Renewable Energy Sources

B. Tech IV-II Sem
JNTUH-R15

Prepared by

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UNIT – I

PRINCIPLES OF SOLAR RADIATION

Introduction

Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste is known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. More over they do not require heavy expenditure.

Non renewable vs. Renewable

Non renewable Natural resources that can be replaced and reused by nature are termed renewable. Natural resources that cannot be replaced are termed nonrenewable.

renewable vs. Renewable

Renewable resources are replaced through natural processes at a rate that is equal to or greater than the rate at which they are used, and depletion is usually not a worry.

Nonrenewable resources are exhaustible and are extracted faster than the rate at which they formed. E.g. Fossil Fuels (coal, oil, natural gas).

How much longer can we depend on Fossil fuels?

- Because they are fossil fuels they do have a life expectancy.
- Burning fossil fuels has increased atmospheric pollution.
- The carbon stored in fossil fuels is released as carbon dioxide when they are burnt – this leads to the green house effect and global warming.

Sl. No.	Per Capita onsumption (kWh)		
	Name of the Country	2011	2012
1	Canada	16406	15558
2	USA	13227	12947
3	Australia	10514	10218
4	Japan	7847	7753
5	France	7318	7367
6	Germany	7083	7138
7	Korea	10162	10346
8	UK	5518	5452
9	Russia	6533	6602
10	Italy	5393	5277
11	South Africa	4694	4410
12	Brazil	2441	2509
13	China	3298	3475
14	India*	819	884
15	World	2933	2972

	T & D Losses (%)		
Sl. No.	Name of the Country	2011	2012
1	Korea	3.57	3.47
2	Japan	4.98	4.79
3	Germany	4.70	4.46
4	Italy	6.46	6.61
5	Australia	5.94	5.68
6	South Africa	9.61	10.19
7	France	6.47	7.99
8	China	6.54	6.56
9	USA	6.41	6.73
10	Canada	6.27	8.19
11	UK	8.06	8.26
12	Russia	12.59	12.59
13	Brazil	16.08	16.63
14	India	23.97	23.65
15	World	8.90	8.89

Note :-

Basic data obtained from IEA Website (Except India)

* Per Capita Consumption= (Gross Electrical Energy Availability/Midyear Population).

Source wise and state wise estimated potential of renewable power in INDIA as on 31.03.2012

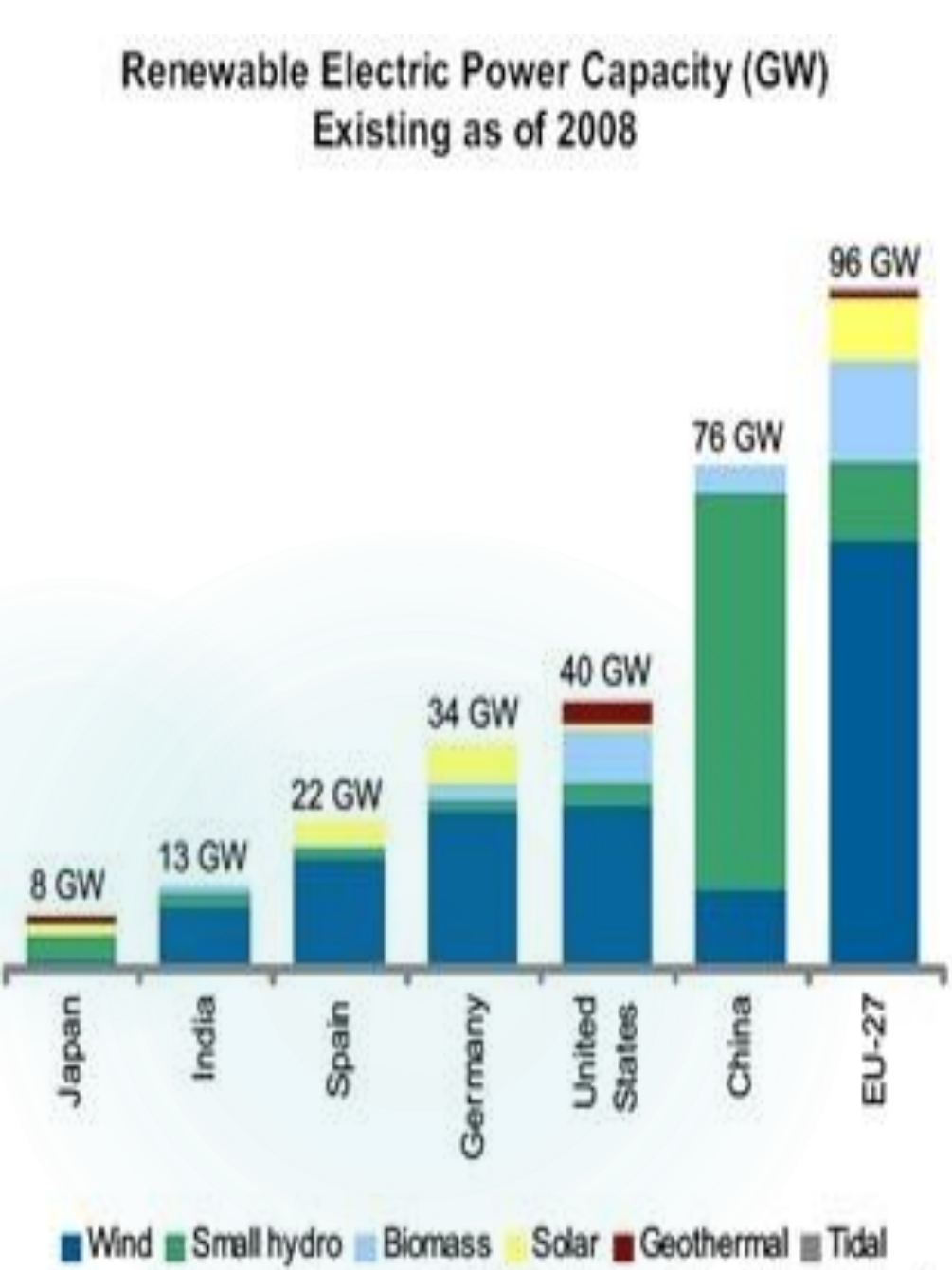
(In MW)

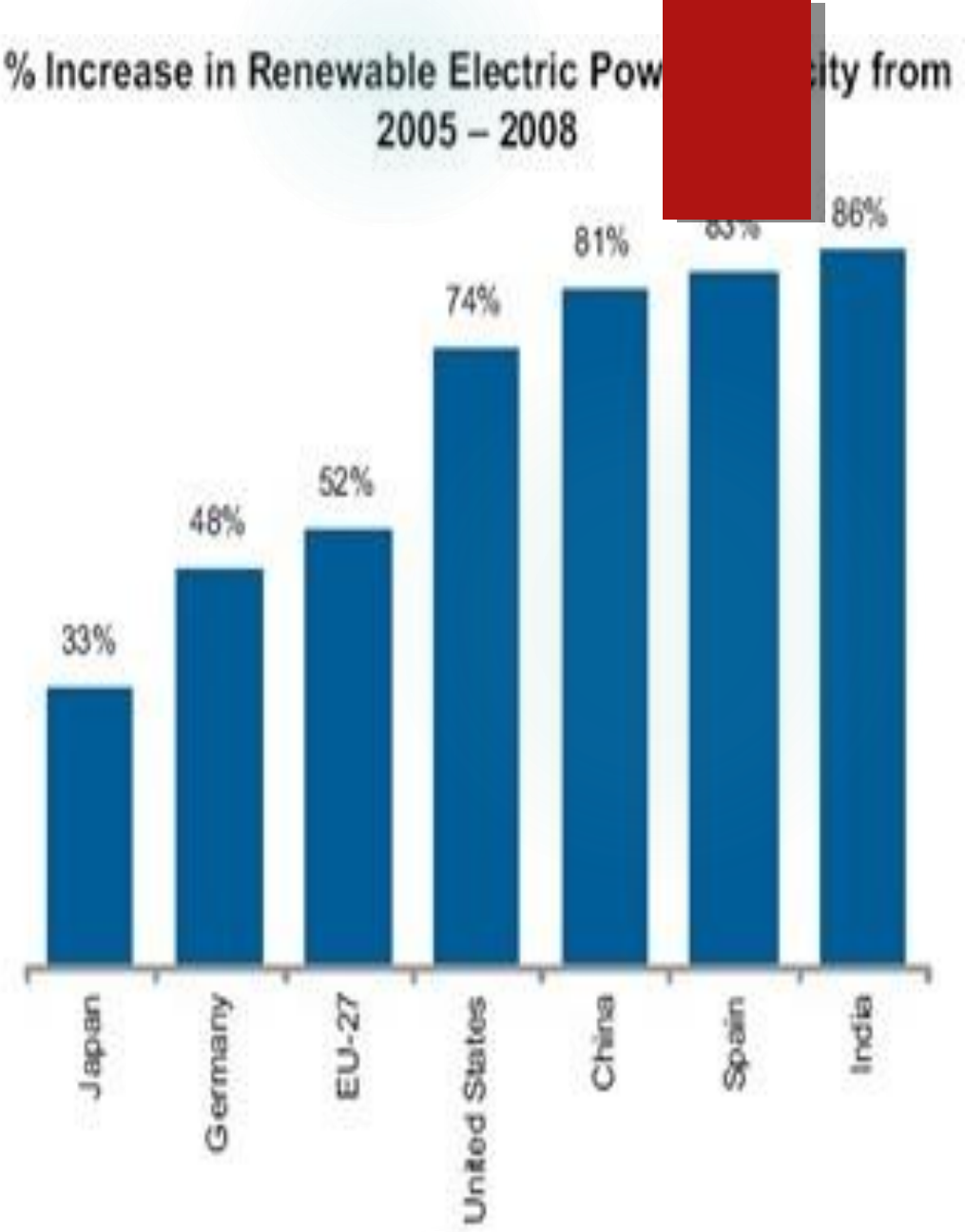
States/ UTs	Wind Power	Small Hydro Power	Biomass Power	Cogeneration-bagasse	Waste to Energy	Total	
						Estimated Reverses	Distribution (%)
1	2	3	4	5	6	7	8
Andhra Pradesh	5394	560	578	300	123	6955	7.75
Arunachal Pradesh	201	1334	8	0	0	1543	1.72
Assam	53	239	212	0	8	512	0.57
Bihar	0	213	619	300	73	1205	1.34
Chhattisgarh	23	993	236	0	24	1276	1.42
Goa	0	7	26	0	0	33	0.04
Gujarat	10609	197	1221	350	112	12489	13.91
Haryana	0	110	1333	350	24	1817	2.02
Himachal Pradesh	20	2268	142	0	2	2432	2.71
Jammu & Kashmir	5311	1418	43	0	0	6772	7.54
Jharkhand	0	209	90	0	10	309	0.34
Karnataka	8591	748	1131	450	151	11071	12.33
Kerala	790	704	1044	0	36	2574	2.87
Madhya Pradesh	920	804	1364	0	78	3166	3.53
Maharashtra	5439	733	1887	1250	287	9596	10.69
Manipur	7	109	13	0	2	131	0.15
Meghalaya	44	230	11	0	2	287	0.32
Mizoram	0	167	1	0	2	170	0.19
Nagaland	3	197	10	0	0	210	0.23
Odisha	910	295	246	0	22	1473	1.64
Punjab	0	393	3172	300	45	3910	4.36
Rajasthan	5005	57	1039	0	62	6163	6.87
Sikkim	98	266	2	0	0	366	0.41
Tamil Nadu	5374	660	1070	450	151	7705	8.58
Tripura	0	47	3	0	2	52	0.06
Uttar Pradesh	137	461	1617	1250	176	3641	4.06
Uttaranchal	161	1577	24	0	5	1767	1.97
West Bengal	22	396	396	0	148	962	1.07
Andaman & Nicobar	2	7	0	0	0	9	0.01
Chandigarh	0	0	0	0	6	6	0.01
Dadar & Nagar Have	0	0	0	0	0	0	0.00
Daman & Diu	0	0	0	0	0	0	0.00
Delhi	0	0	0	0	131	131	0.15
Lakshadweep	16	0	0	0	0	16	0.02
Puducherry	0	0	0	0	3	3	0.00
Others *	0	0	0	0	1022	1022	1.14
All India Total	**49130**	**15399**	**17538**	**5000**	**2707**	**89774**	**100.00**
Distribution (%)	**54.73**	**17.15**	**19.54**	**5.57**	**3.02**	**100.00**	

* Industrial waste
Source: Ministry of New and Renewable Energy

Power production status of non-conventional energy in India

Renewable Power	Potential	Achieved
Wind Power	20,000 MW	1,000 MW
Small Hydro Power	10,000 MW	172 MW
Biomass	20,000 MW	141 MW
Solar photo-voltic Power	20 MW/sq.km	810 KW





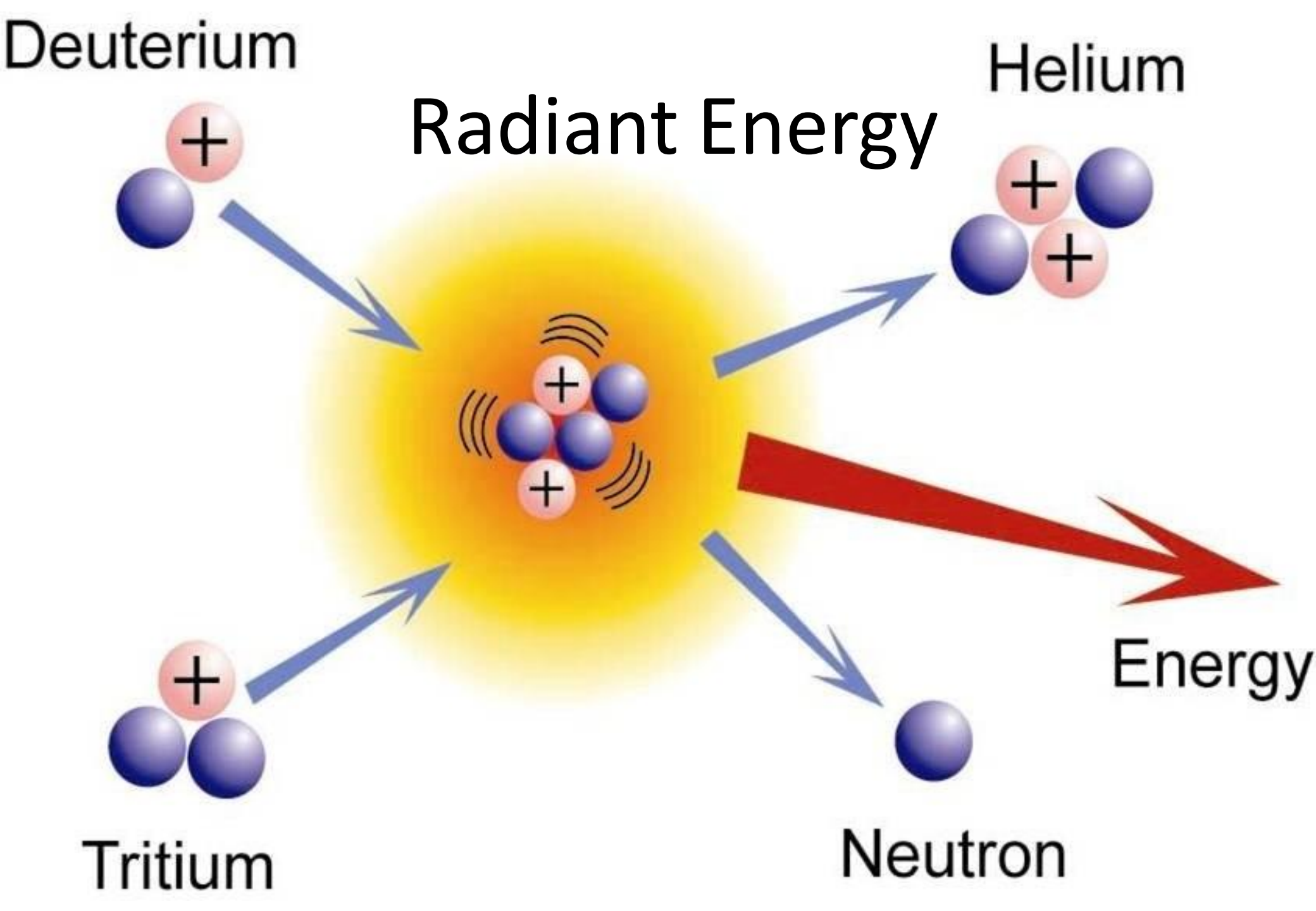
Source: DBCCA analysis, 2010; REN21, "Renewables Global Status Report," 2006 and 2009.

Renewable energy scenario in India

Government created the Department of Non-conventional Energy Sources (DNES) in 1982. In 1992 a full fledged Ministry of Non- conventional Energy Sources was established under the overall charge of the Prime Minister.
The range of its activities cover

1. Promotion of renewable energy technologies,
2. Create an environment conducive to promote renewable energy technologies,

3.Create an environment conducive for their commercialization, 4.Renewable energy resource assessment,
5.Research and development,
6.Demonstration,
7.Production of biogas units, solar thermal devices, solar photovoltaics, cookstoves, wind energy and small hydropower units.


