

Power Resources

Power Resources: are all natural resources capable of generating energy/power. 2 Types:

Renewable Power Resources: are those which be naturally used/regenerated. They can replenish once they are used up. It is cheap, environmentally friendly, readily available, limitless & can be easily used in remote areas. Low running cost, but high initial installation cost. However, the locations are limited, lack of investment & technical experts. Other than HEP, is incapable of producing large amounts of electricity.

Continuous Renewable: are resources that are limitless in supply.

E.g. Wind Power, Solar Power, Geothermal Energy, Tidal Power

Sustainable Renewable: these are the resources which can be regenerated/reproduced at a fixed rate. If your consumption is at a faster rate than they can be reproduced, these resources can finish, but are re-generatable.

E.g. HEP, Biomass, Biogas

Non-Renewable Power Resources: are those which can't be regenerated/reproduced if they run out. Their quantities are limited & fixed in the environment. Once exhausted, they can't be or take billions of years to be reproduced/replenished. It is however cheaper to establish, with a high running cost. It can increase import bill & power production by nuclear is dangerous. It polluted the environment.

E.g. Coal, Oil, Gas, Nuclear Energy

Fossil Fuels: are hydrocarbons formed from the decomposition of organic matter such as remains of plants, animals or marine creatures, mostly formed underneath the earth's surface under high temperature & pressure resulting in coal, oil, gas (non-renewable resources).

Coal: is a very old fossil fuel formed millions of years by the decomposition of natural vegetation comprising mainly carbon. It is hard & porous rock, dark-grey in color comprising mainly of carbons. 4 types of Coal:

Types of Coal	Carbon Content	Hardness	Heat Capacity	Ash	Moisture	Sulphur Content	Volatile
Anthracite	Very High	Very High	Very High	None	None	None	None
Bituminous	High	High	High	Very Low	Very Low	Very Low	None
Lignite	Low	Low	Low	High	High	High	Very High
Peat	Very Low	Very Low	Very Low	Very High	Very High	Very High	None

Coal Mining Methods:

Open-Cast Mining: Some minerals like coal & iron often lie near the surface.

Underground Mining:

1. Adit Mining: Horizontal digging done in hilly districts. They are dug into the side of a valley or hill to reach for minerals as in Sor coalfield near Quetta.
2. Shaft Mining: Vertical shafts are dig. The problems faced can be dangerous gases that may also be present underground, with the risk of poisoning and explosions, causing the tunnel roofs to collapse. Another hazard is flooding.

Economic Importance of Coal:

- Employment: mining & transportation.
- Raw Material: cement industries & steel mills. Good quality can be exported.
- Source of Power: thermal power plants, brick kilns & ceramic industries.
- Domestic Fuel: domestic heating & cooking purposes.
- Source of Energy: it is a local, indigenous resource found in all 4 provinces which is cheaper than oil. There are large deposits of lignite coal in Pakistan which can reduce import bills. Coal mining provides employment.

Coal Processing & Transport:

1. After mining, coal is brought to the surface by either trollies, animal draft power or human force.
2. On the surface coal is separated on the basis of its quality (pure & impure).
3. After segregation, sold to the middlemen by the mine owner. Middlemen transports the coal to areas of consumption, small areas by trucks & donkeys, large by railway.

Coal distribution:

Provinces	Balochistan	Sindh	Punjab	KPK
Coal Field	Quetta Coal Field	Lower Sindh Coal Field	Salt Range Coal Field	Makarwal Coal Field
Mining Sites	Sor, Degari, Hernai	Lakhra, Sondha, Thar,	Dandot Pidh	Makarwal
Quality/Type	Sub-Bituminous-Lignite	Lignite	Sub-Bituminous-Lignite	Sub-Bituminous
Uses	Brick Kiln, steel mill for rock blasting	Thermal Power Production	Brick Kiln, Ceramic & Cement Industries	Brick Kiln, Ceramic Industries
Organization	Pakistan Mineral Development Corporation (PMDC)			(Priv. C) Habibullah Mining Ltd.

