RENEWABLE ENERGY SYSTEMS

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Lecture 2: Conventional Power Plants

Electric Power Generation Systems

Electric power generation systems are named as ‘power plants’.

The mentioned power plants can fundamentally be classified as follows:

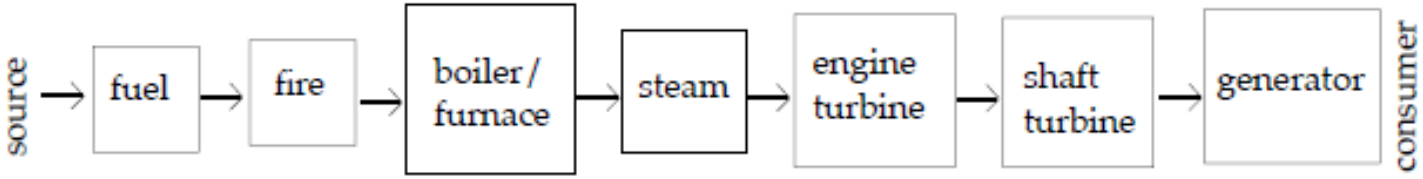
1. Conventional Power Plants
2. Alternative and Renewable Power Plants

CONVENTIONAL POWER PLANTS

Conventional Power Plants

Power generating plants, like other manufacturing plants, process raw materials into useful products, often accompanied by some waste products. For power plants the useful product is electrical energy. The waste products for fossil plants include ash and smoke visibly and heat invisibly.

In the larger central generating plants, input fuel (petroleum, coal, natural gas, nuclear, hydro, etc.) is first converted into heat energy (in the form of steam), then into mechanical energy (in an engine or turbine), and finally into electrical energy (in a generator) to be utilized by consumers.



Schematic Diagram of Energy Conversion in Power Plants

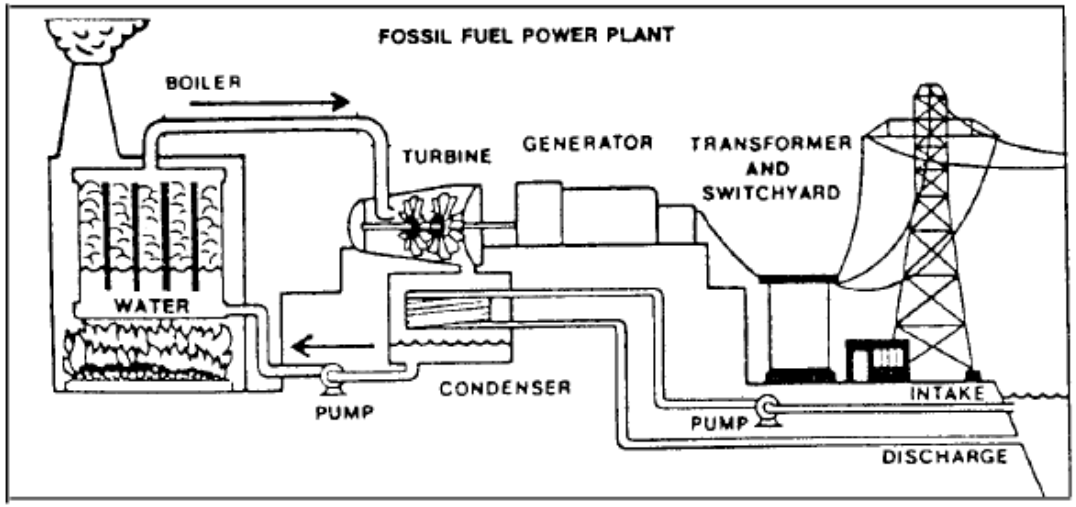
Conventional Power Plants

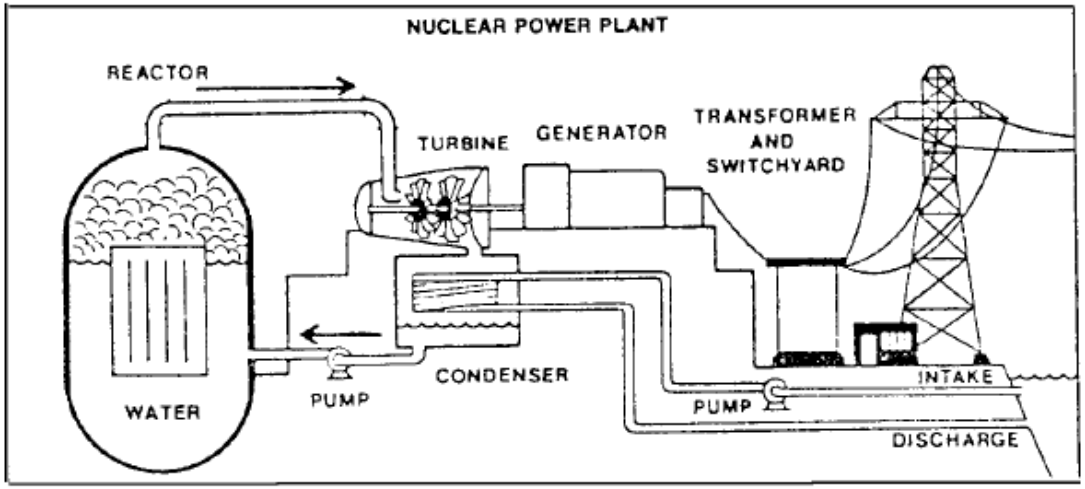
Most commonly, electricity is produced by burning a fossil fuel (coal, oil or natural gas) in the furnace of a steam boiler. Steam from the boiler drives a steam engine or turbine connected by a drive shaft to an electrical generator.