Deuterium
Radiant Energy
Helium
Energy
Tritium
Neutron

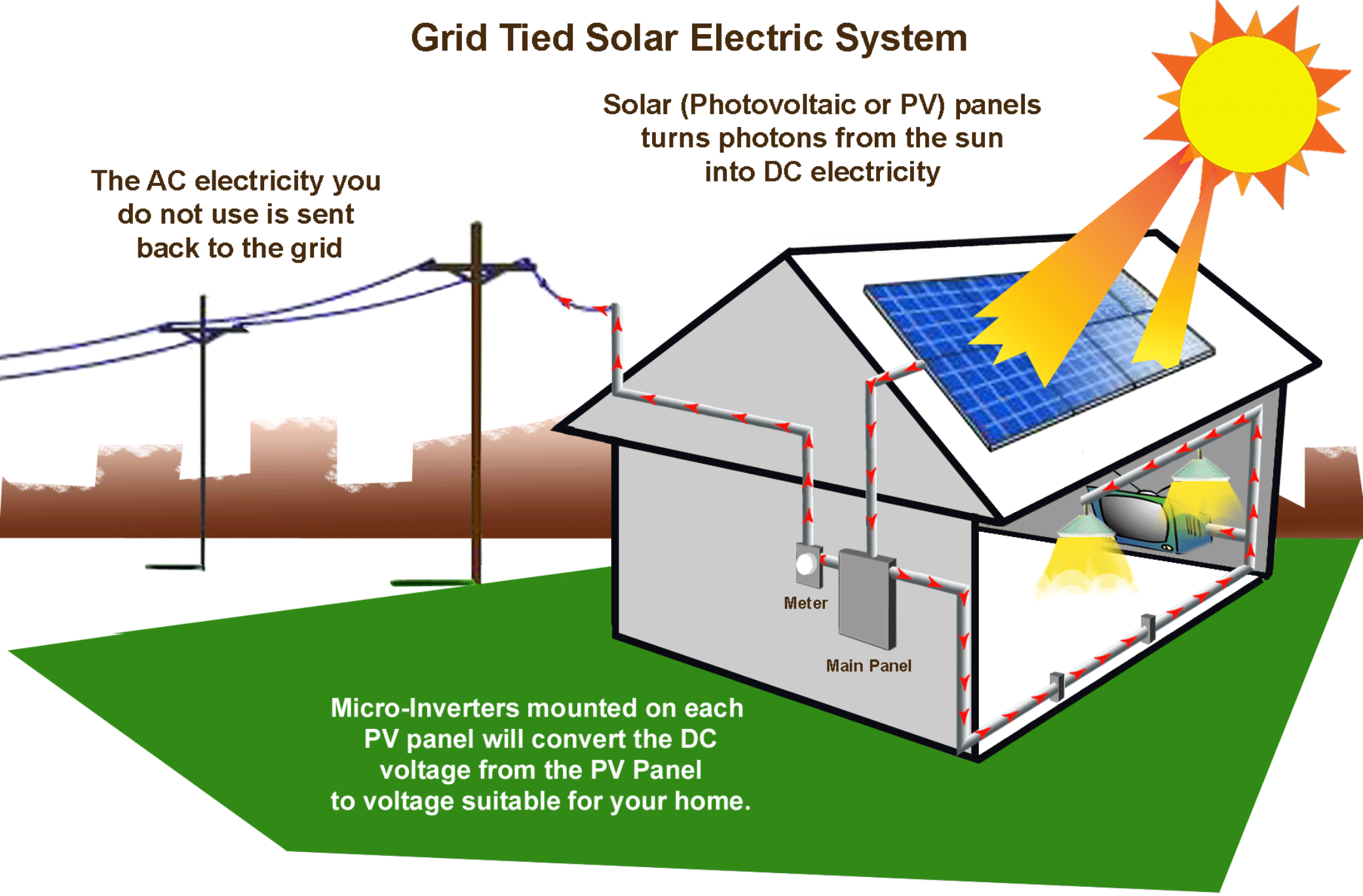
Major uses of Solar Energy

- Heating Water
- Space Heating
- Generating Electrical Energy

Solar Technologies

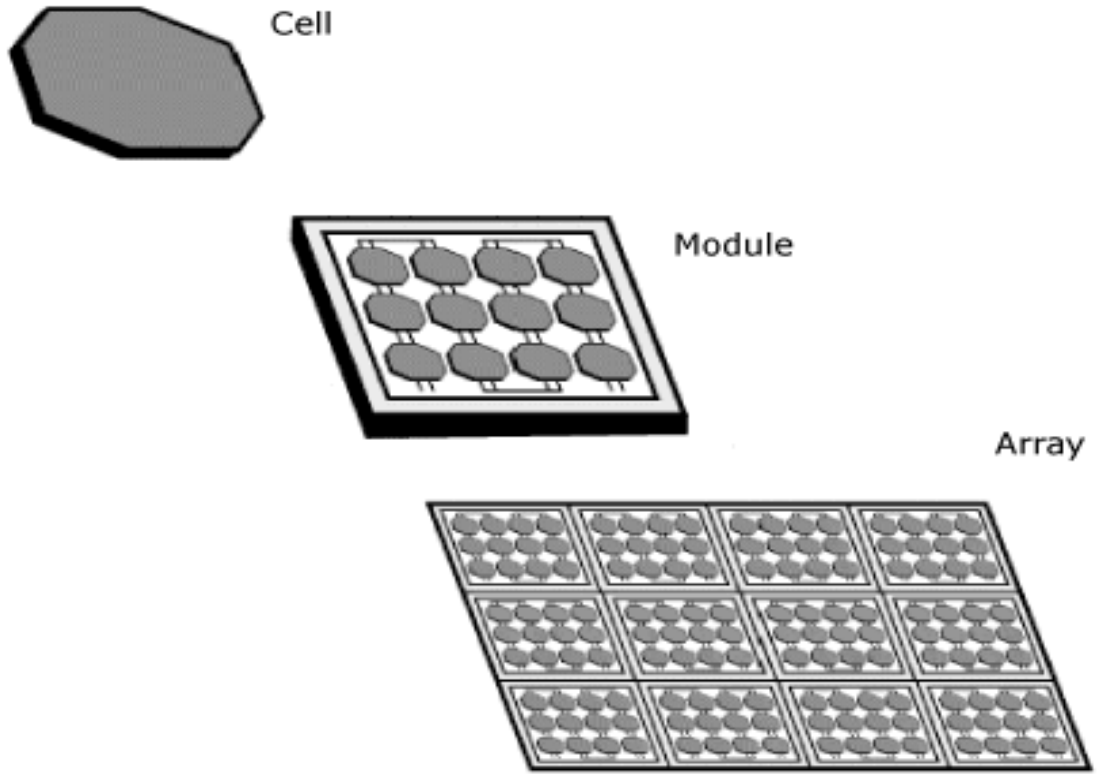
- Day lighting
- Passive Solar Heating
- Concentrating Solar Thermal
- Photovoltaic (PV)

Grid Tied Solar Electric System



Photovoltaic Components

- PV Cells
- Modules
- Arrays



Advantages of Solar Energy

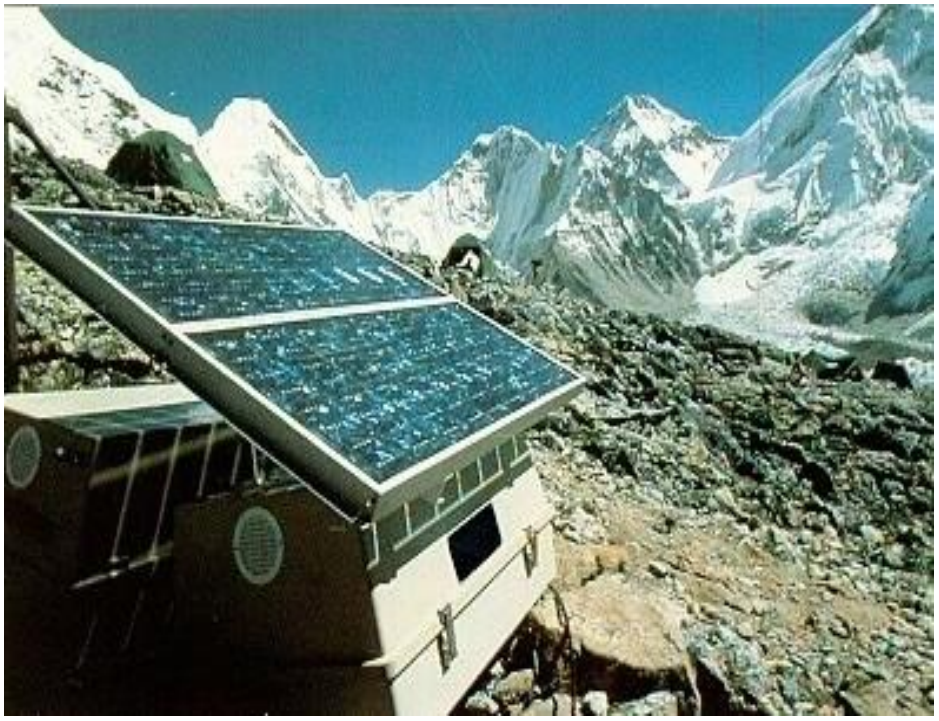
- Clean
- Sustainable (can be used for longer duration)
- Free of cost
- Provide Electricity to Remote Places

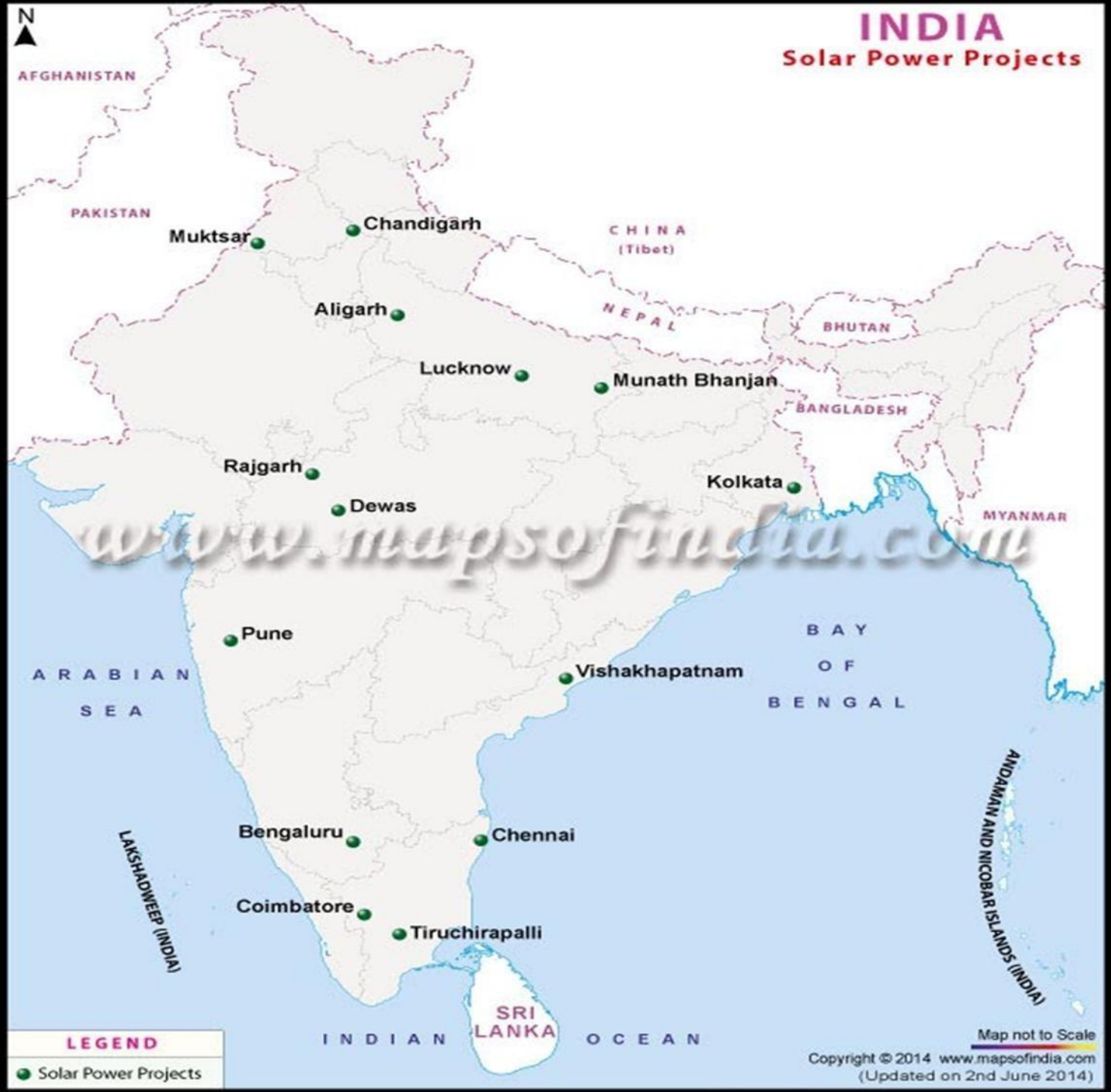
Disadvantages of Solar Energy

- Inefficient – maximum efficiency up to 30%.
- Costly equipment.
- Part Time.
- High maintenance cost.