Coal Gasification:

A process where hard solid coal is converted into easily transportable coal gas which is a mixture of Methane, Hydrogen & Carbon Monoxide forming C_2H_6O .

Coal is heated in the presence of steam & oxygen to produce a mixture of Methane, Hydrogen & Carbon Monoxide called Coal Gas.

Advantages & Disadvantages of Using Coal:

Advantages	Disadvantages
Coal gas is cheap to Produce. It is present extensively.	Coal mining is dangerous, labor extensive, capital intensive, requires skills & machinery making is difficult to extract.
Can be produced in large quantities.	Coal is bulky & heavy thus can't be transported easily.
More gas can be supplied to northern areas where natural gas is unavailable.	Gives lesser overall energy than gas or oil & requires more volume for sufficient heat energy.
Helps control deforestation by providing alternative fuel to people of northern mountains to Pakistan.	High transport cost as unlike gas it can't be transported by pipelines & needs to cover long distances by trucks.
Easily transportable into cylinder, through trucks by roads.	While burning coal, sulphur converts into oxides causing acid rain. It produces CO ₂ , which is a greenhouse gas causing global warming.

Mineral Oil: is a liquid form of fossil fuel formed by the decomposition of organic matter under the earth's surface mostly by the remains of plants & dead marine organisms. A result is folding of tectonic plates called anticline n & syncline u. Oil is found on the anticline structure, on or under the surface. Anticline structure is also called an oil trap.

- A petroleum reservoir is a subsurface pool of hydrocarbons contained in porous rock formation.
- The hydrocarbons are trapped by overlying impermeable rock formation. Oil neither rises up nor seeps down.
- Gas above, water down are products of anaerobic digestion (when things decomposes without oxygen).
- Possible to have anticlines with oil only.

Oil Drilling Methods:

Drilling Bit: A derrick is constructed. A Derrick is a steel structure with houses drilling tools. These tools consists of the drilling bit & drilling pipes. The drilling bit is a cutting tool of tough metal, studded with diamonds to cut the hardest rock. The drilling pipe turns powered by large engines to drive the drilling bit downwards until the oil tap is reached. A dense mud mixture is pumped through the pipe in the drilling bit to cool it. This mud lubricates & brings the rock cutting to the surface. Once the oil trap is reached, derrick and other machinery is removed. A production valve called the Christmas tree is installed on the top of the pipe to separate oil & gas. A pump jacked finally pumps out oil and gas.

Economic Importance & Uses of Oil:

- Electricity: Burn oil to heat, heat turns water to steam powered turbines, turbines are connected to generators & generators produce electricity.
- To power car and vehicles: oil is used to run different types of transport vehicles to facilitate the passenger & freight movement from one place to another.
- Lubricants to reduce friction: it reduces friction in moving parts of machines to prevent loose grip, wear & tear.
- Oil as a source of agriculture development: oil is used to run farming machineries such as tractors, tube wells, harvesters etc. Oil is also used as a raw material to make fertilizers and pesticides.
- Solvent in industries: Used for cleaning & important industrial solvents such as benzene to dissolve.
- Jet fuel and domestic heating: Kerosene is burnt for heating, lighting & powers jet engines in planes.
- Raw material: Furnace Oil
- As road construction material: bitumen along with tar is a byproduct of crude oil, a black substance which acts a binding agent for hard rock particles in the construction of roads.
- A source of Liquefied Petroleum Gas (LPG): LPG like Propane & Butane are produced which is used as fuel in outdoor grills and cooking appliances. It is a replacement for liquid petrol & can be transported to Northern Areas by road for domestic fuels instead of forest wood preventing deforestation.

Oil Refining & Oil Fields in Pakistan: Oil is refined by fractional distillation by extracting different products by crude oil. Oil refinery is located near oil fields so oil can be easily transported from the mining site which is cheap as less distance is covered, oil can be safely transported, less chances of leakage or accidents.