The processes and the equipment to achieve these energy transformations will be described in fundamental terms, encompassing arrangements and modifications to meet specific conditions. Some may be recognized as belonging to older practices (for example burning lump coal on iron grates). While serving purposes of illustration, it must be borne in mind that for a variety of reasons, some of the equipment and procedures continue in service and, hence, knowledge of their operation is still desirable. Pertinent changes, developments and improvements, brought about by technological, economic and social considerations are included.

The four conversion processes in a typical steam generating plant may be conveniently separated into two physical entities, following accepted general practice. The first two processes comprise operations known as the BOILER ROOM, while the latter two are included in those known as the TURBINE ROOM.

Conventional Power Plants



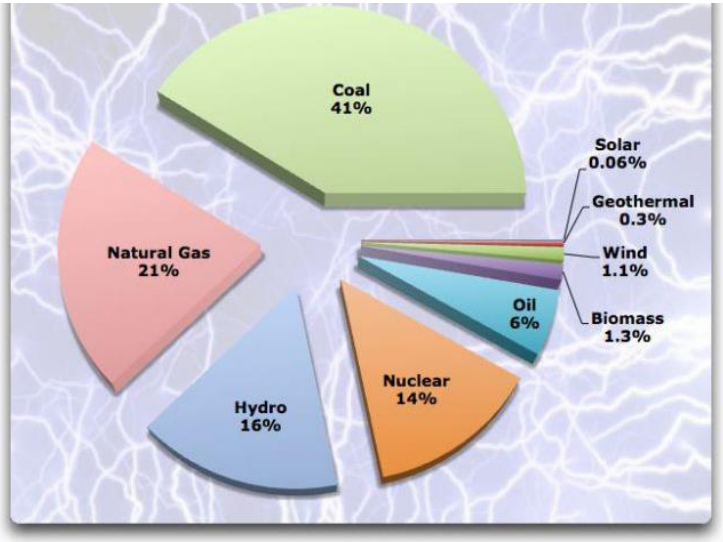


Except for the source of heat they use to create steam, conventional nuclear and fossil power plants are basically the same.

Conventional Power Plants

INPUT FUELS (SOURCES OF ENERGY)

Sources of energy for the production of electricity are many and varied. In addition to the energy contained in falling water, the more common are contained in fuels which contain chemical energy. These can be characterized as fossil and non-fossil fuels; the former, formed from animal and plant matter over thousands of years, while the latter comprises radioactive-associated materials. Coal, oil and natural gas fall into the first category as fossil fuels, while uranium and plutonium (and less known thorium) comprise so-called nuclear fuels. All fuels may be classified as solid, liquid or gaseous, for handling purposes.



World electricity production by fuel type. Renewables (defined by AGW activists as solar-, geothermal-, wind-, and biomass-generated electricity, but not-hydroelectricity) are 2.7% of the total electricity use. Data from ***National Geographic****.*

Conventional Power Plants

FOSSIL FUEL POWER PLANTS WITH FUEL TYPE SEPERATION

Fossil fuel power plants related to type of input fuel can be classified basicaly as:

1. Oil based fossil fuel power plants
2. Coal based fossil fuel power plants
3. Natural gas based fossil fuel power plants
4. Nuclear resources based power plants

Conventional Power Plants

OIL AS INPUT TO POWER PLANTS

- Oil sits in deep underground reservoirs. Like other fossil fuels, this liquid is the end-product of millions of years of decomposition of organic materials. Since the ultimate amount of oil is finite -- and cannot be replenished once it is extracted and burned - it cannot be considered a renewable resource. Once extracted, oil can be refined into a number of fuel products -- gasoline, kerosene, liquefied petroleum gas (such as propane), distillates (diesel and jet fuels) and "residuals" that include industrial and electricity fuels.
- Though most oil is used for transportation or home heating purposes, a small percentage is still used as a fuel for electricity generating plants.

