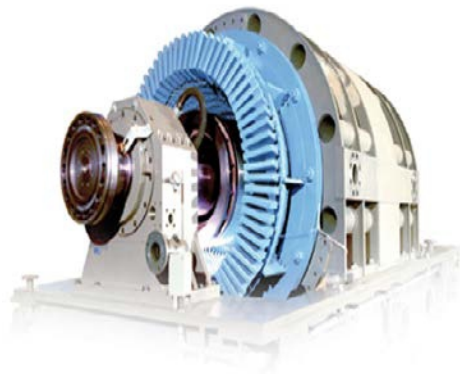


Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently fuel 41% of global electricity. In some countries, coal fuels a higher percentage of electricity.

Coal in Electricity Generation		
South Africa 93%	Poland 87%	PR China 79%
Australia 78%	Kazakhstan 75%	India 68%
Israel 58%	Czech Rep 51%	Morocco 51%
Greece 54%	USA 45%	Germany 41%

## 2. THERMAL POWER GENERATIONS

Small electricity generators are often powered by reciprocating engines burning diesel, biogas or natural gas. Diesel engines are often used for back up generation, usually at low voltages. However most large power grids also use diesel generators, originally provided as emergency back up for a specific facility such as a hospital, to feed power into the grid during certain circumstances. Biogas is often combusted where it is produced, such as a landfill or wastewater treatment plant, with a reciprocating engine or a micro turbine, which is a GE-Gas turbine and CAT –IE- Engine as below.



### 3. NUCLEAR POWER GENERATION

A nuclear reactor produces and controls the release of energy from splitting the atoms of uranium. Uranium-fuelled nuclear power is a clean and efficient way of boiling water to make steam which drives turbine generators. Except for the reactor itself, a nuclear power station works like most coal or gas-fired power stations.

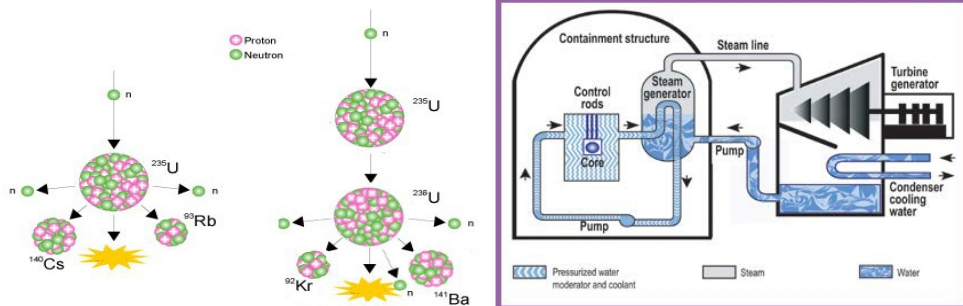


Diagram of Pressurized Water Reactor

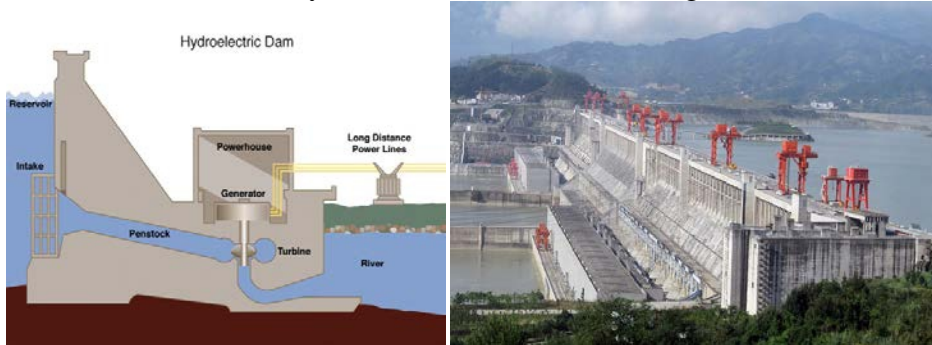
#### **PWRs and BWRs**

The main design is the pressurized water reactor (PWR) which has water in its primary cooling/heat transfer circuit, and generates steam in a secondary circuit. The less popular boiling water reactor (BWR) makes steam in the primary circuit above the reactor core, though it is still under considerable pressure. Both types use water as both coolant and moderator, to slow neutrons.