Oil Fields:

- Lower Sindh Oil field on Dhabi & Mazari Sites.
- Potwar Plateau on Meyal & Dhumal Sites

Oil Refinery in Punjab:

- Attock refinery on Morgah on Potwar Plateau.
- PARCO 3 pipelines for mid-country neat Mehmood Kot on Muzaffargarh in lower or south Punjab.

Oil Refinery in Sindh:

- PRL in Karachi near the port to refine local & imported crude oil.
- NRL in Karachi near the port to refine local & imported crude oil.

Oil Refinery in Balochistan:

- BYCO near the port of Karachi to refine local & imported crude oil.
- Hub Refinery (HRL) near the port of Karachi to refine local & imported crude oil.

White Oil Pipeline Project (WOPP): A pipeline project for transporting refined oil (White Oil) from the sea port to upper Pakistan from Port Qasim to Mahmood Kot (in Punjab), & from Mahmood Kot to Faisalabad in Upper Pakistan.

Also a pipeline from Karachi to PARCO at Mahmood Kot which is 817 km will be used to transport refined oil from Karachi to mid-country.

Transport of Oil:

Oil is transported to seaports of Kemari & Port Qasim in Pakistan through large oil containers. Then the oil is pumped into large storage tanks established near the oil terminal. These tanks are established by oil refineries & private oil distribution companies.

- Pipes: Expensive and needs monitoring, high pumping cost & can only be done on plain areas.
 - High initial cost but cheaper running cost, feasible.
 - Safer and transports large quantities, environmentally friendly.
- Roads:
 - In case of accidents, oil may catch fire & tanker can explode. E.g. Quetta incident.
 - However, wide spread road networks where railway tracks are not available.
 - Small quantities can be easily & cheaply transported.
- Railway:
 - Safer.
 - Less damaging to environment.
 - No traffic.
 - Cheaper than roads.
 - Easily transports bulk quantity
 - Slower and careful.
 - Lots of oil can be transported.
 - Not every part is connected.
 - Less feasible.

Gas: is a gaseous form of fossil fuel formed by the decomposition of organic matter under the earth's surface. It is composed of CH_4 gas. Sometimes mixed with N_2 & CO_2 . Gas is found on the anticline n within the pores of the porous rock trapped b/w 2 impermeable surfaces of non-porous rock. It is above oil, but can be found without it. E.g. 1 reserve at Sui in Balochistan. Easily transported and pollution free, local & cheaply available.

Cylinders - Liquefied natural gas (LNG) - Fuel - Raw material, cooking, power and heating.

Gas Fields in Pakistan:

Gas field in Balochistan:

- Sui gas field is in Balochistan but not the plateau region. It is located near the border of Sindh & Punjab.

Gas field in Sindh:

- Mari gas field is in upper Sindh near the Khairpur District. This gas is rich in Nitrogen which is dangerous for domestic use so it is used for fertilizer instead.
- Lower gas field is in South East Sindh.
- Khairpur Gas Field is in Khairpur.

Gas field in Potwar Plateau:

- Potwar Gas Field is in Potwar Plateau.

Transport of Gas:

- 2 gas lines extend South of Sui connecting Hyderabad & Karachi.
- A branch from Sindh to Northwest, connecting Quetta in Balochistan.
- All the networks south of SUI are controlled by Sui Southern Gas Company Limited (SSGCL). North Networks are controlled by Sui Northern Gas Pipeline Limited (SNGPL).
- A branch of SUI connects Multan further extending to Faisalabad, Lahore & Sialkot while the other branch of Faisalabad reaches Islamabad, Rawalpindi & Peshawar.
- Areas away from gas pipeline (Northern Mountains)

Economic Importance & Uses of Gas:

- Thermal Power Plants: gas to power furnaces to turn water into pressurized steam for electricity.
- Source of power in industries.
- Fertilizer industries: Mari gas a raw material for fertilizer industries.
- Domestic fuel: easily transportable fuel transported through pipelines, burns readily, doesn't produce pollution. Cheap, local & abundant fuel.
- CNG: is cheap motor fuel such as Suzuki Bolan.
- Cooking Purposes.