Conventional Power Plants

OIL AS INPUT TO POWER PLANTS

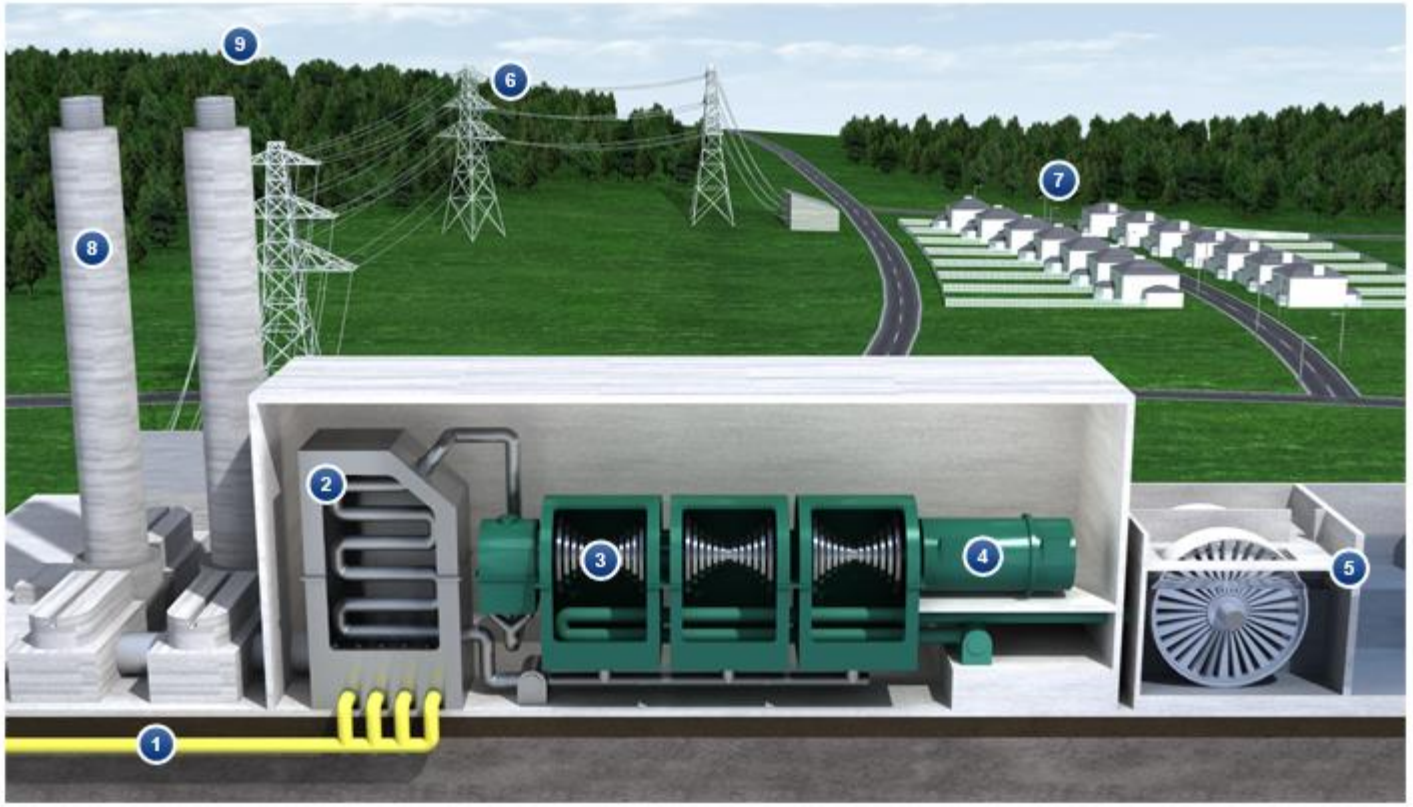
Country	Share of total in the world (%)
Venezuela	17.5
Saudi Arabia	17.2
Canada	9.7
Iran	9.1
Iraq	8.4
Russia	6.2
Kuwait	5.9
United Arab Emirates	5.6
US	4.0
Libya	2.8
Nigeria	2.1
Kazakhstan	1.7
Quatar	1.5
China	1.5
Brazil	0.7
Algeria	0.7
Norway	0.7
Other	6.2

Share of proved oil reserves in all over the world

**BP Statistical Review of World Energy June 2021*

Conventional Power Plants

How is electricity generated by oil?



1. Oil supply
2. Boiler
3. Steam turbine
4. Turbine generator
5. Water supply
6. Electricity transmission (power lines)
7. Consumer homes and businesses
8. Exhaust stack
9. Exhaust gas plume

Conventional Power Plants

- An oil power station turns the chemical energy in oil into electrical energy that can be used in homes and businesses.
- The oil (1) is piped into the boiler (2), where it is burned, converting its chemical energy into heat energy. This heats water in pipes coiled around the boiler, turning it into steam. The hot steam expands in the narrow pipes, so when it emerges it is under high pressure.
- The pressure drives the steam over the blades of the steam turbine (3), causing it to spin, converting the heat energy released in the boiler into mechanical energy. A shaft connects the steam turbine to the turbine generator (4), so when the turbine spins, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.
- After passing through the turbine, the steam comes into contact with pipes full of cold water. In coastal stations this water is pumped straight from the sea (5). The cold pipes cool the steam so that it condenses back into water. It is then piped back to the boiler, where it can be heated up again, turn into steam again, and keep the turbine turning.
- Finally, a transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines (6) to the homes and businesses that need it (7). Here, other transformers reduce the voltage back down to a usable level.
- As well as heat, burning oil produces exhaust gases. These are piped from the boiler to the exhaust stack (8), which contains equipment that filters out any particles, before venting into the atmosphere. The stack is built tall so that the exhaust gas plume (9) can disperse before it touches the ground. This ensures that it does not affect the quality of the air around the station.

Conventional Power Plants

COAL AS INPUT TO POWER PLANTS

- Coal is a fossil fuel and is the altered remains of prehistoric vegetation that originally accumulated in swamps and peat bogs.
- The energy we get from coal today comes from the energy that plants absorbed from the sun millions of years ago. All living plants store solar energy through a process known as photosynthesis. When plants die, this energy is usually released as the plants decay. Under conditions favourable to coal formation, the decaying process is interrupted, preventing the release of the stored solar energy. The energy is locked into the coal.
- The quality of each coal deposit is determined by: (1) varying types of vegetation from which the coal originated, (2) depths of burial, (3) temperatures and pressures at those depths, (4) length of time the coal has been forming in the deposit.