Photovoltaic Array Fields

Photovoltaic Array Fields

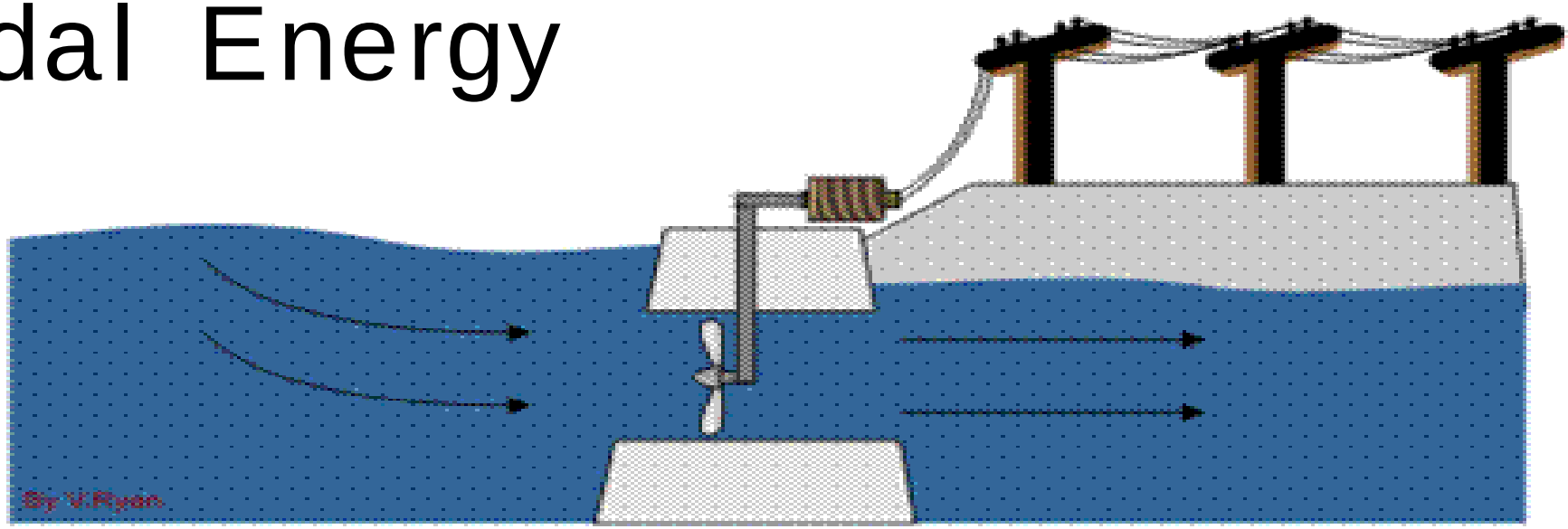




UNIT-II

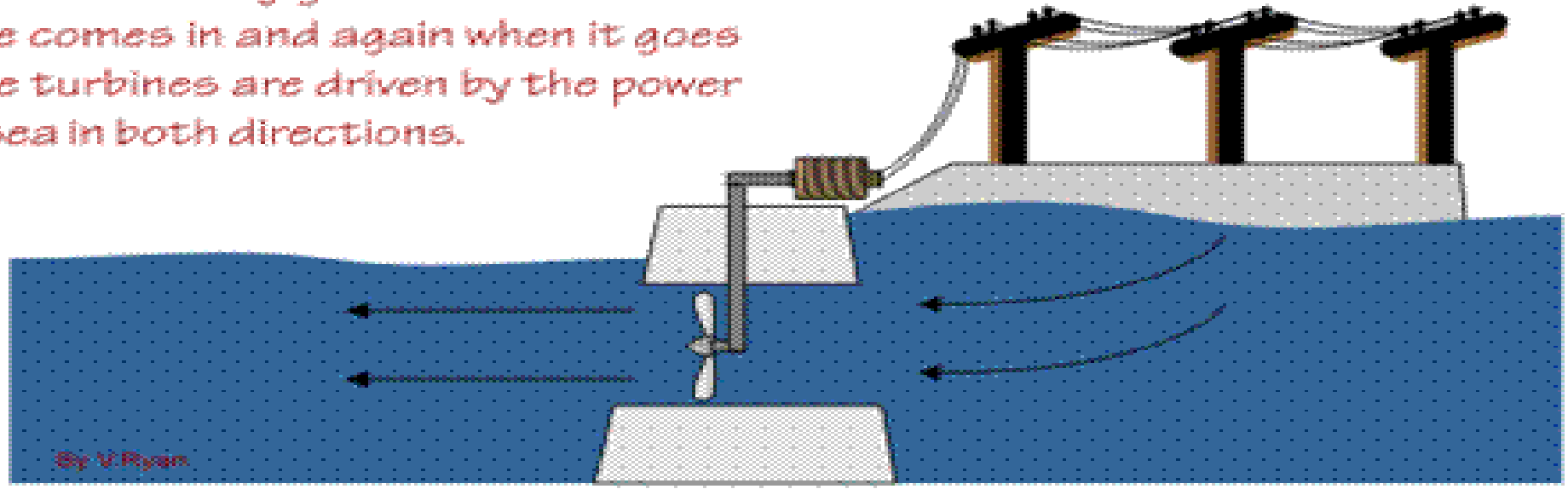
SOLAR ENERGY COLLECTION

Tidal Energy



TIDE COMING IN

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



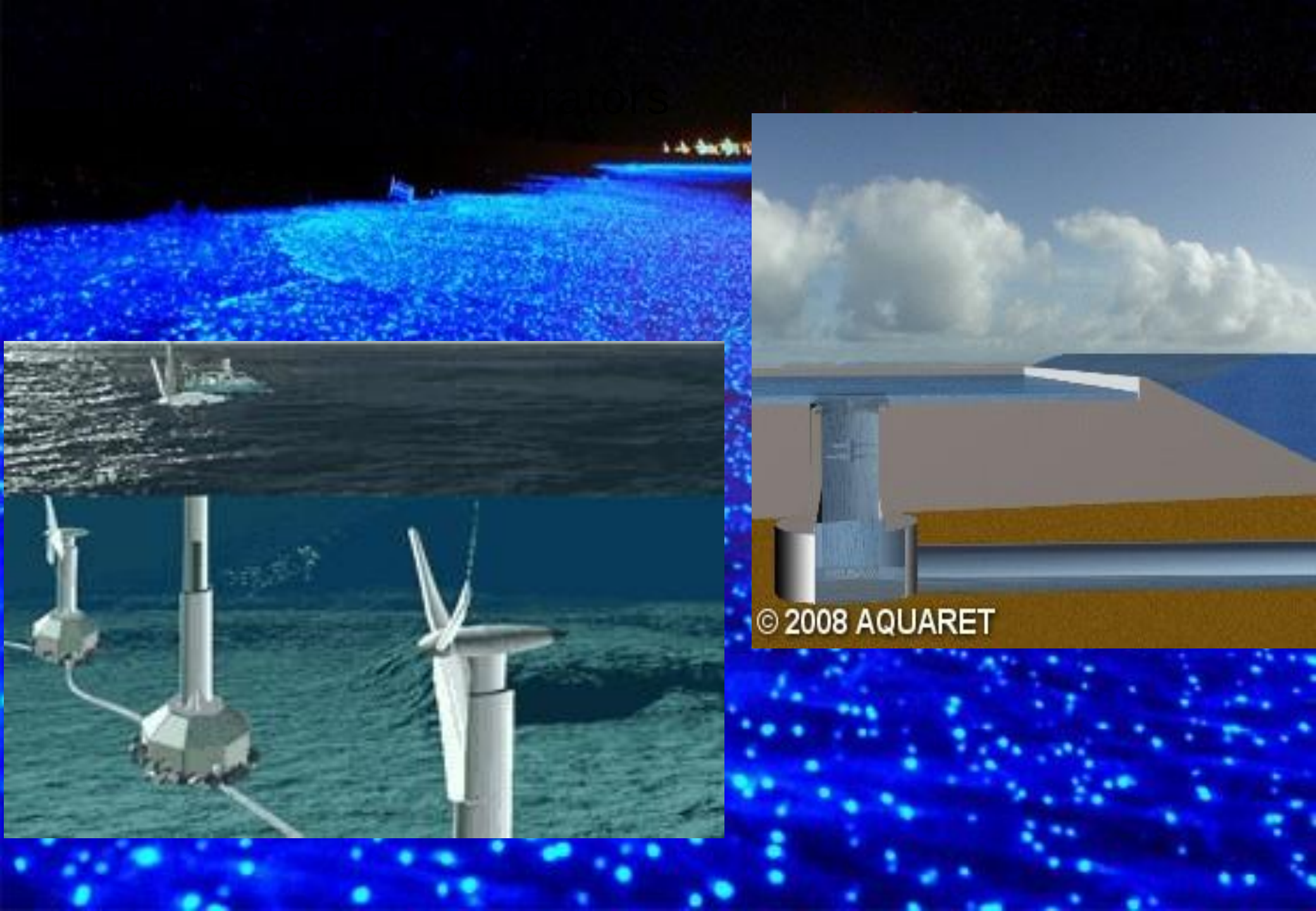
TIDE GOING OUT

Tidal Energy

- Millions of gallons of water flow onto shore during tidal flows and away from shore during ebb (move away from the land) tide periods.

- The larger the tidal influence, the greater the displacement of water and therefore the more potential energy that can be harvested during power generation.

- Tidal energy is one of many forms of hydropower generation.
- Tidal power has many advantages as compared to other forms of renewable energy.
  - It is predictable
  - Global Climate Change should only increase its generating capacity due to higher ocean levels.
  - It is completely carbon neutral like wind or hydro energy.


© 2008 AQUARET

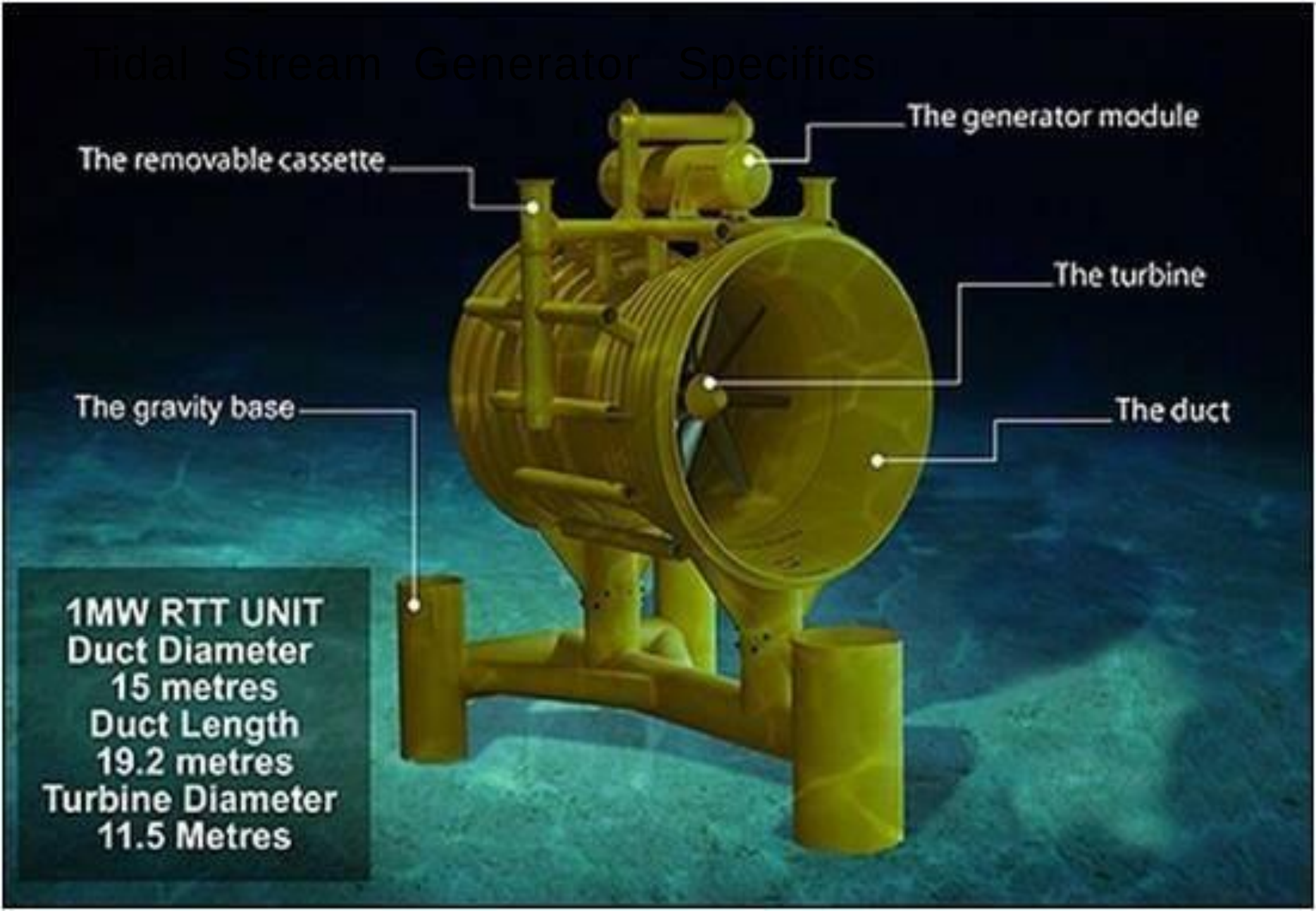
Tidal Stream Generators

The world's only operational commercial-scale tidal turbine, SeaGen, was installed in Strangford Narrows in Northern Ireland in 2008.

The prototype SeaGen turbine produces 1.2MW with currents of 2.4m/s or more. The capacity factor exceeds 60%.

The facility is an accredited UK power station, and can contribute up to 6,000MWh annually to the UK grid, the equivalent of approximately 1500 homes.

Tidal Stream Generator Specifics



Advantages of using Tidal Power

- Predictable source of “green" energy during lifetime of barrage
- It produces no greenhouse gases or other waste; it needs no fuel.
- Not expensive to maintain.
- Tidal energy has an efficiency of 80% in converting the potential energy of the water into electricity
- Vertical-axis tidal generators may be joined together in series to create a ‘tidal fence’ capable of generating electricity on a scale comparable to the largest existing fossil fuel based, hydroelectric and nuclear energy generation facilities

Disadvantages of using Tidal Power

- A barrage across an estuary is very expensive to build, and affects a very wide area – the environment is changed for many miles upstream and downstream.
- It provides power for around 10 hours each day, when the tide is actually moving in or out, which is not very much
- Existing ecosystems would be heavily altered, with new species moving in and perhaps dominating old species.
- Tidal power schemes have a high capital cost.

Environmental Effects

- A tidal power scheme is a long-term source of electricity. A proposal for the Severn Barrage, if built, has been projected to save 18 million tones of coal per year of operation. This decreases the output of greenhouse gases into the atmosphere.

- If fossil fuel resource is likely to decline during the 21st century, as predicted by Hubbert peak theory, tidal power is one of the alternative source of energy that will need to be developed to satisfy the human demand for energy.

What is Geothermal?

- Geothermal comes from the Greek words Ge (earth) and thermos (hot).

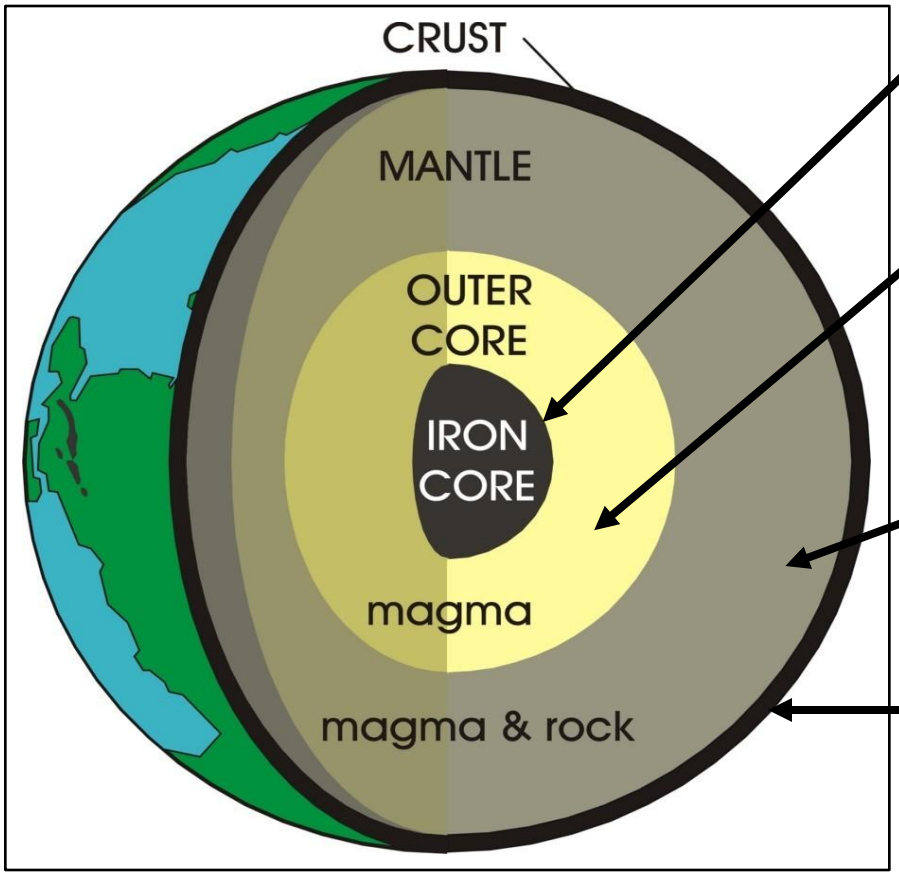
- Thus, geothermal energy means heat inside the earth.

What is Geo thermal?

Geothermal comes from the Greek words Ge (earth) and thermos (hot).

Thus, geothermal energy means heat inside the earth.

The Earth Is Made of Layers



At the center is a **core** of molten iron.

Around that is an outer core of iron and rock so hot that rock is in molted state.

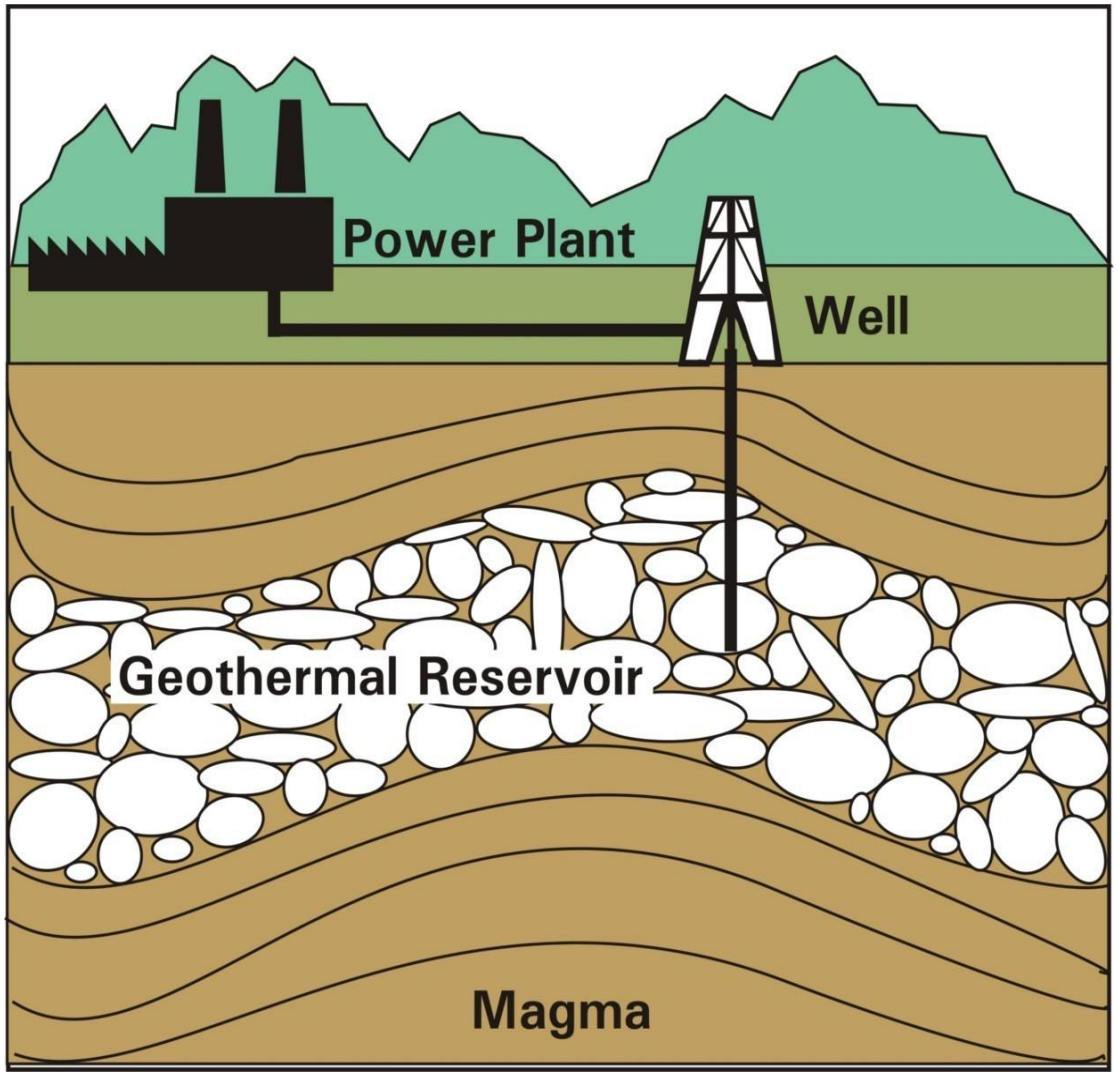
The liquid rock is called **magma** .