#### **4. HYDRO-POWER GENERATION**

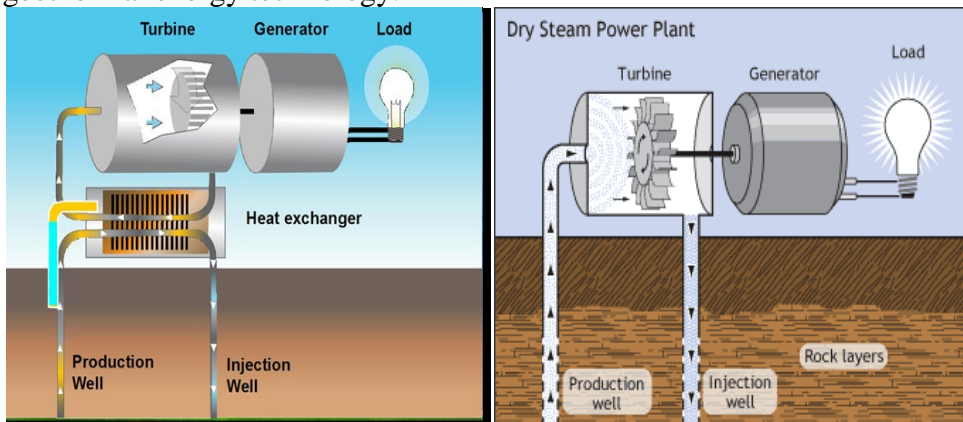
Hydro power is generated by using electricity generators to extract energy from moving water. Historically people used the power of rivers for agriculture and wheat grinding. Today, rivers and streams are re-directed through hydro generators to produce energy, although there are pros and cons as far as local ecosystems are concerned and diagram as below.



The Three Gorges Dam is a hydroelectric dam that spans the Yangtze River by the town of Sandouping, located in Yiling District, Yichang, Hubeiprovince, China. The Three Gorges Dam is the world's largest power station in terms of installed capacity (22,500 MW). In 2012, the amount of electricity the dam generated was similar to the amount generated by the Itaipu Dam.

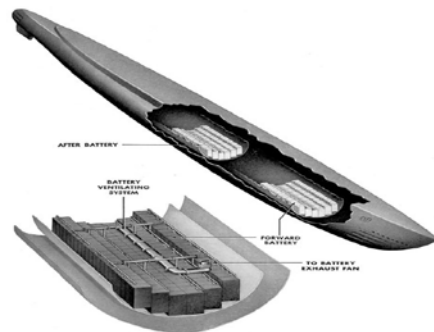
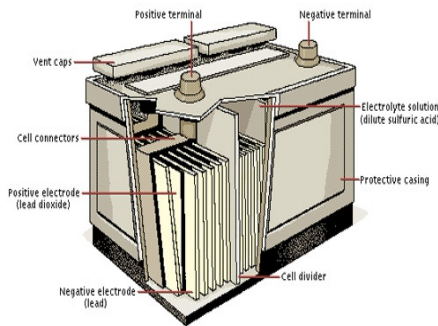
#### **5. GEOTHERMAL POWER GENERATION**

Geothermal energy is created by harnessing geothermal energy from the earth. Contrary to popular belief geothermal energy is not technically a renewable energy source. There is widespread debate as to its effectiveness for electricity generation or heating. The articles on this page explore geothermal energy technology.