Conventional Power Plants

COAL AS INPUT TO POWER PLANTS

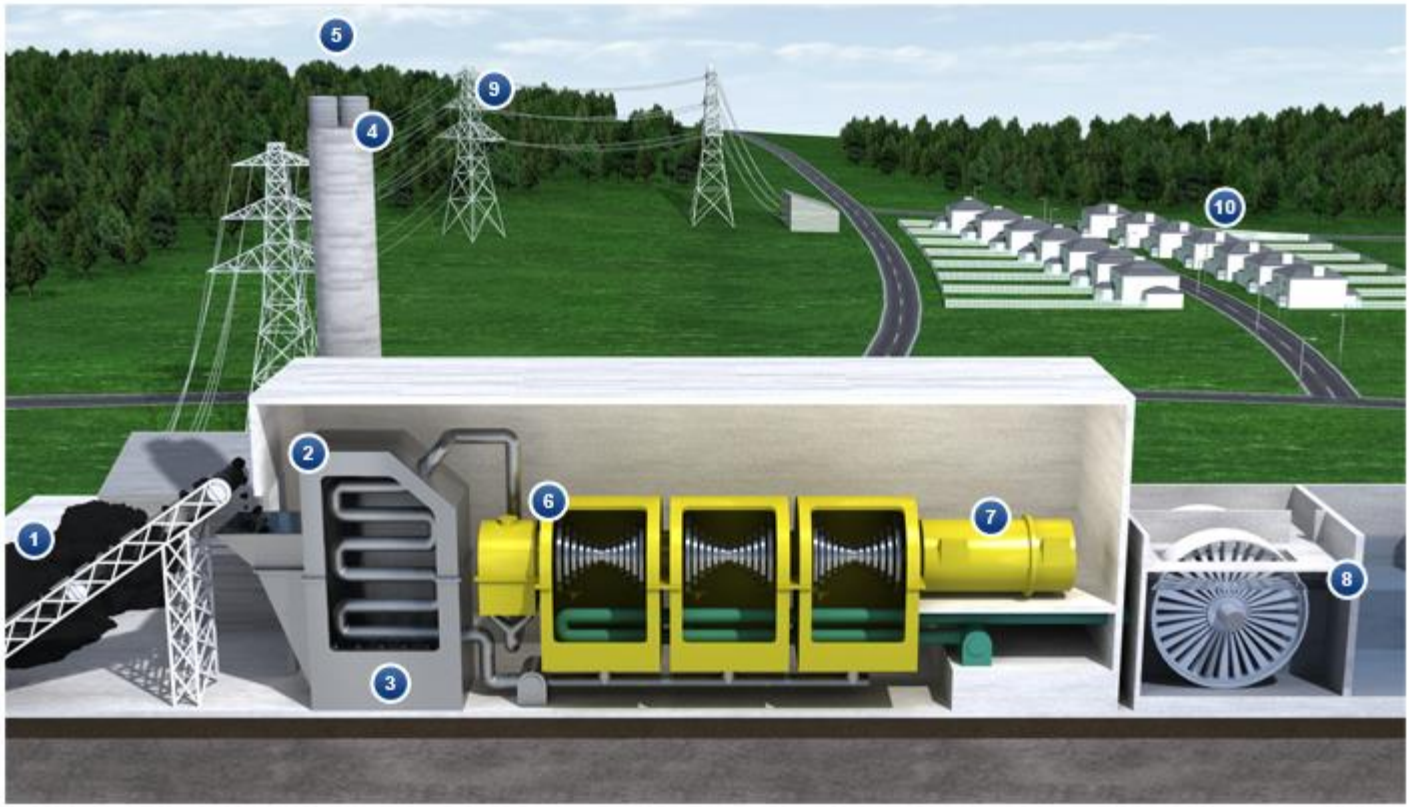
Country	Share of total in the world (%)
US	23.2
Russia	15.1
Australia	14.0
China	13.3
India	10.3
Germany	3.3
Indonesia	3.2
Ukraine	3.2
Poland	2.6
Kazakhstan	2.4
Turkey	1.1
South Africa	0.9
Serbia	0.7
New Zeland	0.7
Brazil	0.6
Canada	0.6
Other	5.0

Share of proved coal reserves in all over the world

**BP Statistical Review of World Energy* 2021

Conventional Power Plants

How is electricity generated by coal?



1. Coal supply
2. Boiler
3. Ash systems
4. Exhaust stack
5. Exhaust plume
6. Steam turbine
7. Turbine generator
8. Water supply
9. Electricity transmission (power lines)
10. Consumer homes and businesses

Conventional Power Plants

- A coal power station turns the chemical energy in coal into electrical energy that can be used in homes and businesses.
- First the coal (1) is ground to a fine powder and blown into the boiler (2), where it is burned, converting its chemical energy into heat energy. Grinding the coal into powder increases its surface area, which helps it to burn faster and hotter, producing as much heat and as little waste as possible.
- As well as heat, burning coal produces ash and exhaust gases. The ash falls to the bottom of the boiler and is removed by the ash systems (3). It is usually then sold to the building industry and used as an ingredient in various building materials, like concrete.
- The gases enter the exhaust stack (4), which contains equipment that filters out any dust and ash, before venting into the atmosphere. The exhaust stacks of coal power stations are built tall so that the exhaust plume (5) can disperse before it touches the ground. This ensures that it does not affect the quality of the air around the station.
- Burning the coal heats water in pipes coiled around the boiler, turning it into steam. The hot steam expands in the pipes, so when it emerges it is under high pressure. The pressure drives the steam over the blades of the steam turbine (6), causing it to spin, converting the heat energy released in the boiler into mechanical energy.
- A shaft connects the steam turbine to the turbine generator (7), so when the turbine spins, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.
- After passing through the turbine, the steam comes into contact with pipes full of cold water. In coastal stations this water is pumped straight from the sea (8). The cold pipes cool the steam so that it condenses back into water. It is then piped back to the boiler, where it can be heated up again, turn into steam again, and keep the turbine turning.
- Finally, a transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines (9) to the homes and businesses that need it (10). Here, other transformers reduce the voltage back down to a usable level.