Coal, Oil or Gas are burned to generate heat to make water vapor. Pressurized steam is used to power turbines connected to generators which produce electricity. Water vapor is sent to condenser or water to be reused.

Nuclear Fusion: is when light nuclei are combined at high temperatures giving enormous energies which is difficult to be handled or stored. Coal, Oil or Gas are burned to generate heat to make water vapor. Pressurized steam is used to power turbines connected to generators which produce electricity. Water vapor is sent to condenser or water to be reused. Nuclear fission reaction is the process by which a nucleus splits into 2 or more fragments. Neutrons & energy are released. This process can cause a nuclear chain reaction that is controlled as in nuclear power or uncontrolled as in nuclear weapon.

Coal, Oil, Nuclear Energy or Gas are burned to generate heat to make water vapor. Nuclear reaction is used to generate heat for the boiler to work. Pressurized steam is used to power turbines connected to generators which produce electricity. Water vapor is sent to condenser or water to be reused.

- Karachi Nuclear Power Plant (KANUPP): near hawks-bay was established during the 70's. It is operated by the Pakistan Atomic Energy Commission (PAEC). Being old, obsolete, antediluvian, outmoded, with poor maintenance & outdated machinery, the electricity supply is infrequent, inefficient & fluctuated.
- Chashma Nuclear Power Plant (CHASNUPP) is located on the Chashma Barrage on River Indus in North-West Punjab. It is a commercial nuclear power generation complex containing of two plants. It is being operated by the Pakistan Atomic Energy Commission (PAEC) with Chinese support.

Solar Energy: energy of the sun, heat & light.

1. Photo voltaic cells: Calculators use these cells in which the energy produced by the sun light can be stored in batteries & use when needed. This is a small procedure.
2. Solar thermal/ Furnace: uses energy of the sun to heat large boilers where water turns into pressurized steam to rotate turbines. Big

Solar panels absorb photons & convert them to electrons to power houses to make electricity. At night, batteries store excess heat for electricity. When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow. Hot pressurized steam is used to power turbines connected to generators which produce electricity.

Advantages and Disadvantages:

Advantages	Disadvantages
Low running cost	High initial cost
Minimal maintenance with no moving or wearing parts.	Somewhat inefficient compared to thermal power.
No fuel is required	Batteries used to store energy add to the cost and maintenance of the system

No cost of fuel transportation	Inefficient in low sun & cloudy weather
Expandable as needed	Requires skill to develop & maintain the system
Renewable and potentially limitless energy	Requires more land
Pollution free and noise free process	

Wind energy: energy of the wind.

1. Stand Alone system: produce electric current supplying to the nearby community.
2. Wind farms: many turbines are installed at 1 place & electricity is produced on commercial level.

Wind Turbines convert electricity in the wind into mechanical power. The generator converts wind to electricity. The kinetic energy is converted to mechanical energy of the turbine connected to generators which produce electricity which is then connected to transformers to be supplied to consumers.

Advantages and Disadvantages:

Advantages	Disadvantages
Low running cost	High initial cost
Limitless supply	Electricity produced is variable
No fuel is required	Noise pollution
Produces no emissions or waste materials.	Inefficient in less wind
Renewable Source	Requires skill to develop & maintain the system
Reliable source of energy	Requires extensive open land so limited locations
	May kill or restrict the movement of migratory birds

Tidal Power: wave power.