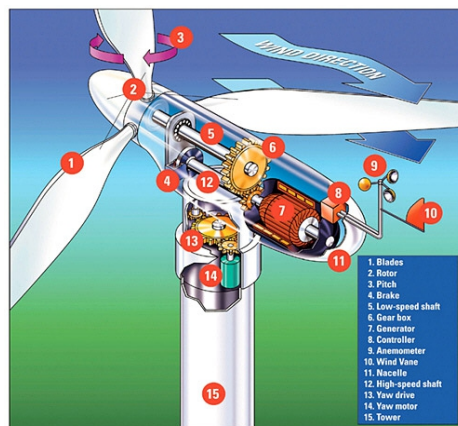
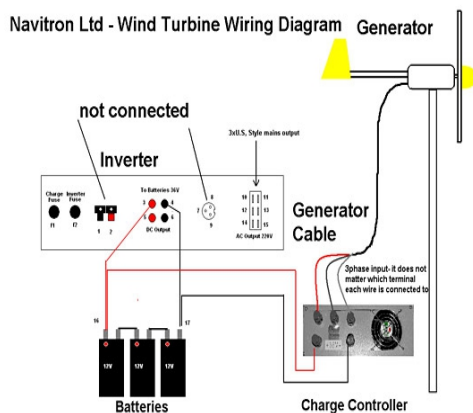
## 6. **BATTERY POWER GENERATION**

Batteries store electricity in a chemical form, inside a closed-energy system. They can be re-charged and re-used as a power source in small appliances, machinery and remote locations. Advances in battery technology may one day help to solve our energy crisis. The submarine and car are using battery power for operational this type. A submarine consists and use 24 cell for their operation in the sea and these cell are chargeable through diesel generator.



## 7. **WIND POWER GENERATION**

Wind power is produced by using wind generators to harness the kinetic energy of wind. It is gaining worldwide popularity as a large scale energy source, although it still only provides less than one percent of global energy consumption.





Wind turbines are used to generate electricity from the kinetic power of the wind. Historically they were more frequently used as a mechanical device to turn machinery. There are two main kinds of wind generators, those with a vertical axis, and those with a horizontal axis. Wind turbines can be used to generate large amounts of electricity in wind farms both onshore and offshore. The articles on this page are about wind turbines.

## **8. WAVES POWER GENERATION**

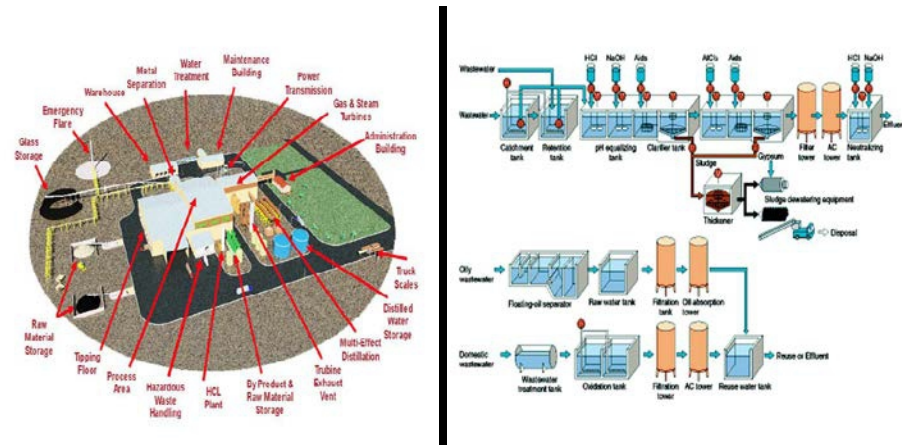
Wave energy is produced when electricity generators are placed on the surface of the ocean. The energy provided is most often used in desalination plants, power plants and water pumps. Energy output is determined by wave height, wave speed, wavelength, and water density. To date there are only a handful of experimental wave generator plants in operation around the world. The articles on this page explore the world of wave energy and its possible applications.

Wave power is the transport of energy by ocean surface waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). Machinery able to exploit wave power is generally known as a wave energy converter (WEC).