Conventional Power Plants

NATURAL GAS AS INPUT TO POWER PLANTS

- Natural gas is a vital component of the world's supply of energy. It is one of the cleanest, safest, and most useful of all energy sources.
- Natural gas is a combustible mixture of hydrocarbon gases. While natural gas is formed primarily of methane, it can also include ethane, propane, butane and pentane. The composition of natural gas can vary widely, but below is a chart outlining the typical makeup of natural gas before it is refined.
- Found in reservoirs underneath the earth, natural gas is often associated with oil deposits. Production companies search for evidence of these reservoirs by using sophisticated technology that helps to find the location of the natural gas, and drill wells in the earth where it is likely to be found.

Conventional Power Plants

NATURAL GAS AS INPUT TO POWER PLANTS

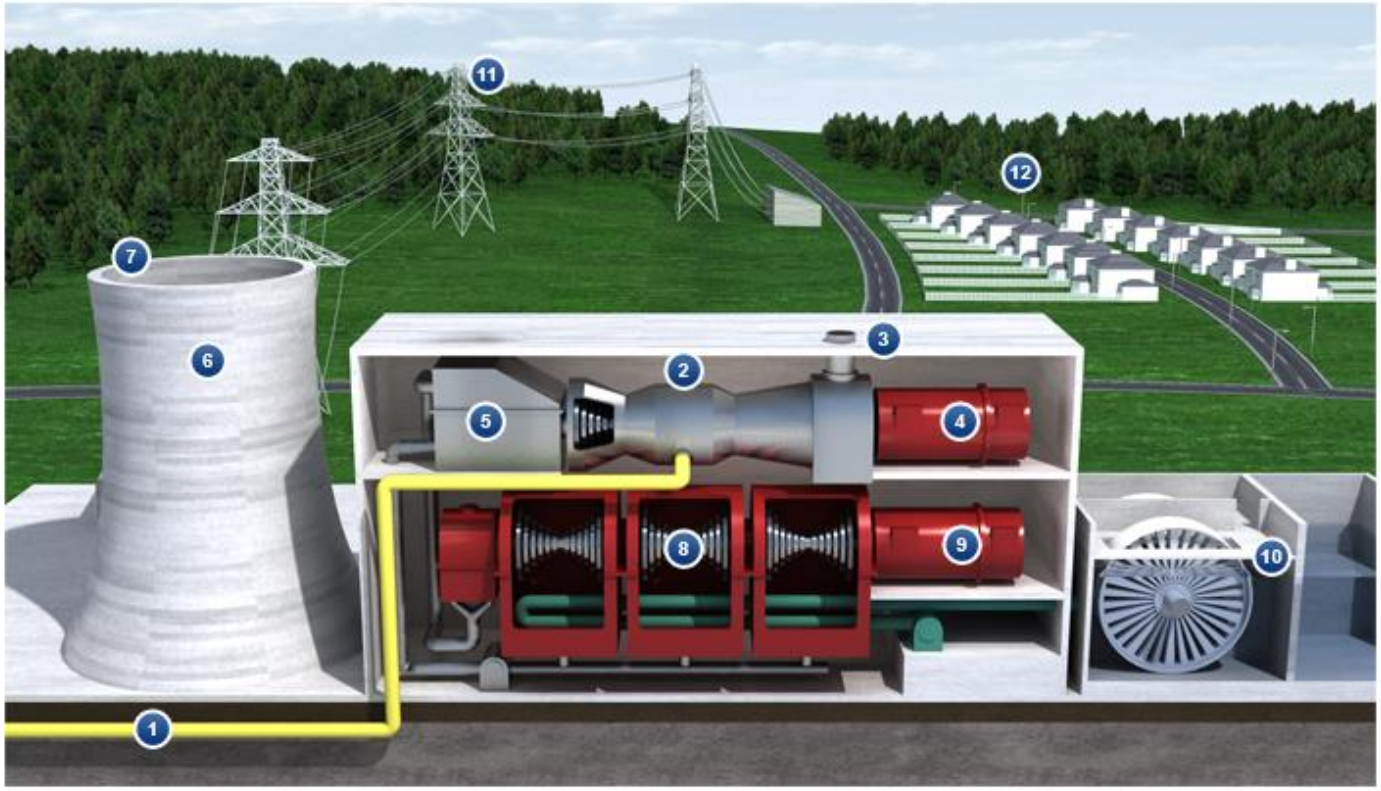
Country	Share of total in the world (%)
Russia	19.9
Iran	17.1
Qatar	13.1
Turkmenistan	7.2
US	6.7
China	4.5
Venezuela	3.3
Saudi Arabia	3.2
United Arab Emirates	3.2
Nigeria	2.9
Australia	1.3
Canada	1.3
Azerbaijan	1.3
Algeria	1.2
Kazakhstan	1.2
Egypt	1.1
Kuwait	0.9
Libya	0.8
Other	9.8

Share of proved natural gas reserves in all over the world

**BP Statistical Review of World Energy* 2021

Conventional Power Plants

How is electricity generated by natural gas?