Advantages and Disadvantages:

Advantages	Disadvantages
Low running cost	High initial cost
Limitless supply	May block outlets to open sea
No fuel is required	Slow
Produces no emissions or waste materials	May restrict movement of fish & small boats
Renewable Source	Requires skill to develop & maintain the system
Reliable source of energy	Limited locations
May protect coastlines against damage from storms	May kill the fish & mangroves

Geothermal Power: lava of the earth's core is hot. Heat from that can be used to make dry steam, power turbines, connected to a generator then a pylon for electricity.

Cold water is pumped down a bore hole several km. deep into the hot granite rocks underground. Water arises as steam. Geothermal energy is converted to the kinetic energy

of the steam converting it to mechanical energy in the turbine connected to a generator then a pylon for electricity.

Advantages and Disadvantages:

Advantages	Disadvantages
Low running cost	High initial cost
Limitless supply	No naturally occurring vents
No fuel is required	Potential artificial vents are often too far & deep
Produces no emissions or waste materials	No knowledge
Renewable Source	Requires skill to develop & maintain the system
Reliable source of energy	Limited locations
Little space & sustainable	Inefficient

Hydro-Electric Power (HEP): is a type of energy in which the head or pressure of water, stored behind the wall of the dam, is used to rotate large turbines which are connected to electric generators through a shaft. The rotational movement inside the generator produces current. More height means more pressure which means more electricity.

- Water is stored behind the wall of the dam.
- Water from the reservoir flows through the wall from a funnel called penstock.
- The water flows with high pressure & on the giant turbines causing them to rotate.
- Turbines are connected to generator through a shaft.
- Movement in generator produces electricity.
- Water then flows into the natural channel of the river.

Requirements:

- Hard, firm, impervious rock to support the structure.
- Large drainage basin.
- Mountainous terrain/steep sided valley.
- Deep reservoir to increase water storage.
- Large Perennial River.
- Glaciers of snow field in drainage basin to increase availability of water.
- Natural glacial lake to increase storage capacity of reservoir.
- Capital.
- Skilled labor & knowledge.
- Machinery & cement.
- Maintenance.
- Siltation cleaners & evacuation by people.
- High precipitation.

Biogas: is produced by the decomposition of organic matter mostly cow dung. Decompose without the presence oxygen. This leads to the production of methane & CO₂.

Uses:

- Rural electrification.
- Street lighting.
- Gas supply & generators.

Advantages & Disadvantages:

Advantages	Disadvantages
Cheap	Manure shortage
Renewable	Limited electricity production
No complex machinery	Environmental pollution as methane is greenhouse gas
Less skills	Soil deficient nitrogen

Biomass: any vegetative organic matter, waste, leftover of agriculture which can burn is biomass.

Uses:

- Domestic heating: mixed with cow dung to make manure cakes to burn.
- Electricity generation: burned in thermal power plants to produce sufficient heat needed for the production of pressurized steam which is used to turn turbines, which are connected to generators, then transformers for electricity.

Advantages & Disadvantages:

Advantages	Disadvantages
Reduces waste & available anywhere.	Expensive then fossils
Renewable	Limited electricity production
Inexhaustible	Environmental pollution
Utilized fellow lands	Releases emission if burned improperly so care

Electricity Profile & National Grid System:

National Grid System:

Production → Transmission through cable lines & pylons → Distribution to consumers

Power Production:

- WAPDA: supply electricity to the whole Pakistan except Karachi.
- K-Electric: supply electricity to Karachi. (Private)
- KANUPP: on hawks-bay Paradise Point
- CHASNUP: Chashma Barrage
- Kohinoor Energy: Independent power producers which sell power to main companies.
- Liberty: Independent power producers which sell power to WAPDA & K-Electric.

Network of electricity supply is called National Grid System. This ensures electricity flow across the country. It is well-established on the Indus Plain, but not Balochistan Plateau & Mountainous area except for a few areas which do not have a national grid system. Gwader is a potential site so a thermal power plant supplies electricity to locals. There is no railway of proper roads so transmission of electricity by power cables is difficult.