The next layer is a mixture of rock and magma called the **mantle** .

The shell of the earth – with the oceans and mountains - is called the **crust** .

How Do We Use Geothermal Energy?

- Today, power plants use steam from geothermal wells to make electricity.
- The steam is used to spin turbines .
- The turbines spin magnets in coils of copper wire to make electricity .



Where Can We Find Geothermal Energy?

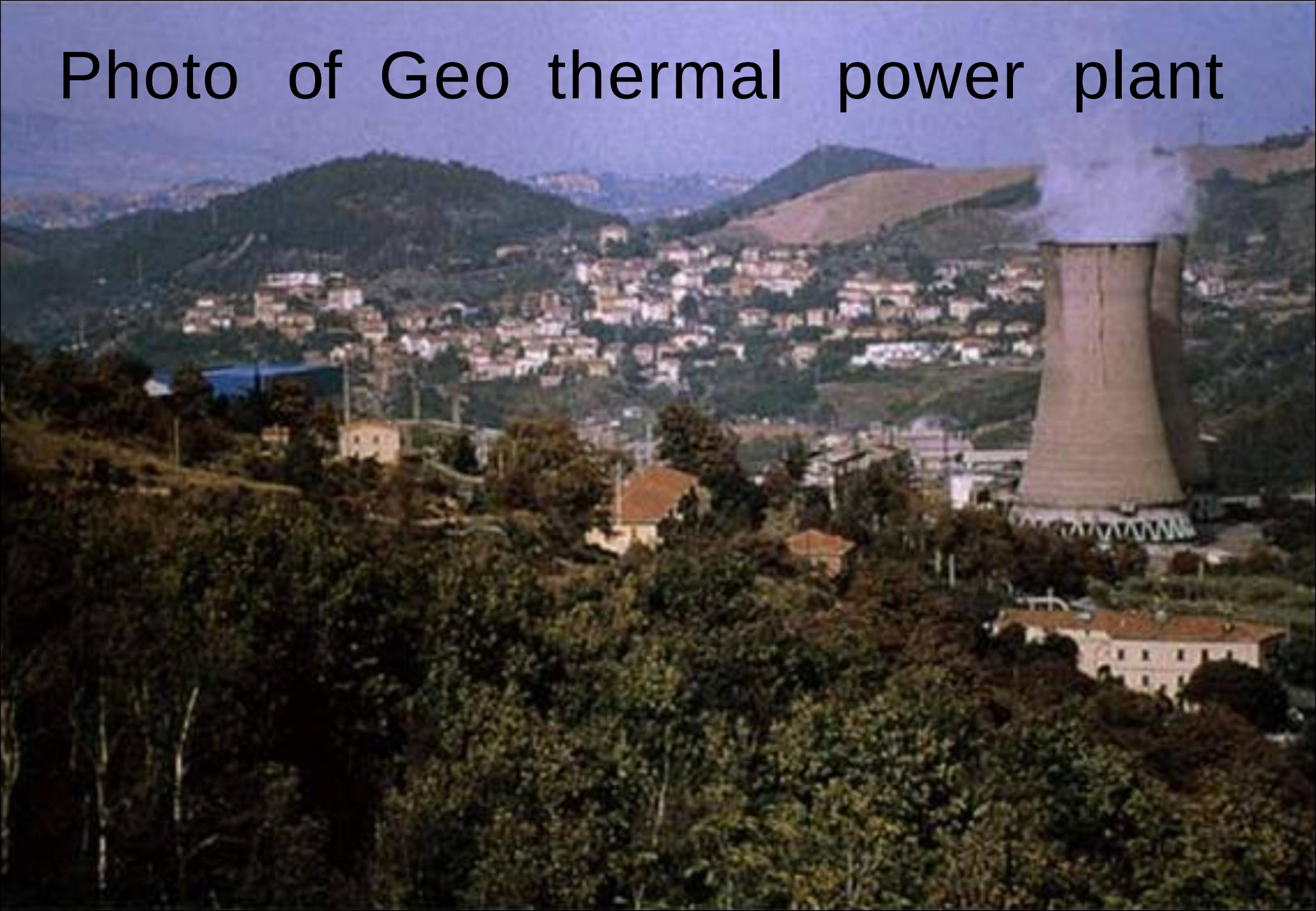
The most active geothermal resources are usually found where earthquakes occur volcanoes , hot springs, geysers, volcanoes are concentrated.

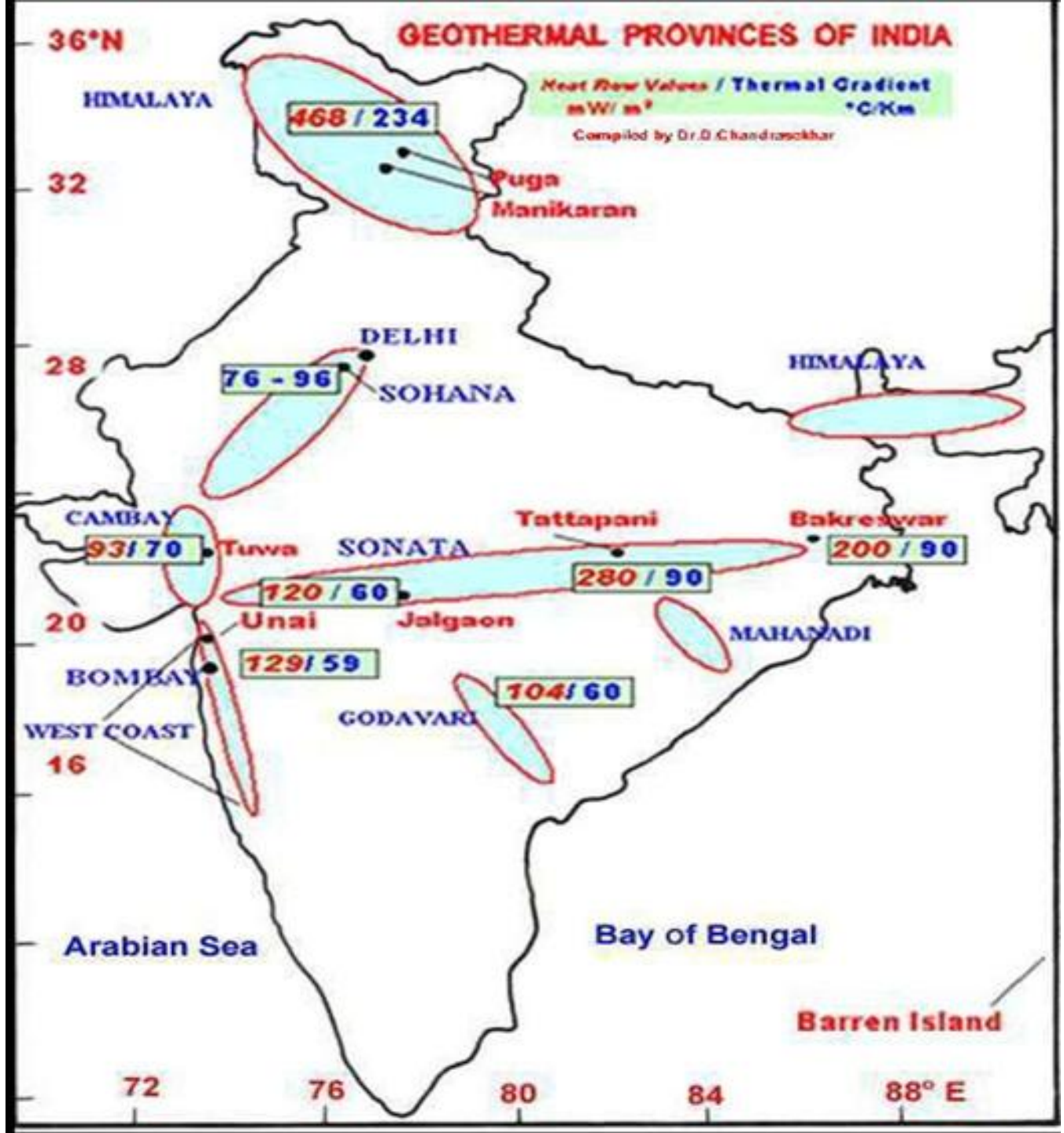
Geothermal Energy is Clean & Cheap.

- No fuel is burned, so there is no air pollution.
- The steam is turned into water and put back into the earth.
- Geothermal energy is cheap – new power plants can make electricity for about the same as coal power plants.

Geo thermal power plant in USA

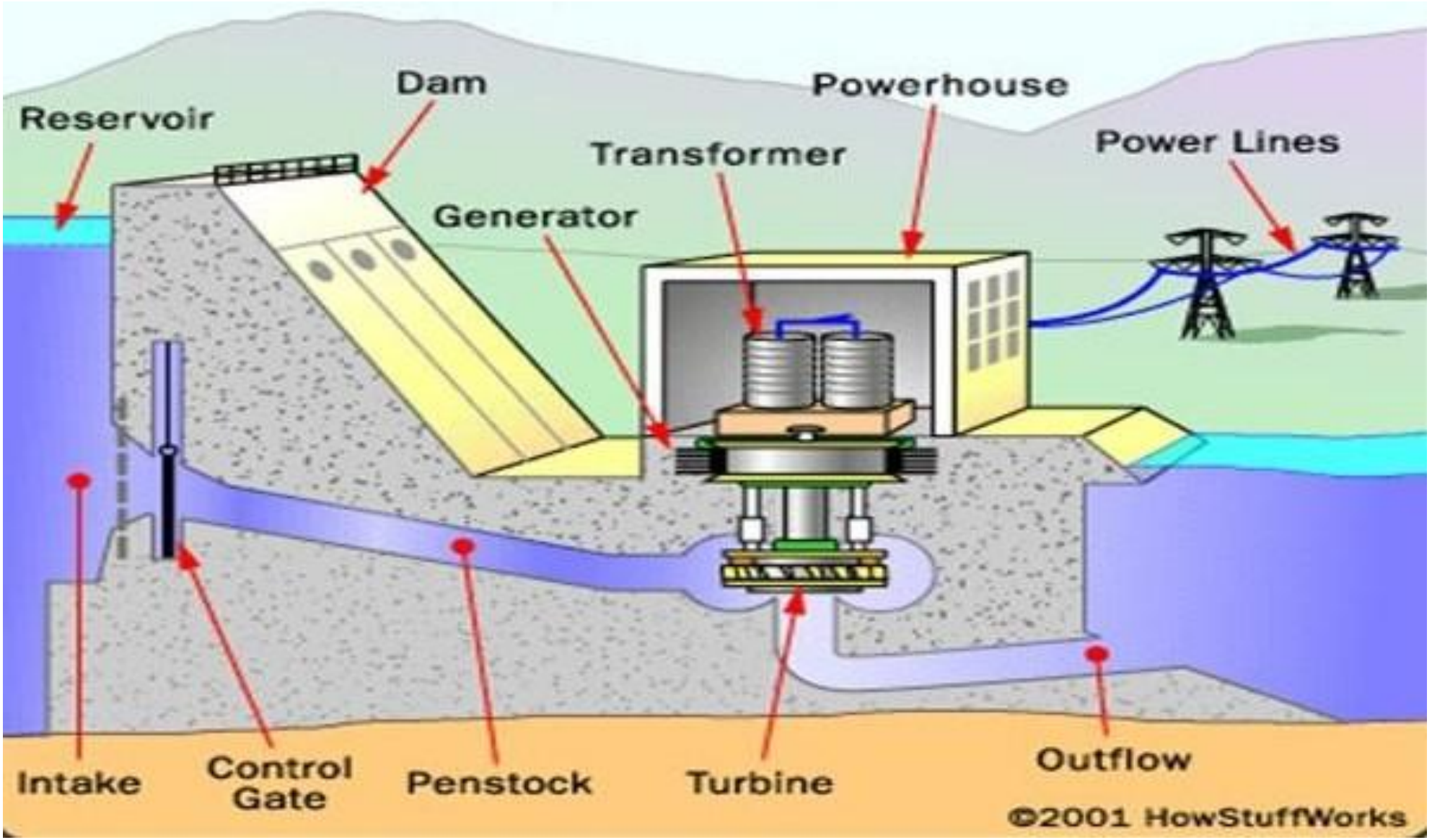
Photo of Geo thermal power plant




GEOTHERMAL PROVINCES OF INDIA
Heat flow Values / Thermal Gradient
mW/ m²
°C/Km
Compiled by Dr.D.Chandrasekhar
36°N
32
28
20
16
HIMALAYA
468 / 234
Puga
Manikaran
DELHI
76 - 96
SOHANA
HIMALAYA
CAMBAY
93/ 70
Tuwa
SONATA
Tattapani
280 / 90
Bakreswar
200 / 90
120 / 60
Unai
Jalgaon
MAHANADI
BOMBAY
129/ 59
104/ 60
GODAVARI
WEST COAST
Arabian Sea
Bay of Bengal
Barren Island
72
76
80
84
88° E

Hydroelectric Energy

Layout **nt**


Reservoir
Dam
Powerhouse
Transformer
Power Lines
Generator
Intake
Control Gate
Penstock
Turbine
Outflow
©2001 HowStuffWorks

Location Of hydro power plants

- Generally located near rivers
- Dams
- Streams
- High pressure water sources

UNIT-III

SOLAR ENERGY STORAGE AND APPLICATIONS

HYDRO ELECTRIC DAM IN INDIA

- The Koyna Hydroelectric Project is the largest completed hydroelectric power plant in India. It is a complex project with four dams including the largest dam on the Koyna River known as the Koyna Dam hence the name

  Koyna Hydro electric Project. The project site is in Satara district near Patan.

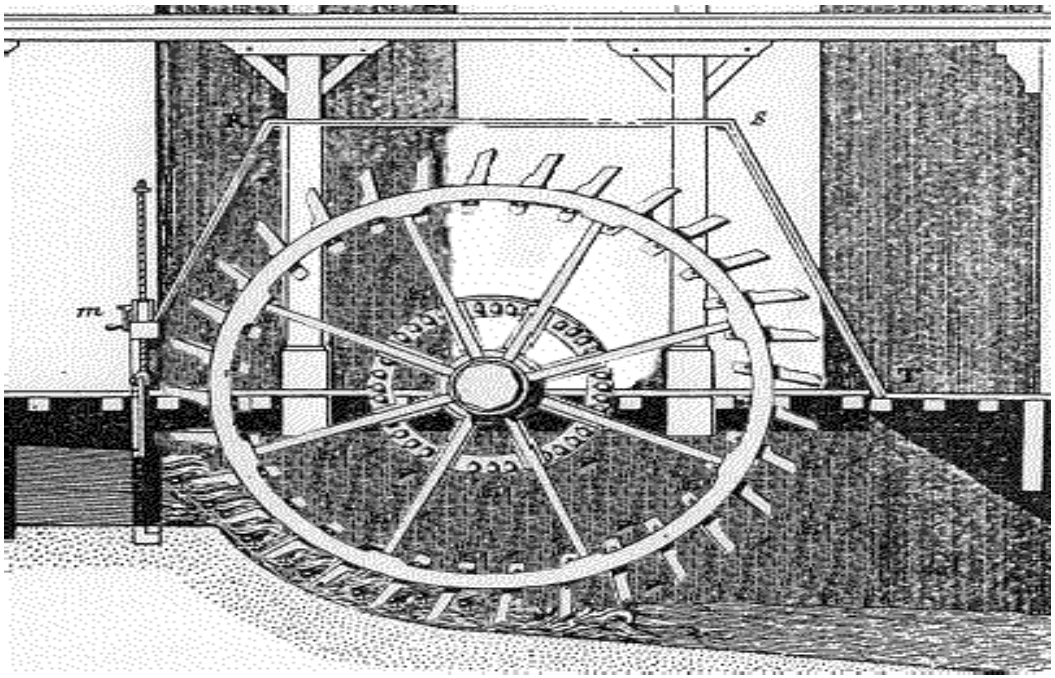
Electrical Switch Yard at a Dam

- India and one of the tallest in the world. It is a multi-purpose rock and earth-fill embankment dam on the Bhagirathi River near Tehri in Uttarakh and, India. It is the
- primary dam of the THDC India Ltd. and the Tehri hydroelectric complex.
- After a transformer raises the voltage (and decreases the current), the high lines connect to the red-and-white tower's insulators to be connected into the grid