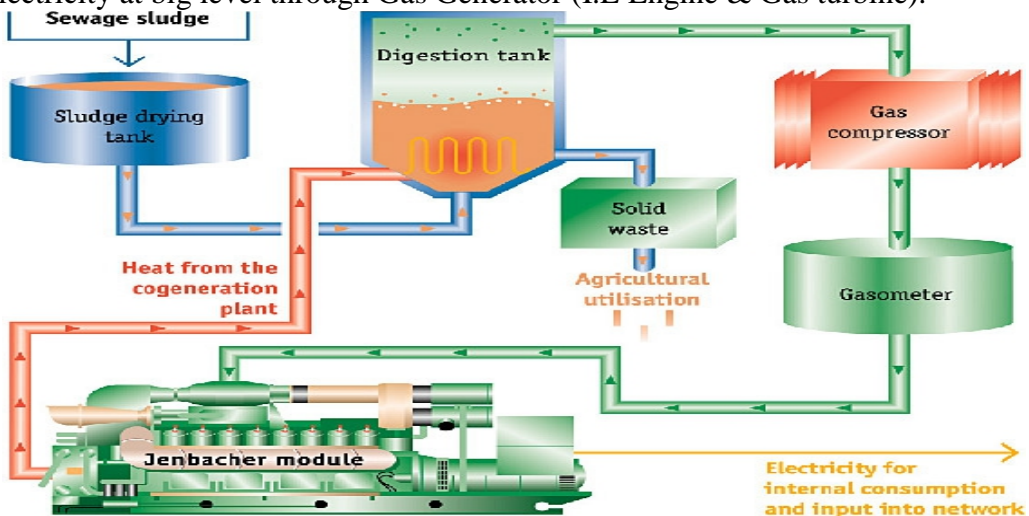
## **9. WASTE WATER & BIO-GAS POWER**

The consumption habits of modern consumer lifestyles are causing a huge worldwide waste problem. Having overfilled local landfill capacities, many first world nations are now exporting their refuse to third world countries. This is having a devastating impact on ecosystems and cultures throughout the world. Some alternative energy companies are developing new ways to recycle waste by generating electricity from landfill waste and pollution.



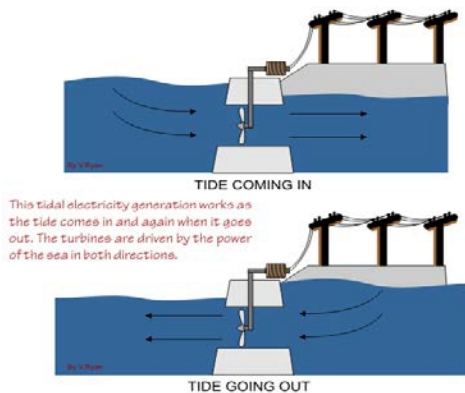
**Note:- Wastage Water Hydro-Dam** can be make in the metropolitan and big city .We can study the total wastage water of big city per day and design the continuous wastage water available Hydro-Dam.

The Bio Gas of city wastage can also be used to produce the electricity at big level through Gas Generator (I.E Engine & Gas turbine).



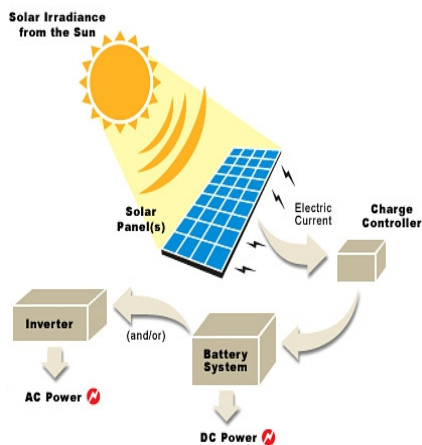
## 10. TIDAL POWER GENERATION

Tidal energy is produced through the use of tidal energy generators. These large underwater turbines are placed in areas with high tidal movements, and are designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity. Tidal power has great potential for future power and electricity generation because of the massive size of the oceans.