1. Gas line in
2. Gas turbine
3. Air in
4. Gas turbine generator
5. Heat recovery steam generator
6. Stack for exhaust gases
7. Exhaust gas plume
8. Steam turbine
9. Steam turbine generator
10. Cooling water supply
11. Electricity transmission (power lines)
12. Consumer homes and businesses

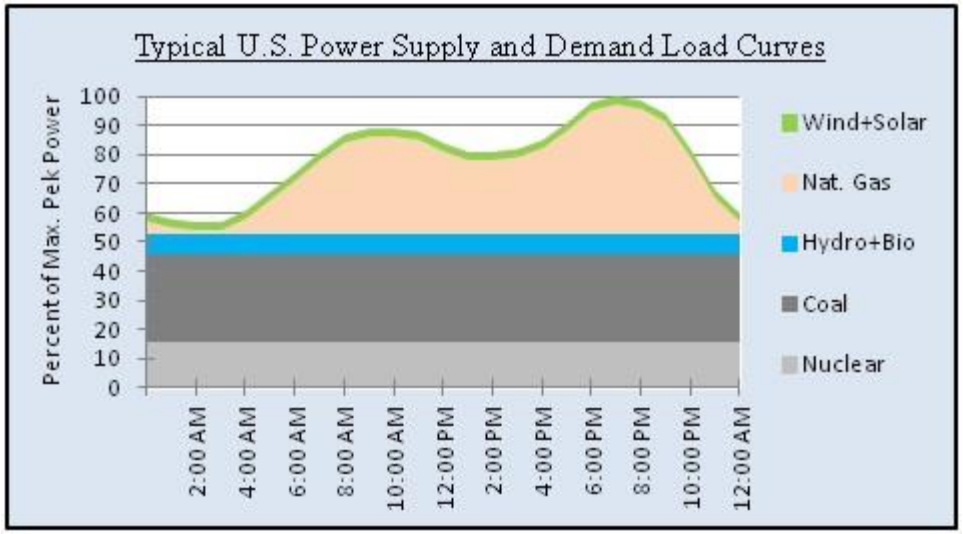
Conventional Power Plants

- A gas power station turns the chemical energy in natural gas into electrical energy that can be used in homes and businesses.
- Natural gas (1) is pumped into the gas turbine (2), where it is mixed with air (3) and burned, converting its chemical energy into heat energy. As well as heat, burning natural gas produces a mixture of gases called the combustion gas. The heat makes the combustion gas expand. In the enclosed gas turbine, this causes a build-up of pressure.
- The pressure drives the combustion gas over the blades of the gas turbine, causing it to spin, converting some of the heat energy into mechanical energy. A shaft connects the gas turbine to the gas turbine generator (4), so when the turbine spins, the generator does too. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.
- After passing through the gas turbine, the still-hot combustion gas is piped to the heat recovery steam generator (5). Here it is used to heat pipes full of water, turning the water to steam, before escaping through the exhaust stack (6). Natural gas burns very cleanly, but the stack is still built tall so that the exhaust gas plume (7) can disperse before it touches the ground. This ensures that it does not affect the quality of the air around the station.
- The hot steam expands in the pipes, so when it emerges it is under high pressure. These high-pressure steam jets spin the steam turbine (8), just like the combustion gas spins the gas turbine. The steam turbine is connected by a shaft to the steam turbine generator (9), which converts the turbine's mechanical energy into electrical energy.
- After passing through the turbine, the steam comes into contact with pipes full of cold water. In coastal stations this water is pumped straight from the sea (10 and 11). The cold pipes cool the steam so that it condenses back into water. It is then piped back to the heat recovery steam generator to be reused.
- Finally, a transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines (12) to the homes and businesses that need it (13). Here, other transformers reduce the voltage back down to a usable level.

Conventional Power Plants

NUCLEAR RESOURCES AS INPUT TO POWER PLANTS

- Nuclear technology split uranium atoms inside a reactor in a process called fission. It was first developed in the 1940s, and during the Second World War to 1945 research initially focussed on producing bombs by splitting the atoms of particular isotopes of either uranium or plutonium.
- Nuclear energy is a vital potential of source especially for base power production!
- Nuclear technology is also used for weapon production, etc. apart from electric energy production
- However, there are concerns of safety for radioactive materials! Examples from Chernobyl, Fukushima, etc…