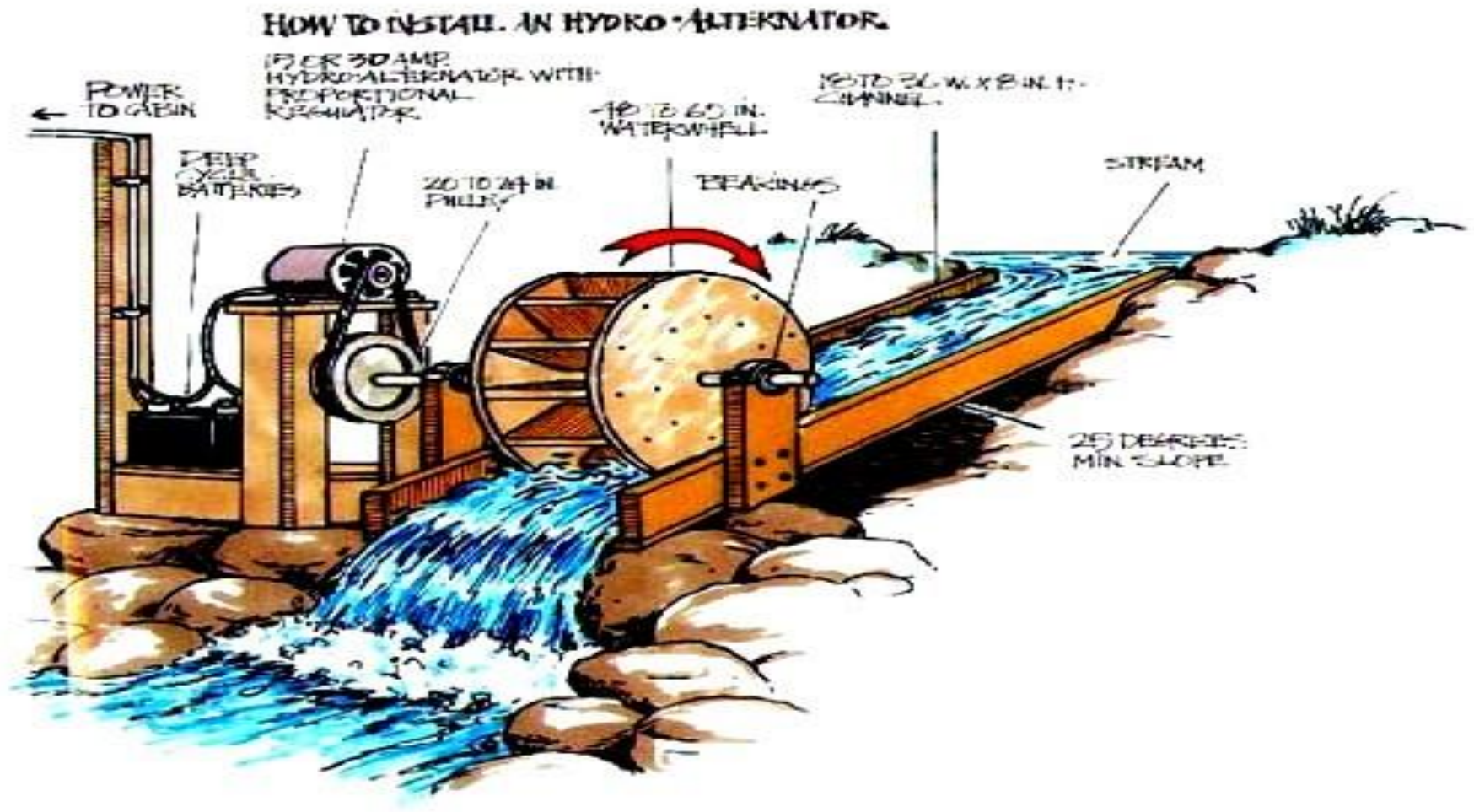
Working Of Water Wheels

- The water strikes the wheel about mid-way up so the inertia and the weight of the water push the wheel around

Water Flow



Micro Hydropow

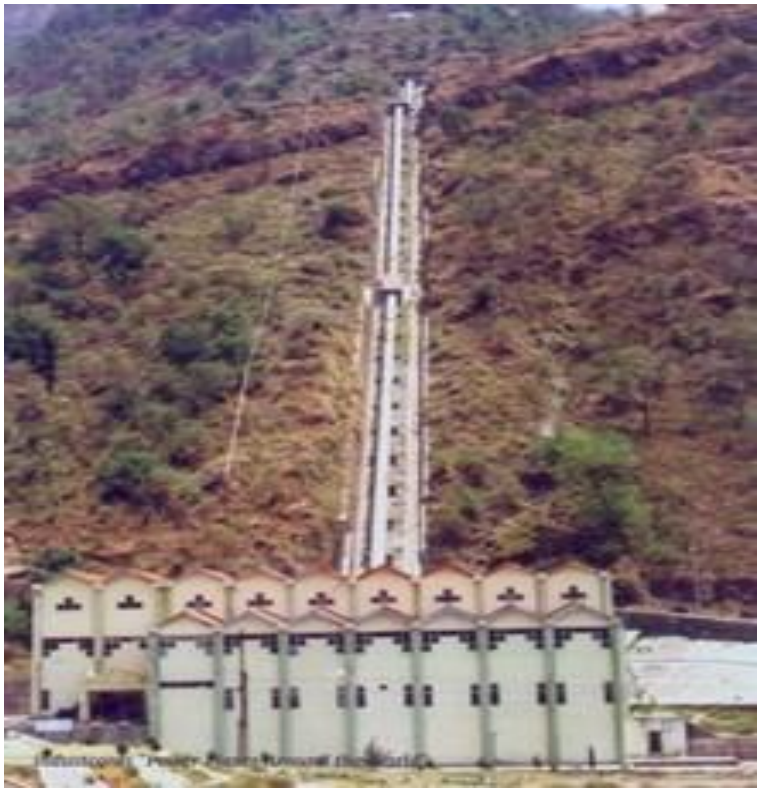


Hydroelectric Power Plants in India

na dam, Maharashtra

Ujjani dam, Maharashtra

Continued …



Gaj

Nathpa Jakri

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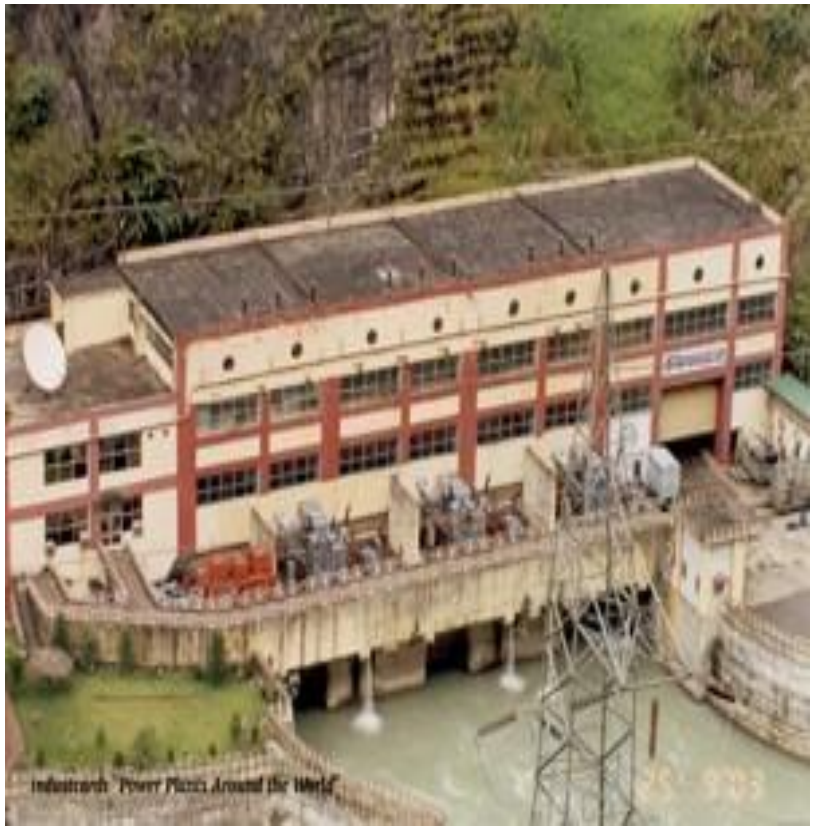
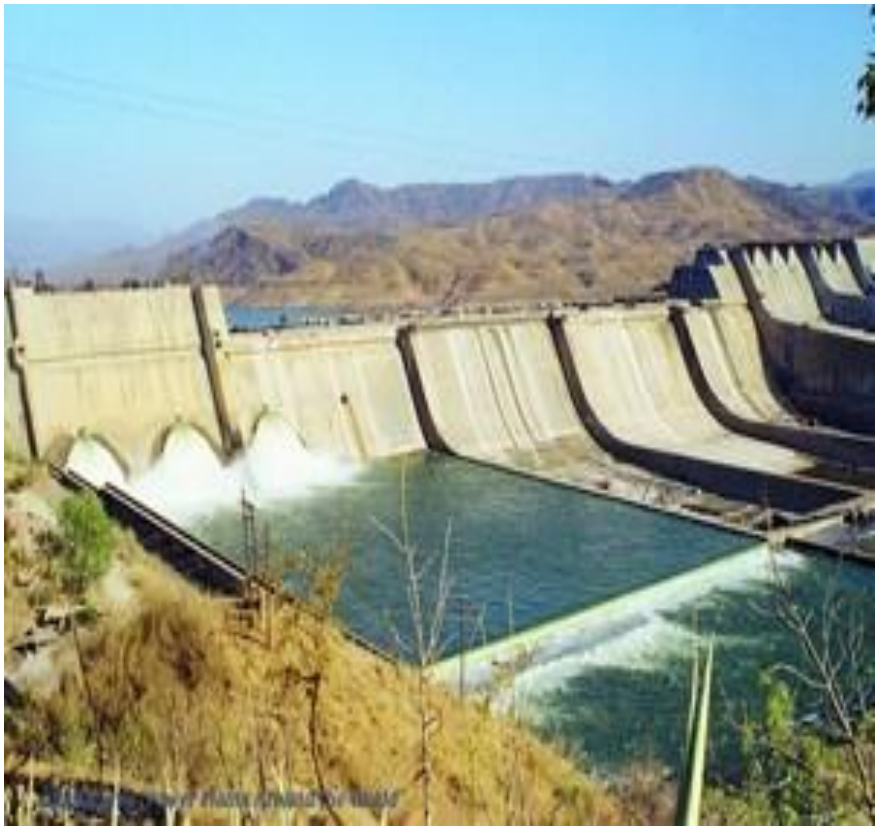


Rangit



Sardar Sarovar


INDIA
Hydro Power Plants
N
AFGHANISTAN
PAKISTAN
CHINA
(Tibet)
NEPAL
BHUTAN
BANGLADESH
MYANMAR
Sindh
Lower Jhelum
Pong
Dehar
Giri Bata
Yamuna (Stage 2)
Bhakra
Yamuna (Stage 1&4)
Nangal
Tehri
Gandki
Rana Pratap Sagar
Jawahar Sagar
Obra
Bihand
Loktak
Gandhi Sagar
Ukai
Hirkund
Bhivpuri
Khopoli
Koyna
Balimela
Upper Sileru
Lower Sileru
Nagarjuna sagar
Malprabha
Tungbhadra
Kalindi
Sharawati
Bhadra
Jog
Iduki
Kodayar
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
SRI LANKA
LAKSHADWEEP (INDIA)
ANDAMAN AND NICOBAR ISLANDS (INDIA)
LEGEND
Hydro Power Plant
Map not to Scale
Copyright © 2014 www.mapsofindia.com
(Updated on 2nd June 2014)


Wind Energy

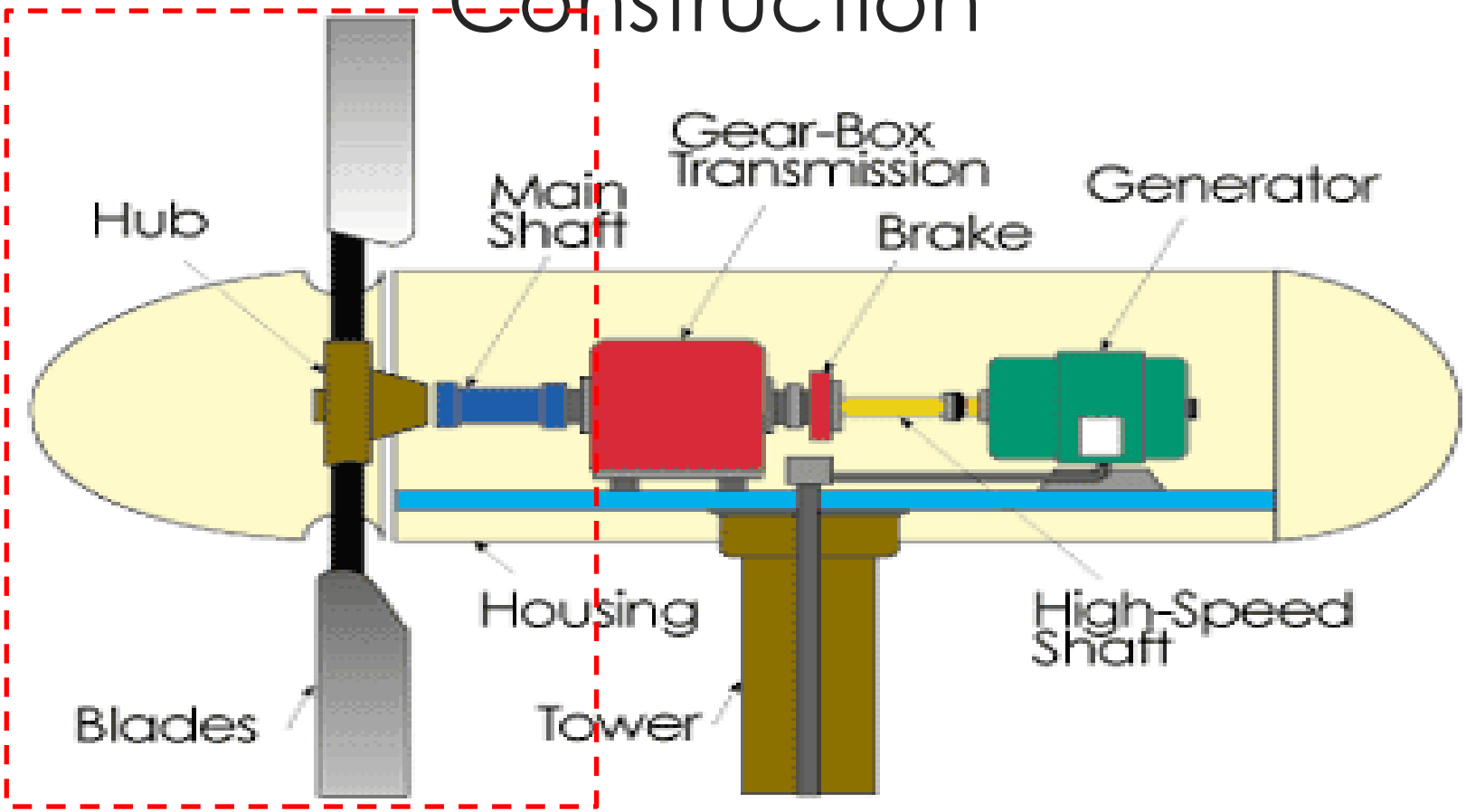
Wind Energy

- Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth.