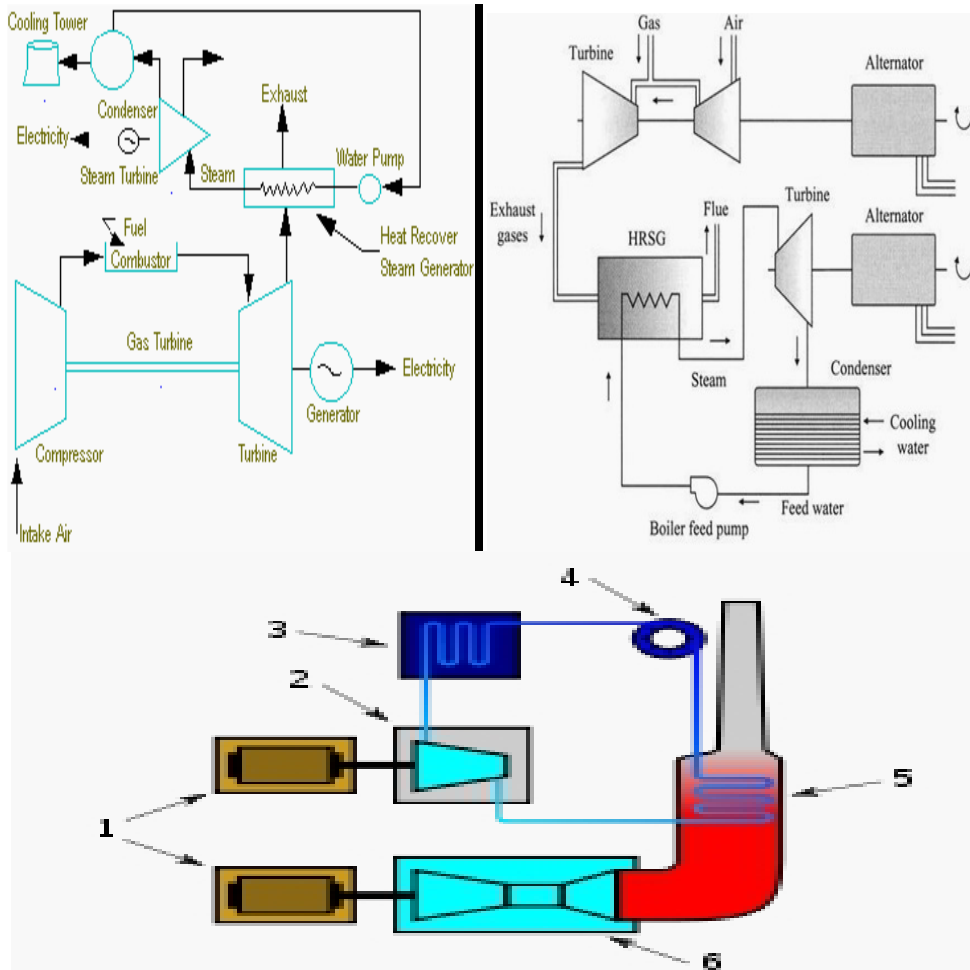
## 11. SOLAR POWER GENERATION

Solar power is produced by collecting sunlight and converting it into electricity. This is done by using solar panels, which are large flat panels made up of many individual solar cells. It is most often used in remote locations, although it is becoming more popular in urban areas as well.



## 12. COMBINE CYCLE POWER PLANT & GENERATION

In electric power generation a **combined cycle** is an assembly of heat engines that work in tandem from the same source of heat, converting it into mechanical energy, which in turn usually drives electrical generators. The principle is that the working fluid of the first heat engine is; after completing its cycle (in the first engine), still low enough in its Entropy, that a second; subsequent, heat engine may extract energy from the waste heat (energy) of the working fluid of the first engine.