Conventional Power Plants

NUCLEAR RESOURCES AS INPUT TO POWER PLANTS

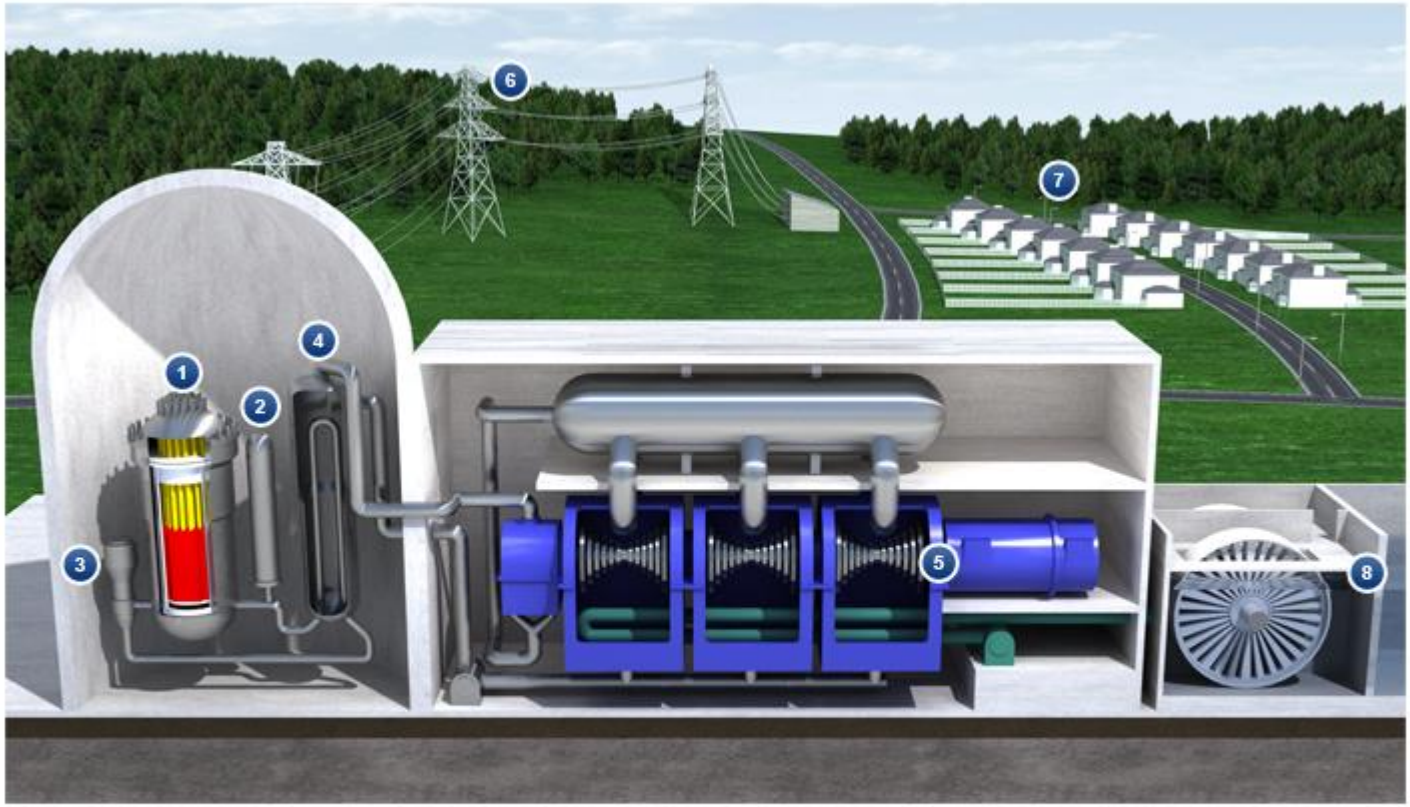
Country	Share of total in the world (%)
US	33.4
France	17.0
Russia	6.9
South Korea	5.6
China	4.4
Canada	4.1
Germany	3.9
Ukraine	3.3
United Kingdom	2.8
Sweden	2.7
Spain	2.3
Taiwan	1.7
Belgium	1.7
India	1.3
Czech Republic	1.2
Switzerland	1.1
Finland	1.0
Other	5.6

Share of nuclear power consumption in all over the world

**BP Statistical Review of World Energy June 2014*

Conventional Power Plants

How is electricity generated by nuclear power?



Conventional Power Plants

- A nuclear power station turns the nuclear energy in uranium atoms into electrical energy that can be used in homes and businesses.
- The reactor vessel (1) is a tough steel capsule that houses the fuel rods – sealed metal cylinders containing pellets of uranium oxide. When a neutron – a neutrally charged subatomic particle – hits a uranium atom, the atom sometimes splits, releasing two or three more neutrons. This process converts the nuclear energy that binds the atom together into heat energy.
- The fuel assemblies are arranged in such a way that when atoms in the fuel split, the neutrons they release are likely to hit other atoms and make them split as well. This chain reaction produces large quantities of heat.
- Water flows through the reactor vessel, where the chain reaction heats it to around 300° C. The water needs to stay in liquid form for the power station to work, so the pressuriser (2) subjects it to around 155 times atmospheric pressure, which stops it boiling.
- The reactor coolant pump (3) circulates the hot pressurised water from the reactor vessel to the steam generator (4). Here, the water flows through thousands of looped pipes before circulating back to the reactor vessel. A second stream of water flows through the steam generator, around the outside of the pipes. This water is under much less pressure, so the heat from the pipes boils it into steam.
- The steam then passes through a series of turbines (5), causing them to spin, converting the heat energy produced in the reactor into mechanical energy. A shaft connects the turbines to a generator, so when the turbines spin, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.
- A transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines (6) to the homes and businesses that need it (7). Here, other transformers reduce the voltage back down to a usable level.
- After passing through the turbines, the steam comes into contact with pipes full of cold water pumped in from the sea (8). The cold pipes cool the steam so that it condenses back into water. It is then piped back to the steam generator, where it can be heated up again, turn into steam again, and keep the turbines turning.