It connects the HEP to the nuclear & thermal electricity produced in the mid-country. It supplies electricity to the different areas of the country based on their demand for electricity. It also ensures even distribution of electricity in different parts of the country for better economic & social development. More ensured electricity supply means more urbanization, buildings & development, mechanization & increased commercialization, but we don't have enough dams, water, oil etc. However, electricity has to cover long distances to reach consumers from the generation site. Moreover, the cost of these wires, pylons & cables is quite high & it's difficult to set up transmission lines in rugged terrain. The cost of repair & maintenance is quite high & 40% of electricity gets stolen by Kundas.

Power Generation in Pakistan:

- 68.8% Thermal
- 28.2 % HEP
- 3% Nuclear

Electricity Generation by Source:

- 35.1 % Oil
- 33.6% HEP
- 27.3% Gas
- 3.6% Nuclear
- 0.3% Imported
- 0.1% Coal

Consumers of Electricity:

1. Domestic: power appliances such as fans, AC, TV, fridge, iron etc.
2. Industrial: power industrial machinery such as CCTV cameras, lighting, devices etc.
3. Agriculture: power tube-wells, motors & machinery etc.
4. Commercial: power computer system, surveillances, lifts, neon publicity signs, etc.
5. Public Lighting: power street lamps etc.
6. Traction:

Load Shedding: is not power failure. It's a planned power cut-off from certain areas for a certain time to provide electricity to fulfill the needs of other areas. A common outcome of electricity shortage all over the country.

Factors leading to power failure:

1. Siltation in dam reservoirs & turbines.
2. Seasonal shortage of water for HEP production.
3. Lack of rainfall in dam areas.
4. Power theft/Kundas in main transmission lines.
5. Old & worn out machinery for power generation & transmission.
6. Limited raw-material for powering thermal power plants.

Reasons for Electricity shortage & solutions:

1. Limited production.
2. Transmission & distribution losses by theft.
3. Increasing demand/ More population/ Better buying power.
4. Economic problem.
5. Less imported fuel.
1. More dams, control of siltation & maintenance, encouraging IPP's to invest more.
2. New & better machinery.
3. Awareness campaigns.
4. Better transmission & distribution by arresting Kunda thieves, replacing old wires.
5. Developments of more renewable electricity resources.

Transformers that regulate the voltage of current: there are 2 types of transformers that increase or decrease the voltage of electricity.

1. Step-up transformers: once electricity is produced, step-up transformers increase volts to 10,000 so a longer distance can easily be covered. E.g. Tarbella to Karachi. On reaching cities & transmission lines, step-down transformers decrease the voltage to 220 volts to prevent breakdown
2. Step-down transformers: decreases the voltage for domestic use.

Generation areas - step up transformers 1,000v - power lines & cables - cities - step-down transformers 220v - pylons/poles - consumers.

Some foreign countries use 110 volts so their appliances & devices are designed accordingly. In case of using them in Pakistan, step-up transformers are needed increase the voltage or these machines may burn.

Rural Electrification: a process of supplying electricity to the villages. This is stand alone.

Factors:

1. Population
2. Distance of the village from main transmission
3. Natural terrain of areas-plain

4. Economic potential-mining sites, priority, investment so high chance electrification

Advantages:

Economic:

1. Installation of tube-wells.
2. Promotion of small-scale industries.
3. Opportunities for improved trade-links through different means of communication.

Social:

1. Education through virtual learning.
2. Improved living standards.
3. Healthcare, research & online consultancy for diseases.

Political Importance:

1. Improved political awareness through TV & Radio.
2. Better information accessibility by internet & computers.
3. Better understanding of the world & geo-politics.

Programs for Rural Electrification:

- Rural work programs.
- Village aid programs.
- Basic democracy programs.

Disadvantages:

1. Far from transmission lines.
2. Small, not feasible.
3. Less electricity for city supply.
4. No investments.
5. No skilled workers.