**Working principle of a combined cycle power plant (Legend: 1-Electric generators, 2-Steam turbine, 3-Condenser, 4-Pump, 5-Boiler/heat exchanger, 6-Gas turbine)**

A gas turbine compresses air and mixes it with fuel. The fuel is burned and the resultant hot air-fuel mixture is expanded through turbine blades, making them spin about a shaft. The spinning turbine drives a generator that converts the spinning energy into electricity.

- Fuel is burned in a combustor
- The resulting energy in the gas turbine turns the generator drive shaft
- Exhaust heat from the gas turbine is sent to a heat recovery steam generator (HRSG)
- The HRSG creates steam using the gas turbine exhaust heat and delivers it to the steam turbine
- The steam turbine delivers additional energy to the generator drive shaft
- The generator converts the energy into electricity.

### **Economics of Power Generation and Production Of Electricity.**

The world energy economy has the largest influence on the decisions that people and governments make. Current global consumption rates are depleting the planets ability to sustain our way of life. Increased demand means increased prices in every sector of the world economy. The selection of electricity production modes and their economic viability varies in accordance with demand and region. Hydroelectric plants, nuclear power plants, thermal power plants and renewable sources have their own pros and cons, and selection is based upon the local power requirement and the fluctuations in demand.

Nuclear, coal, oil and gas plants can supply base load, with the low-carbon option being nuclear. Thermal energy is economical in areas of high industrial density, as the high demand cannot be met by renewable sources. Nuclear power plants can produce a huge amount of power from a single unit. However, recent disasters in Japan have raised concerns over the safety of nuclear power, and the capital cost of nuclear plants is very high. Hydroelectric power plants are located in areas where the potential energy from flowing water can be harnessed for moving turbines and the generation of power.

It is not an economically viable source of production where the load varies too much during the annual production cycle and the ability to stop the flow of water is limited. Renewable sources other than hydroelectricity (solar power, wind energy, tidal power, etc.) due to advancements in technology, and with mass production, their cost of production has come down and the energy is now in many cases cost-comparative with fossil fuels. There are some very important example and point to study for producing the cheap and high torque bearable electricity for industrial and general consumption in a country.

The cost, quality and capacity of electricity depend upon the country and its nature resource along with economy. The power generation methods should be adopted and selected on the base of free nature fuel, 365 days per year's available, quality and quantity of requirement, characteristics, country economy, Environmental impact, reliability, capital and operational cost etc.

### **Conclusion & Recommendations:**

The quality and usage of solar power, Waves power and battery power is not suitable for industrial and hard load as compare to Hydro, Nuclear, and Thermal electricity etc.

1. The thermal power is produced very expensive electricity in Pakistan but very cheap in Saudi Arabia and middle east.

2. The hydro-electricity will be very expensive in Saudi Arabia and Middle East but very cheap in Pakistan, India, China, Bangladesh etc. The water is not available whole years and face shortage in winter. China have world largest Hydro-Dam Three Gorges which can produce 22,500 MW power.
3. Pakistan has only one cheap and best method of electricity which is hydro-power. Pakistan can product thousand MW from the river and canal systems. The Hydro- power plant 22 MW is best example of HEAD RASOOL hydro-power in 1946.
4. The very method of electricity production has their own cost, quality; production capacity, equipment and machinery depend upon the every country economy and its natural resources which play a vital role for selection of feasible and suitable method in term of cost, capacity and quality of electricity.
5. The coal & HFO power generation is also very important and cheap method as compare to others method but if a country has good quantity and quality as input.
6. The machinery and equipment is also very important to produce cheap and electricity and its application.
7. All method should be adopt according to depend upon the application and area of country for taking best solution method.
8. Coal and thermal power generation method should be adopted and selected when country have it local available fuels. Otherwise it will be very expensive and failure of economy likes Pakistan energy crises. A doctor mistake kills a single person but an engineer mistake kill whole nation.
9. Pakistan should be adopted and selected only Hydro on river and canal, Gas-Turbine, Nuclear, Coal, solar and wind power on specific area for specific purpose. These are suitable and best economical method except thermal oil based. This is greatest blunder of Pakistan who gave the preference to thermal power as compare to others most economical methods. Saudi Arabia and Middle East made the Hydro Dam and take the water from others to fill the dam. What will be capital and operational cost? Who will be taken this decision but only a mad and mental leaders can do this?
10. The Hydro-Power method should be adopted those country which have river and canal systems. Pakistan should be designed the Hydro dam on river and canal which is best example of Head Rasool on Jehlum-link canal in 1946 and still working Two turbine 11MW each black smith –UK and prepared facility for third turbine but Pakistan became into. The Hindu narrow minded thinking did not send into