Conventional Power Plants

ADVANTAGES AND DISADVANTAGES OF CONVENTIONAL POWER PLANTS

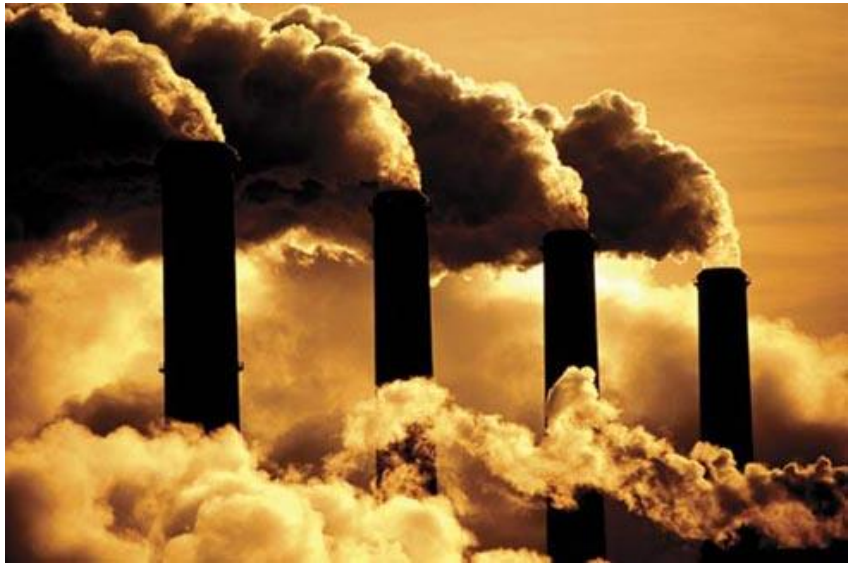
Advantages are:

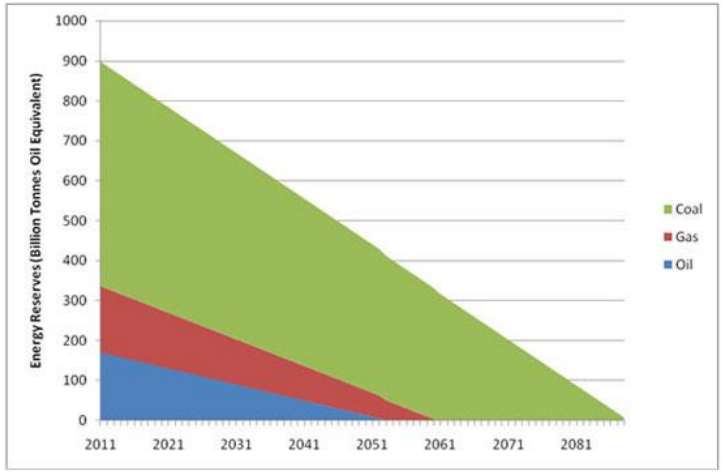
- Cheap to produce large quantities of power
- Building power plants are easy and can be done near cities
- Readily available/convenient -price is lower

Disadvantages Are:

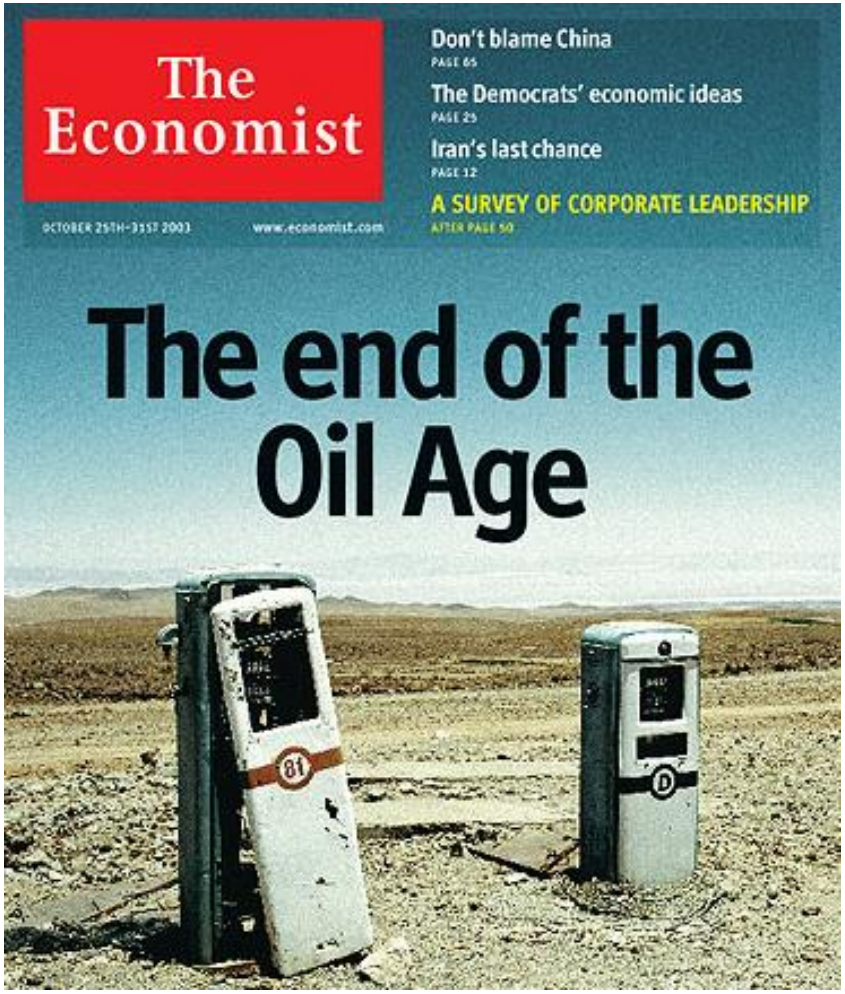
- Burning fossil fuels produce CO_2 --> Global warming
- Nuclear=Danger
- Fossil fuel supply will decrease --> Price increase
- Nuclear waste will remain toxic for many thousands of years

Conventional Power Plants





Conventional Power Plants



Conventional Power Plants

Oil Crisis, 1974

Conventional Power Plants

THANK YOU…