- The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity

Common Wind Turbine Construction

Rotor



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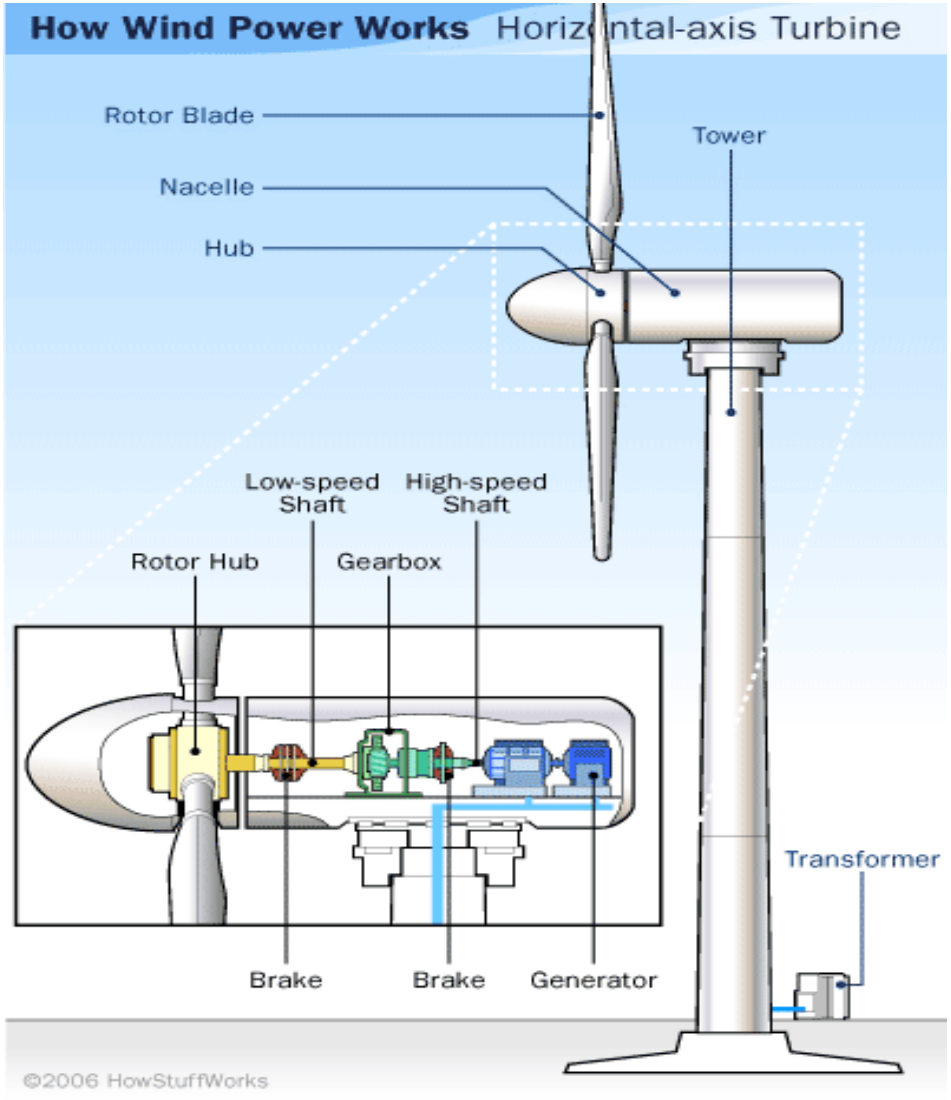
How Wind Power Works
Horizontal-axis Turbine
Rotor Blade
Nacelle
Hub
Tower
Low-speed Shaft
High-speed Shaft
Rotor Hub
Gearbox
Transformer
Brake
Brake
Generator
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Sizes and Applications

Small (≤10 kW)

- Homes
- Farms
- Remote Application

Intermediate (10-250 kW)

- Village Power
- Hybrid Systems
- Distributed Power

Large (660 kW - 2+MW)

- Central Station Wind Farms
- Distributed Power
- Community Wind

Location of wind farms

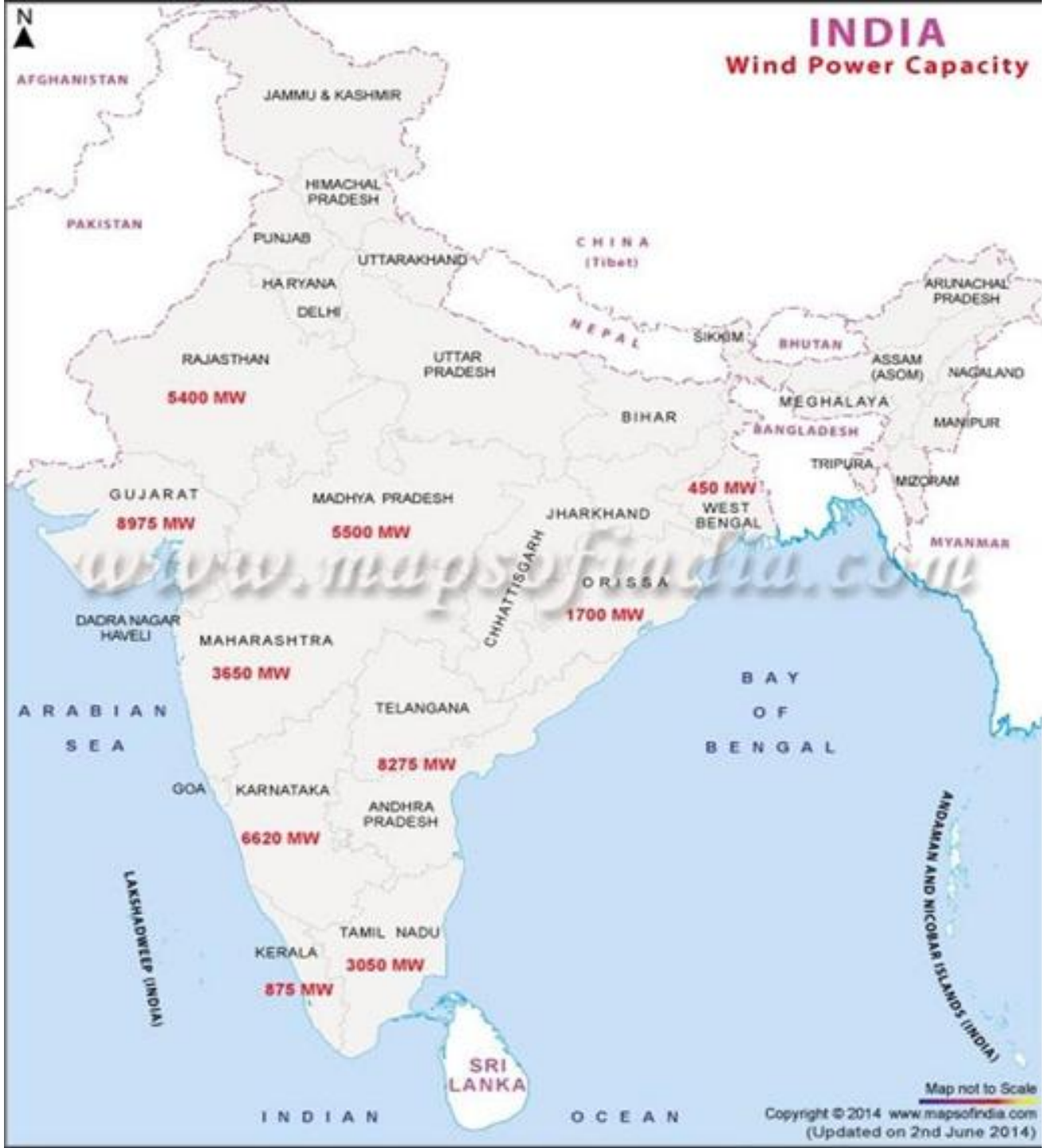
- Mountains or hilly areas
- It can be build even on sea sides or oceans

ADVANTAGES OF WIND POWER

1. No by-product is produced
2. Although wind turbines can be very tall each takes up only a small plot of land.
3. Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply.
4. Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them.

DISADVANTAGES OF WIND POWER:

1. Not uniform
2. Wind turbines are noisy. (About 70 mph).
3. Capacity of wind turbines is less.
4. Less efficiency (About 30%)



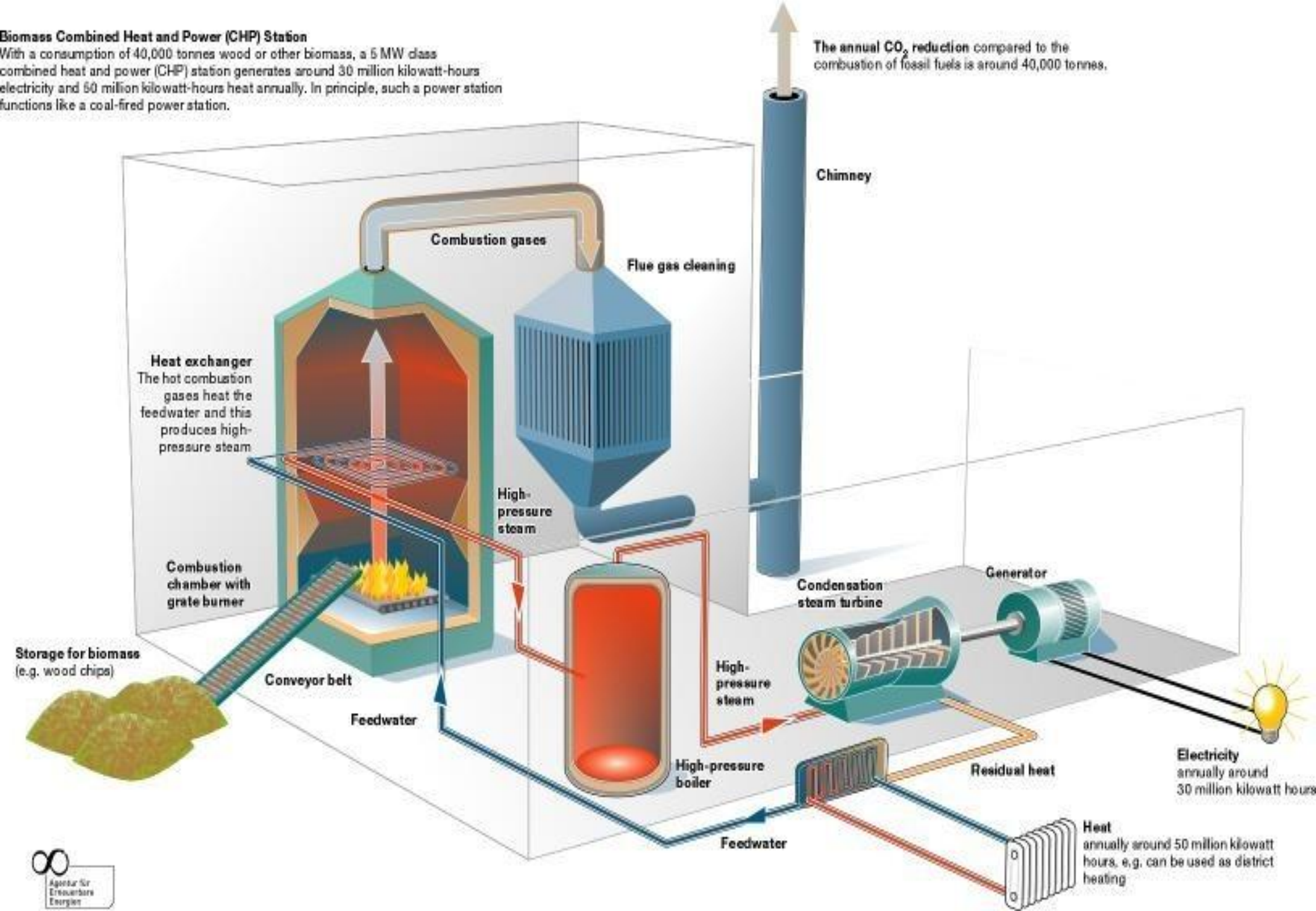

BIOMASS

Biomass fuels come from things that once lived: wood products, dried vegetation, crop residues, aquatic plants and even garbage. It is known as *'Natural Material'* . Plants used up a lot of the sun's energy to make their own food (photosynthesis). They stored the foods in the plants in the form of chemical energy. As the plants died, the energy is trapped in the residue. This trapped energy is usually released by burning and can be converted into biomass energy.

Wood is a biomass fuel. It is renewable. As long as we continue to plant new trees to replace those that were cut down, we will always have wood to burn. Just as with the fossil fuels, the energy stored in biomass fuels came originally from the Sun.

It is such a widely utilized source of energy, probably due to its low cost and indigenous nature, that it accounts for almost 15% of the world's total energy supply and as much as 35% in developing countries, mostly for cooking and heating.

Biomass Combined Heat and Power (CHP) Station
With a consumption of 40,000 tonnes wood or other biomass, a 5 MW class combined heat and power (CHP) station generates around 30 million kilowatt-hours electricity and 50 million kilowatt-hours heat annually. In principle, such a power station functions like a coal-fired power station.



Agentur für Erneuerbare Energien

Biomass converted into energy?

Burning:

- This is a very common way of converting organic matter into energy. Burning stuff like wood, waste and other plant matter
- Releases stored chemical energy in the form of heat, which can be used
- To turn shafts to produce
- electricity. Let's see this simple
- Illustration of how biomass is used to generate electricity.

1.Energy from the sun is transferred and stored in plants. When the plants are cut or die, wood chips, straw and other plant matter is delivered to the bunker

2. This is burned to heat water in a boiler to release heat energy (steam).

3. The energy/power from the steam is directed to turbines with pipes

4.The steam turns a number of blades in the turbine and generators, which are made of coils and magnets.

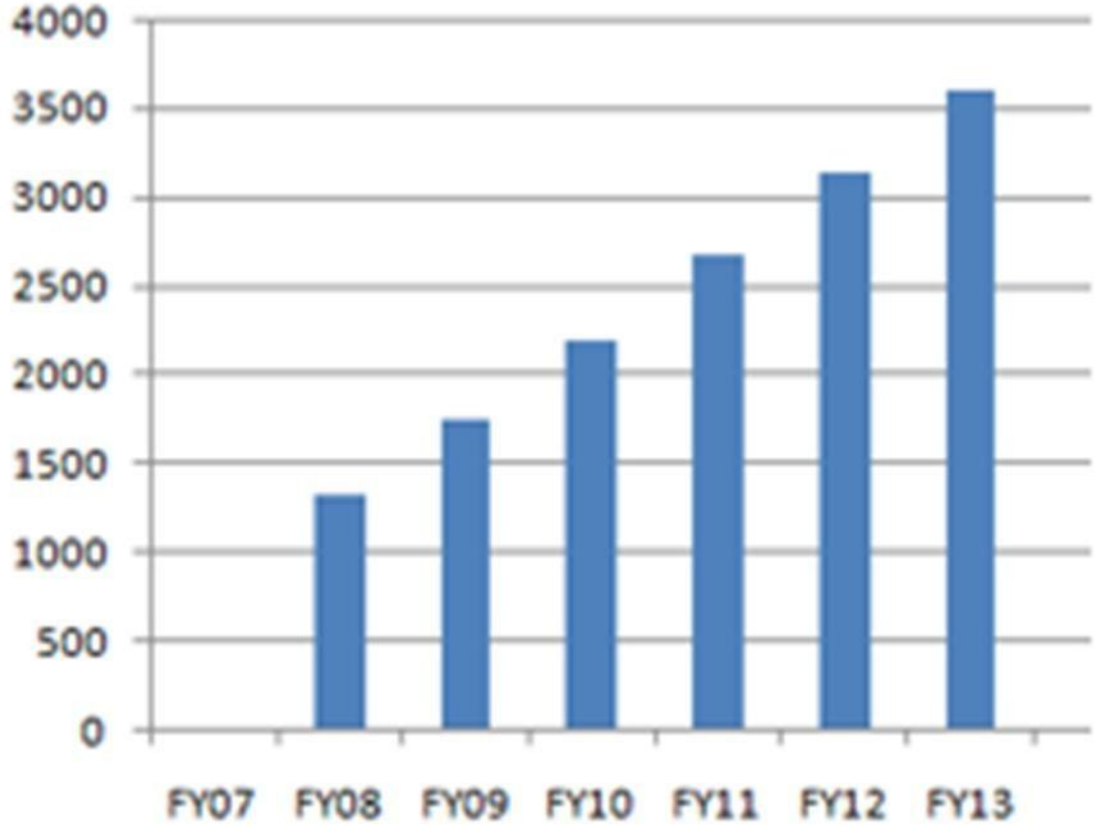
5.The charged magnetic fields produce electricity, which is sent to homes by cables.

Other ways in which organic matter can be converted into energy include:

Decomposition

- Things that can rot, like garbage, human and animal waste, dead animals and the like can be left to rot, releasing a gas called biogas (also known as methane gas or landfill gas). Methane can be captured by a machine called Micro turbine and converted into electricity. Sometimes, animal waste (poop) can also be converted into methane by a machine called 'Anaerobic Digester'
- Fermentation:
- Ethanol can be produced from crops with lots of sugars, like corn and sugarcane. The process used to produce ethanol is called gasification.

Growth of Biomass based power generation installed capacity in India (Mw)



FY07	1,112
FY08	1,324
FY09	1,751
FY10	2,199
FY11	2,665
FY12	3,135
FY13	3,601

Non Renewable sources of energy

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes—or even in many, many lifetimes. Most non-renewableenergy sources are fossil fuels: coal, petroleum, and natural gas. Carbon is the main element in fossil fuels.