Pakistan from Delhi-India. Pakistan did not improve and enhance this project still. This is a level of Pakistan leaders planning and vision.

11. Nuclear method should have uranium as local material because it is very expensive material as compare to others. The water should be also required in good quality and quantity. They should have local capability to enrichment and prepare as raw material. Every country cannot afford and produce the nuclear power due to its Technical ability and resources.
12. Solar and Wind power method is applicable in the heavy sunlight and coastal sea area in small level production for light load. This is very expensive, complex and sensitive technology for small level. This should be adopted only for specific purpose and base feasibility in desert and sea. The huge area and continues sunlight required for solar power project for light load. These methods can produce few MW power with high capital cost as compare to others mechanical methods. The sunlight will be remained up to end of this world but free fuel for producing power through solar methods. Others all fuel can be disturb and shortage time to time but this will be available for every. This is very suitable for those countries which have maximum light per years and intensity of sunlight. Middle East Asia and Arab world are the best example and suitable for solar power production. The main factors and parameter is to select that area which feasibly for this purpose and requirement of solar power feasibility. The solar power is only one method which have fuel of sunlight forever as compare to all others methods and its fuel. It is also used in satellites where no others power available.
13. Waves and tidal power methods are also depend upon the main sources of life which is water. We can also produce the wave's power; if any country have the sea but rough sea is most suitable for this purpose. There is Death Sea which belongs to some country like Saudi Arabia, turkey; Russian etc. this method is depend upon underwater resource and good sea water waves.
14. Geothermal power generation method is used in very small level and available in very few countries. It is not use on commercial level properly and suitable for specific purpose.
15. The battery power method is used to produce DC and AC power for domestic and commercial application. This method is used for stand by and direct commercial application in Submarine, UPS, Telecommunication site and mobile. This power is used in small and specific purpose according to proper feasibility.
16. Waste water and Biogas is also very essential and excellent method to best utilization of your wastage and sewerage water. Sewage water

is used for filling the hydro-power generation dam in every metropolitan city. Hydro-Sewerage Water Dam is best concept and utilization for production of power in all big cities.

Biogas can be produced from wastage of all garbage of all cities and use to product the power through IC. Engine and Gas generators. It is also good process and procedure to adjust the wastage garbage of all cities. It is very simple and good method to produce power and easily available in world. Sugar industries already used this technology in Pakistan (Shakirghunj Sugar mill in Pakistan).