UNIT-IV

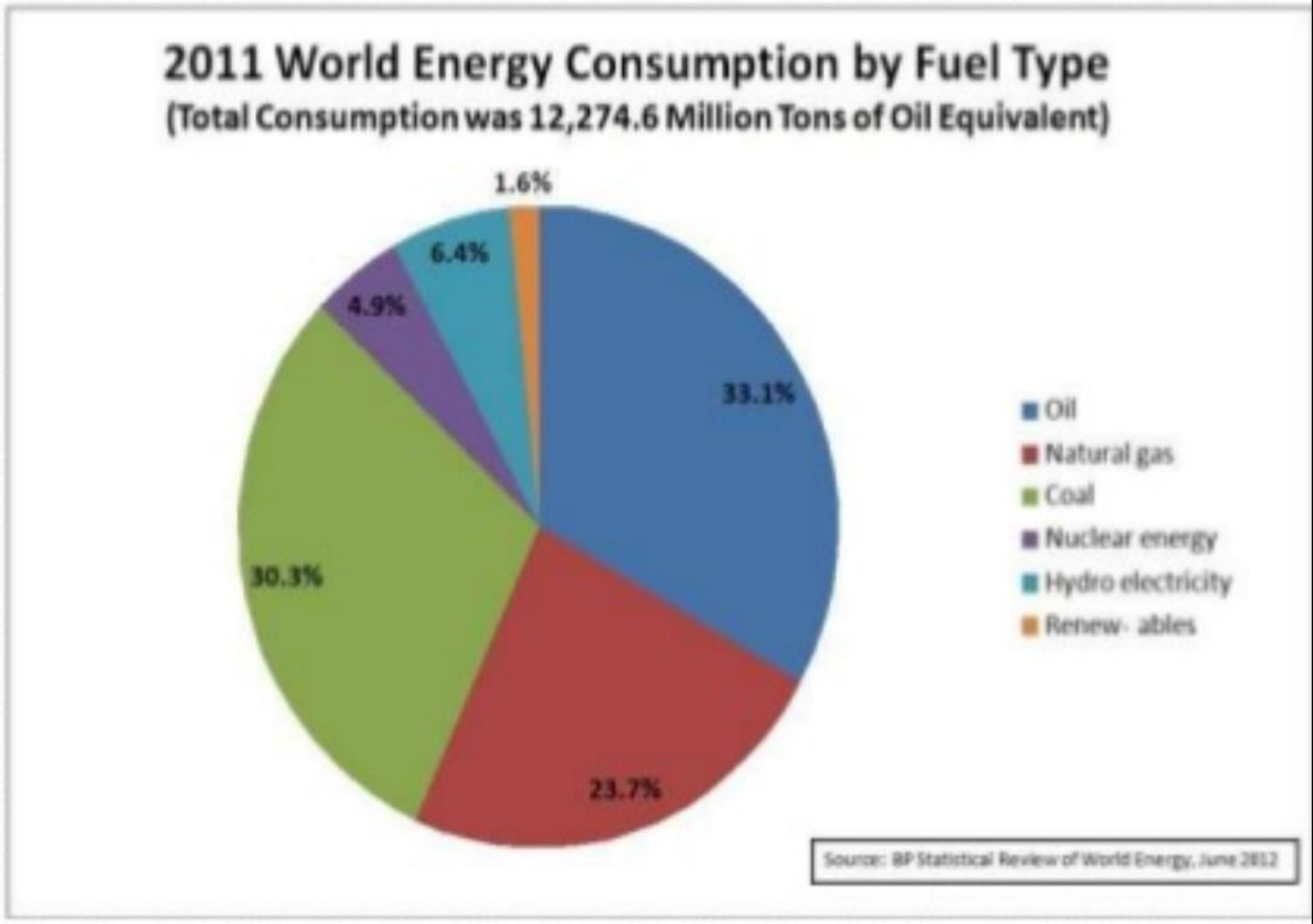
WIND ENERGY

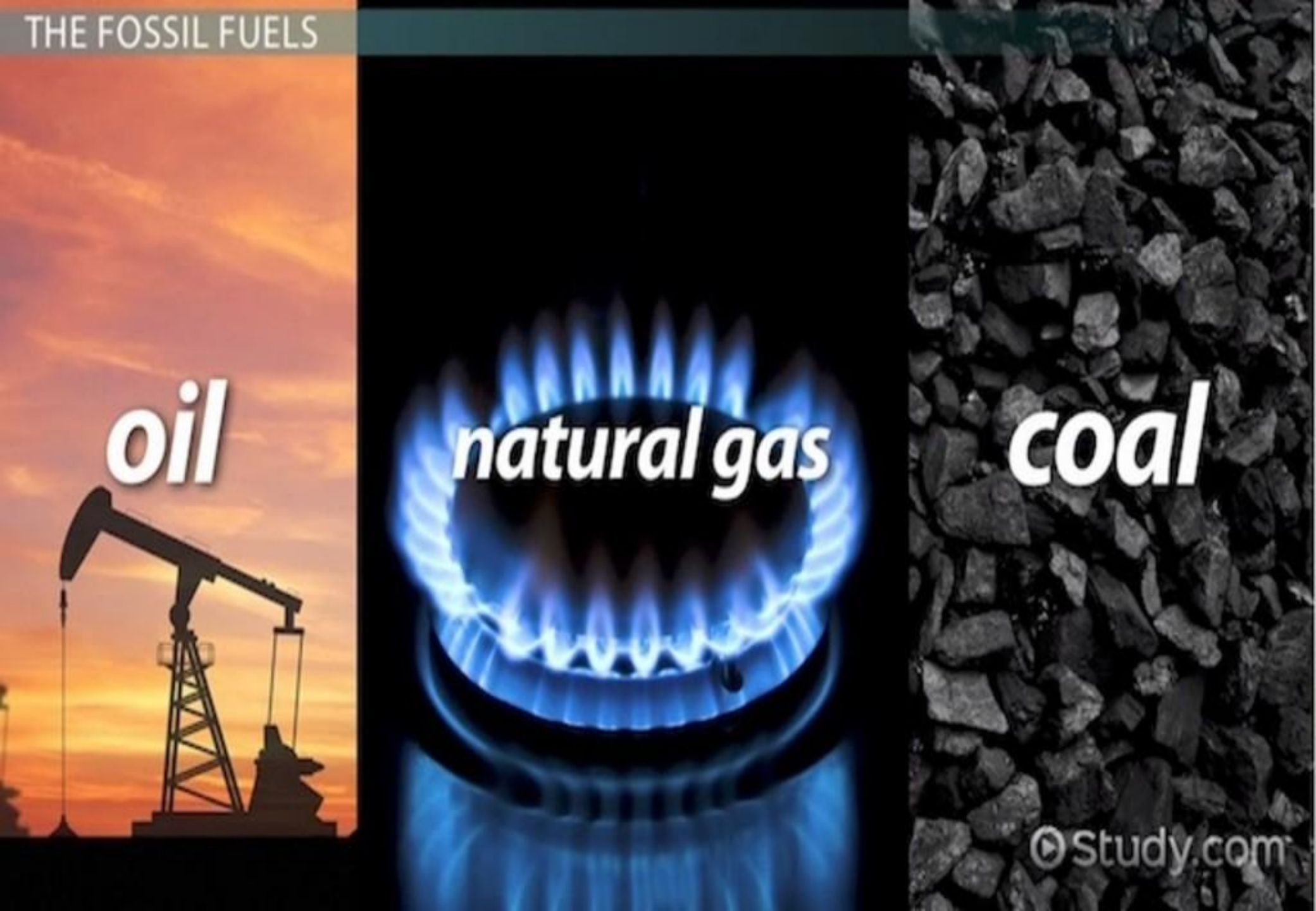
Fossil fuels

- There are three types of fossil fuels which can all be used for energy provision; coal, oil and natural gas. Coal is a solid fossil fuel formed over millions of years by decay of land vegetation. When layers are compacted and heated over time, deposits are turned into coal.

What are the 3 types of fossil fuels most commonly used?

1. Coal
2. Oil/Petroleum
3. Natural Gas




THE FOSSIL FUELS
oil
natural gas
coal
Study.com

- A major advantage of fossil fuels is their capacity to generate huge amounts of electricity in just a single location. Fossil fuels are very easy to find.

- When coal is used in power plants, they are very cost effective. Coal is also in abundant supply.

- Transporting oil and gas to the power stations can be made through the use of pipes making it an easy task. Power plants that utilize gas are very efficient.

- Power stations that make use of fossil fuel can be constructed in almost any location. This is possible as long as large quantities of fuel can be easily brought to the power plants.

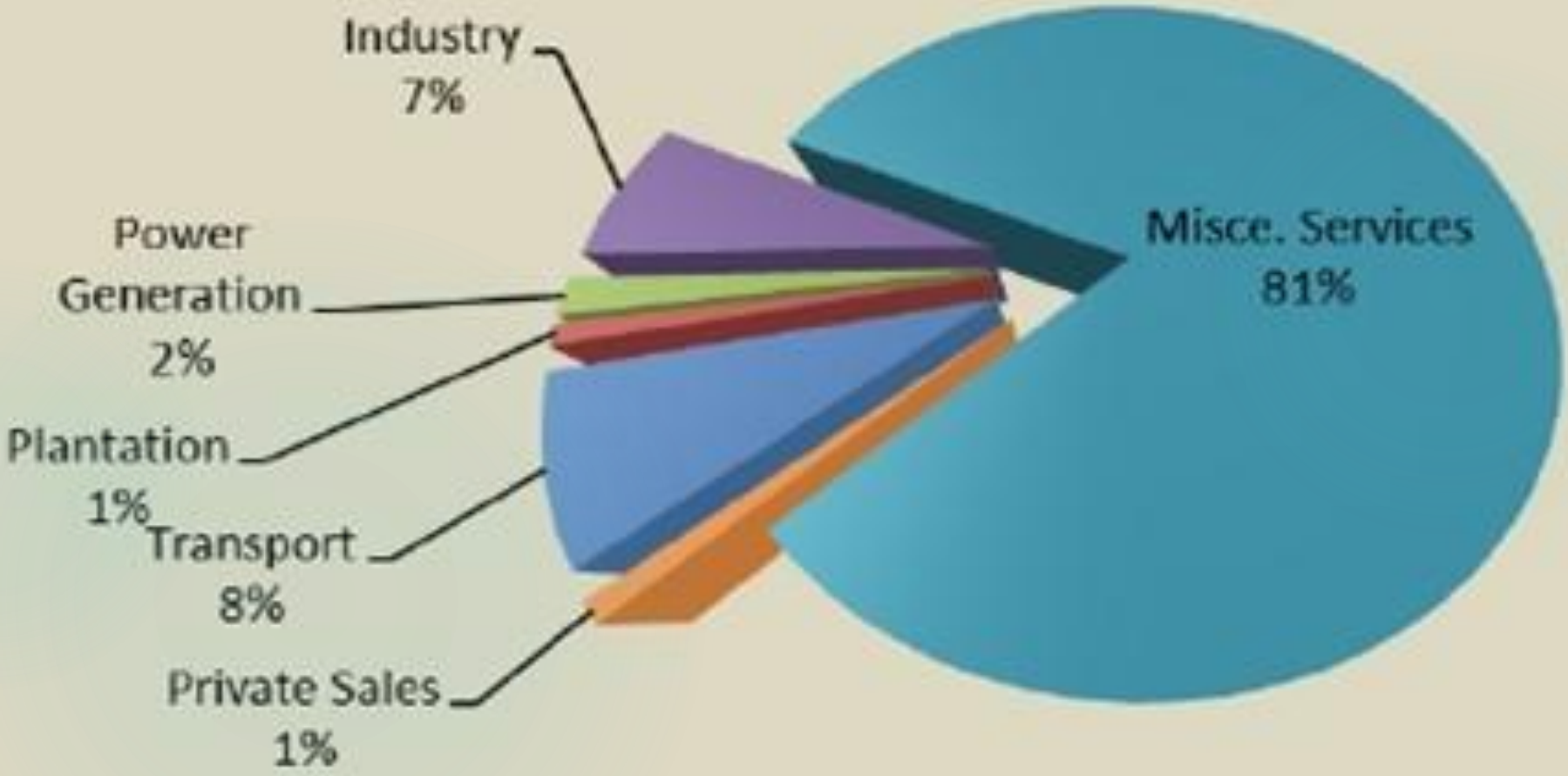
- Pollution is a major disadvantage of fossil fuels. This is because they give off carbon dioxide when burned thereby causing a greenhouse effect. This is also the main contributory factor to the global warming experienced by the earth today.

- Coal also produces carbon dioxide when burned compared to burning oil or gas. Additionally, it gives off sulphur dioxide, a kind of gas that creates acid rain.

- Environmentally, the mining of coal results in the destruction of wide areas of land. Mining this fossil fuel is also difficult and may endanger the lives of miners. Coal mining is considered one of the most dangerous jobs in the world.

- Power stations that utilize coal need large amounts of fuel. In other words, they not only need truckloads but trainloads of coal on a regular basis to continue operating and generating electricity. This only means that coal-fired power plants should have reserves of coal in a large area.
- near the plants location.
- Use of natural gas can cause unpleasant odors and some problems especially with transportation.

Sectorwise Consumption of Petroleum Products du
2011-12



Total Consumption = 74389.11

Natural gas

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higheralkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide,

or helium.[2] It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure supplied by existing under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.

NATURAL GAS

Advantages

Ample supplies (125 years)

High net energy yield

Low cost (with huge subsidies)

Less air pollution than other fossil fuels

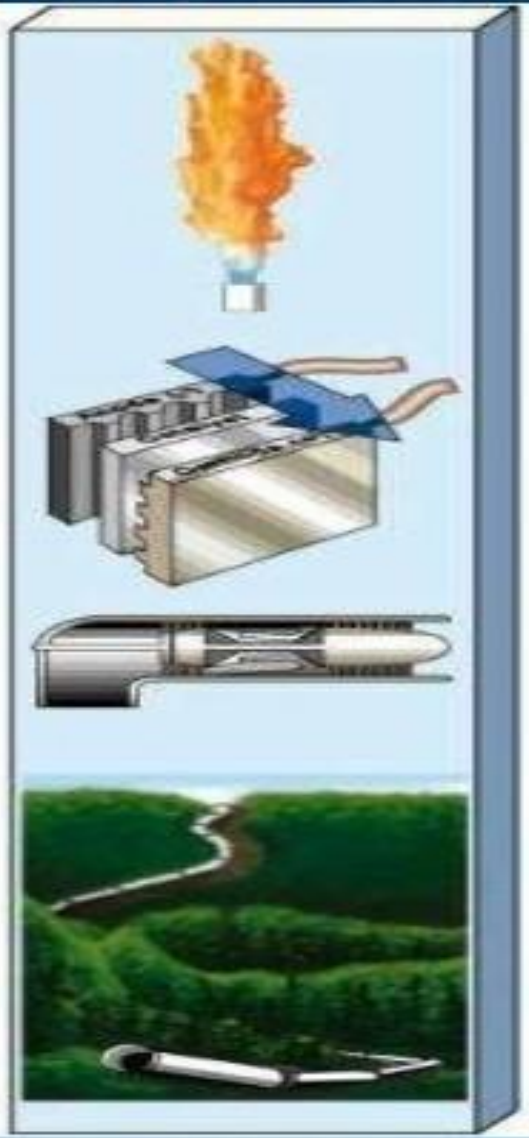
Lower CO_2 emissions than other fossil fuels

Moderate environmental impact

Easily transported by pipeline

Low land use

Good fuel for fuel cells and gas turbines



Disadvantages

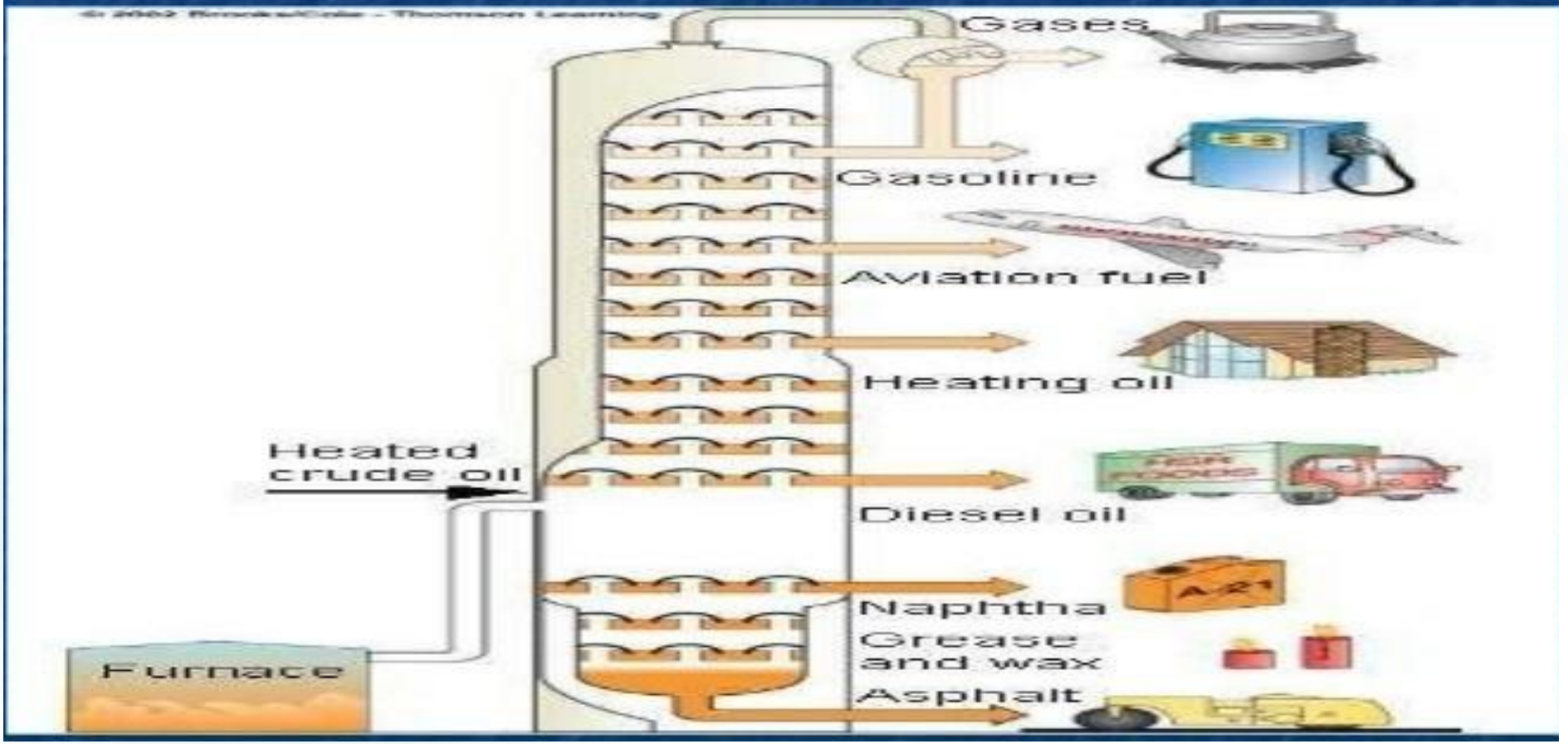
Releases CO_2 when burned

Methane (a greenhouse gas) can leak from pipelines

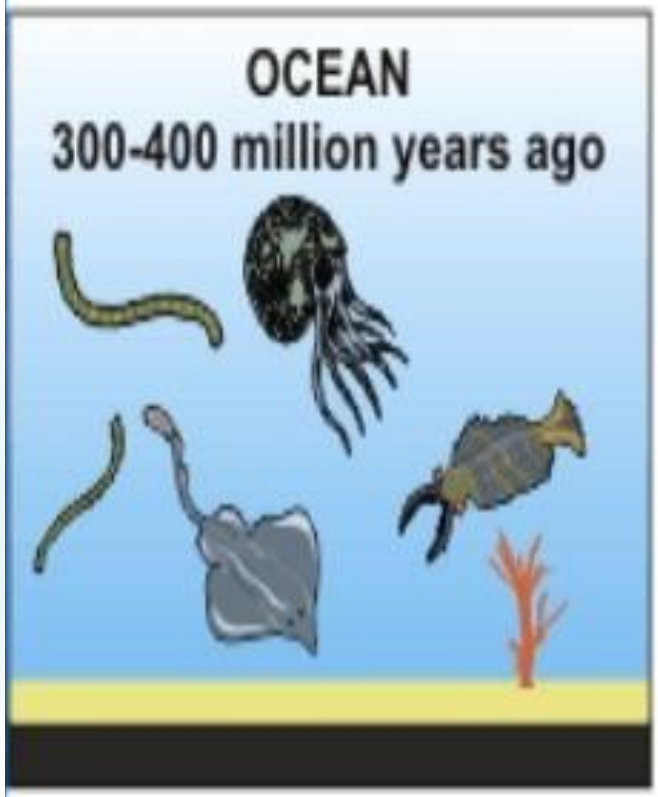
Shipped across ocean as highly explosive LNG