17. In physics, the **law of conservation of energy** states that the total energy of an isolated system cannot change—it is said to be *conserved* over time. Energy can be neither created nor destroyed, but can change form, for instance chemical energy can be converted to kinetic energy in the explosion of a stick of dynamite. The combine cycle power generation method is best technology and utilization of fuel in power sector. We are producing the power after utilization of fuel and the waste exhaust heat recycle into systems and turbine. The wastage of exhaust heat can be used for heating and cooling through chiller, boiler and many industrial process and operations. Still we are not using the exhaust heat of power plant for many fruitful purposes but through it into air. We can use all energy form and convert into another form for useful purpose.
18. All power generation fuel can be disturbed, finished and shortage except sunlight for solar power. The sunlight fuel is only available and reliable fuel forever in power generation till end of this world.
19. Coal power generation is mostly used to produce and popular power generation method in the world which is 41% out of 100%. It is most economical and available fuel 365 days.
20. The Coal, Hydro, Nuclear, Oil and Natural Gas power generations methods are producing 96% of world power and 4 % only through renewable energy methods. These five power Generation methods are using mechanical technique, equipment and machinery.
21. Only mechanical equipment and machinery can produce huge power as compare to others all methods. There is no replacement of internal Combustion engine (I.C Engine) and External combustion Engine (E.C Engine) in power generation sector and only can get maximum power from it.
22. Pakistan has no place in top twenty world largest power producing facilities whenever can do it every easily.
23. Flood water storage dam can also produce and store water in flood time and can also use whole years. Fire, Water and Air is huge a

power in this world and can be used it positive and negative according to Holy Quran 1400 years ago.

24. Pakistan, Bangladesh and India can produce million MW very cheap powers through river and best canal systems through running and storage water.
25. Every country should be adopted and selected a power generation method on base of only technical ground as compare to political decision making. An Engineers Team can make every impossible thing in this world after providing the right things on the base my article "Key of Success (15-Rights).

### **TOP 20 WORLD LARGEST POWER PRODUCING FACILITIES.**

Rank	Station	Country	Location	Capacity (MW)	Annual generation (TWh)	Type
1	Three Gorges	 China	 30°49'15"N 111°00'08"E	22,500	98.1	Hydro
2	Itaipu	 Brazil  Paraguay	 25°24'31"S 54°35'21"W	14,000	98.6 (2013)	Hydro
3	Guri	 Venezuela	 07°45'59"N 62°59'57"W	10,235		Hydro
4	Tucuruí	 Brazil	 03°49'53"S 49°38'36"W	8,370		Hydro
5	Kashiwazaki-Kariwa	 Japan	 37°25'45"N 138°35'43"E	8,212 <sup>[note 1]</sup>	24.63	Nuclear
6	Xiluodu	 China	 28°15'52"N 103°38'47"E	7,700		Hydro
7	Grand Coulee	 United States	 47°57'23"N 118°58'56"W	6,809	24.5	Hydro
8	Longtan	 China	 25°01'38"N 107°00'	6,426	18.7	Hydro

Rank	Station	Country	Location	Capacity (MW)	Annual generation (TWh)	Type
			2°51"E			
9	Sayano-Shushenskaya	 Russia	 54°49'33"N 91°22'13"E	6,400 <sup>[note 2]</sup>	23.5	Hydro
10	Al-Qurayyah	 Saudi Arabia	 25°51'36"N 50°07'06"E	6,273		Oil
11	Bruce	 Canada	 44°19'31"N 81°35'58"W	6,272	36.25	Nuclear
12	Uljin	 South Korea	 37°05'34"N 129°23'01"E	6,157	44.81	Nuclear
13	Hanbit	 South Korea	 35°24'54"N 126°25'26"E	6,139	48.16	Nuclear
14	Krasnoyarsk	 Russia	 55°56'05"N 92°17'40"E	6,000	18.4	Hydro
15		 South Korea	 35°24'54"N 126°25'26"E	5,875		Nuclear
16	Hanul (Uljin)	 South Korea	 <u>37°5'34"N 129°23'1"E</u>	5,873		Nuclear
17	Zaporizhzhia	 Ukraine	 47°30'44"N 34°35'09"E	5,700		Nuclear
18	Shoaiba	 Saudi Arabia	 20°40'48"N 139°31'24"E	5,600		Oil
19	Surgut-2	 Russia	 61°16'46"N 73°30'45"E	5,597.1		Natural Gas
20	Taichung	 Taiwan	 24°12'46"N 120°28'52"E	5,500		Coal

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