Sometimes burned off and wasted at wells because of low price

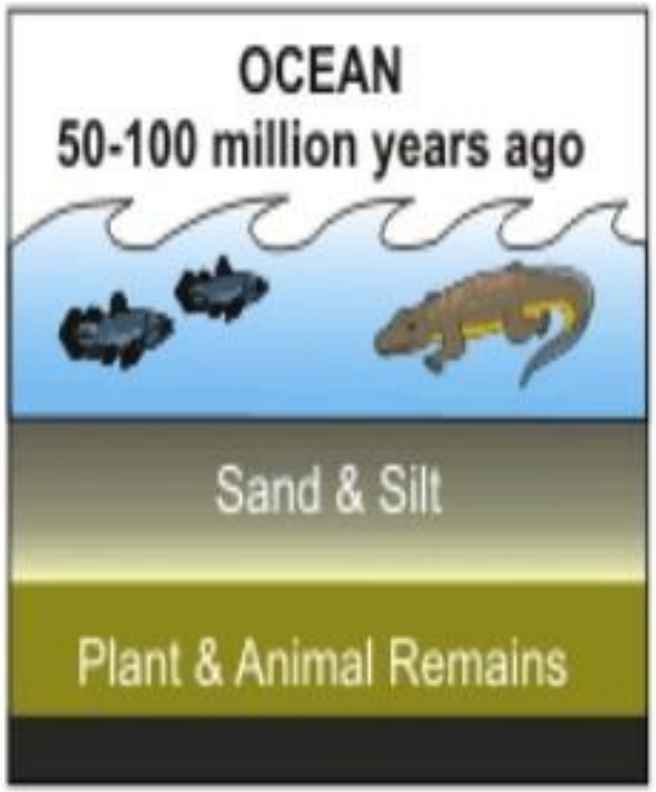
Oil refining process



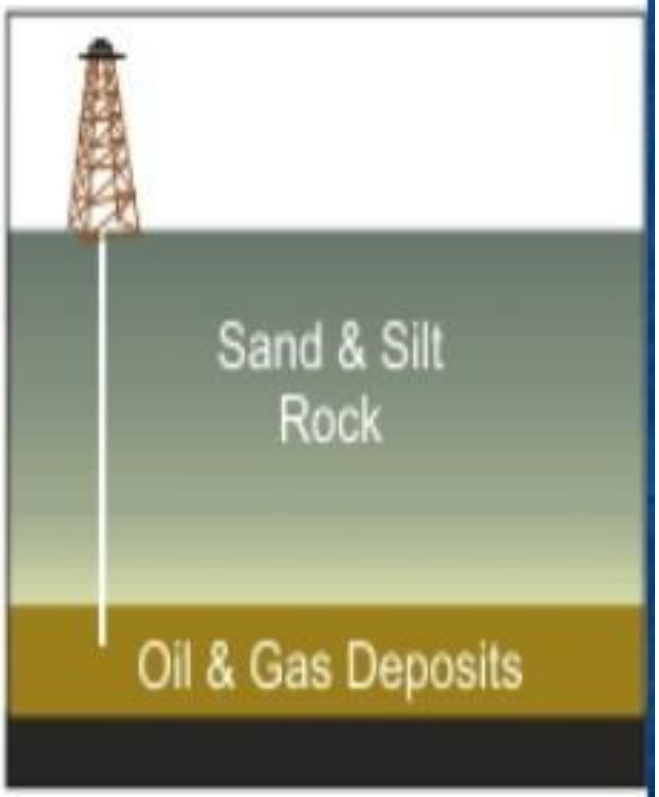
HOW ARE OIL AND GAS MADE ???



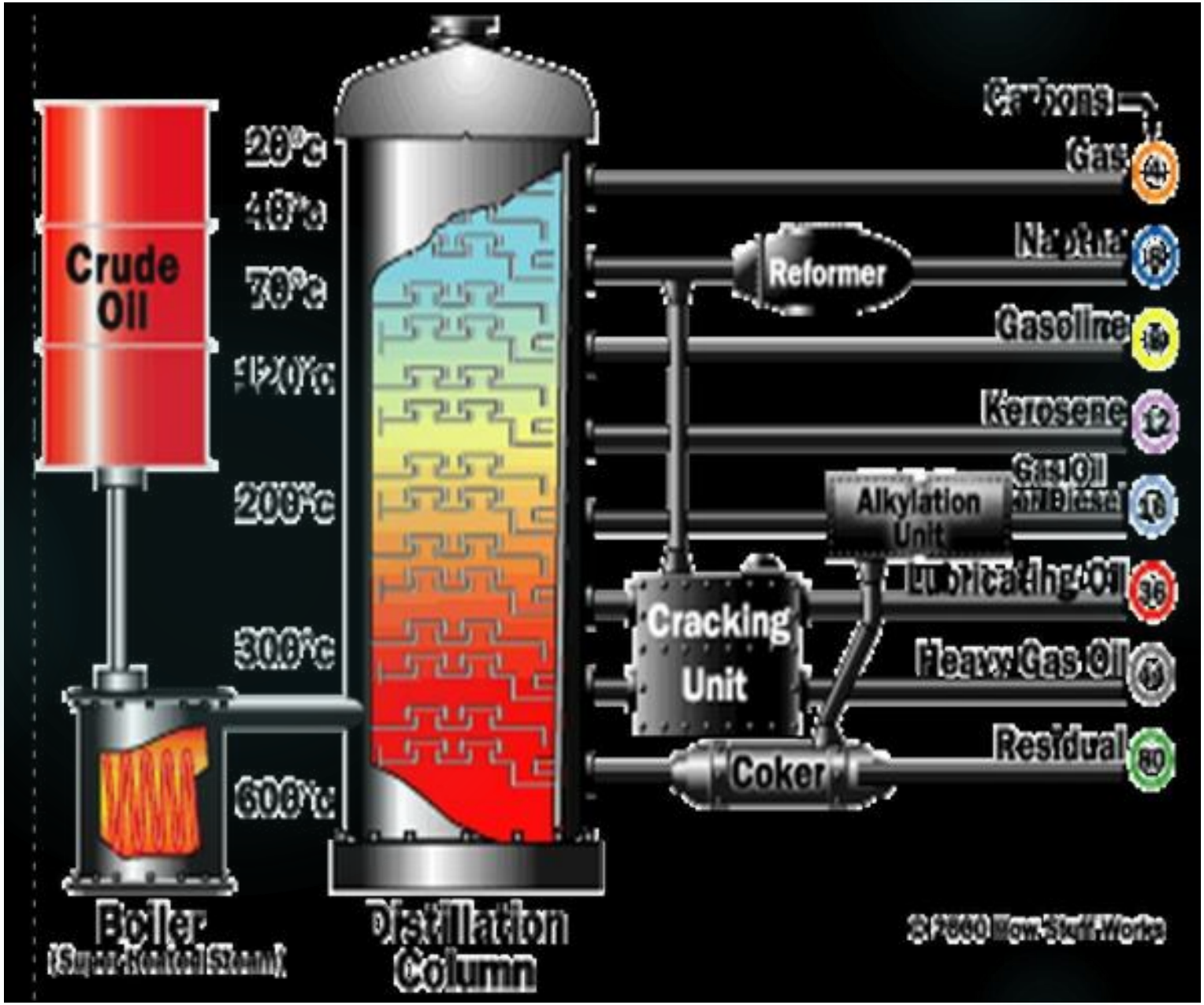
Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.



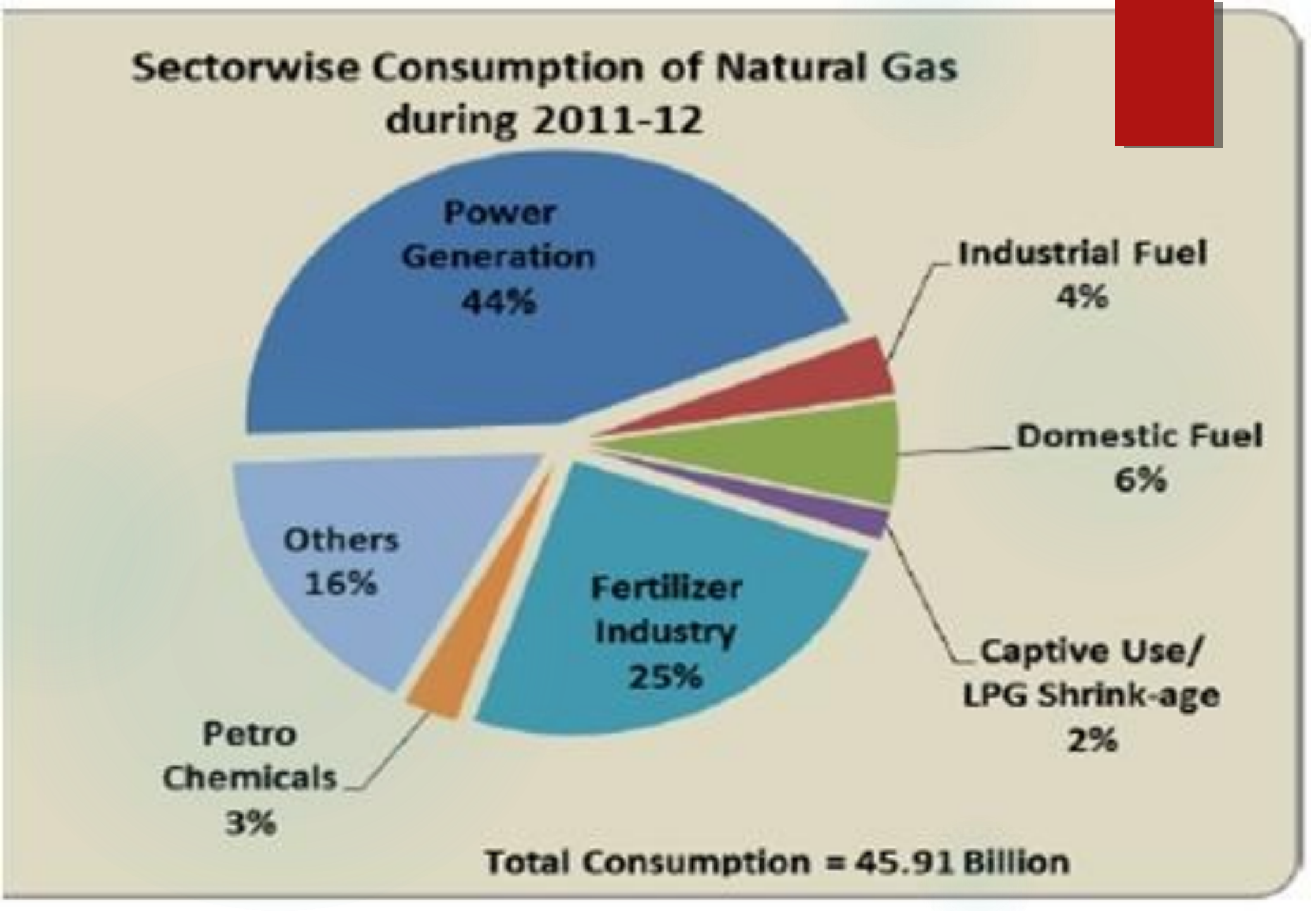
Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.



Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and gas deposits.


Crude Oil
20°c
40°c
70°c
200°c
300°c
600°c
Reformer
Alkylation Unit
Cracking Unit
Coker
Gas
Gasoline
Kerosene
Gas Oil
Lubricating Oil
Heavy Gas Oil
Residual
Boiler
Distillation Column

Sectorwise Consumption of Natural Gas during 2011-12



Total Consumption = 45.91 Billion

UNIT-V
BIO-MASS

Coal Is a Plentiful but Dirty Fuel

- World's most abundant fossil fuel
  - U.S. has 25%
  - Current usage we have a 300 year supply

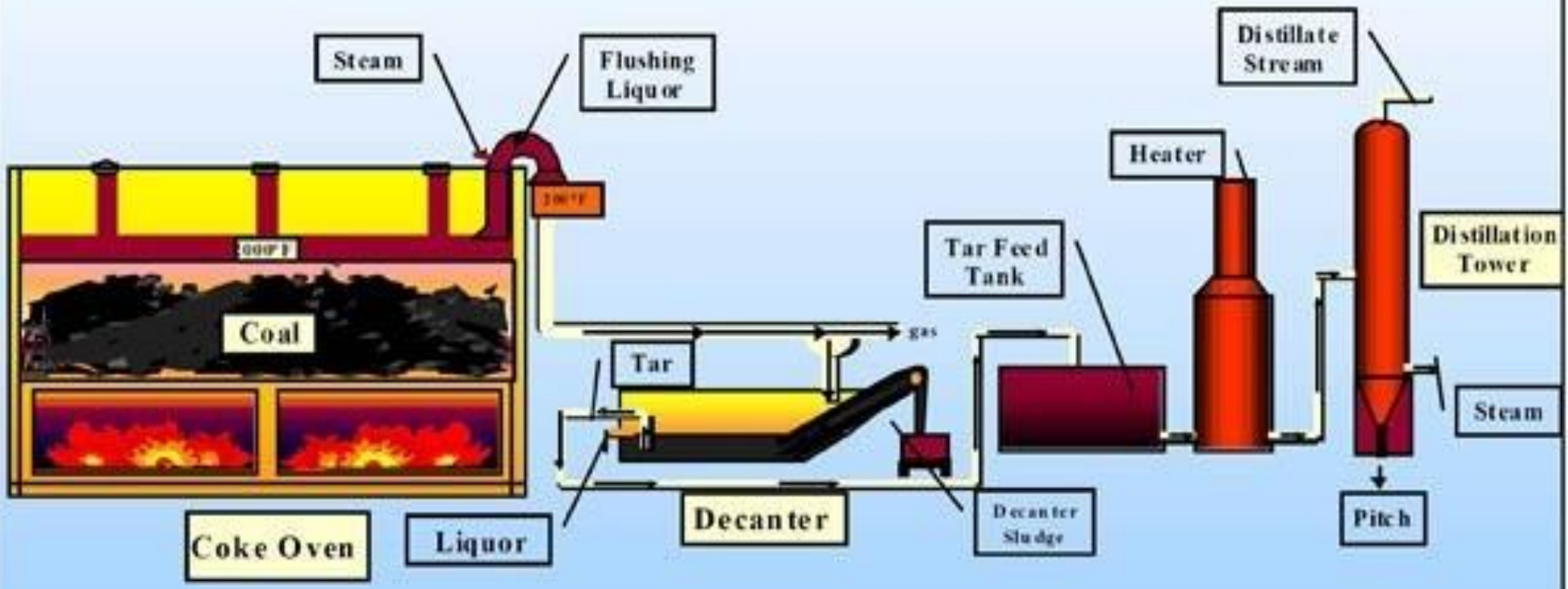
- Environmental costs of burning coal
  - Severe air pollution
    - Sulfur released as SO_2
    - Large amount of soot
    - CO_2
    - Trace amounts of Hg and radioactive materials
    - Dirtiest fossil fuel to burn.

Advantages
of using coal as a source of energy

Coal is

- The least expensive fossil fuel because it is rather simple to mine.
- Powered generation scales well, making it economically possible to build a wide variety of sizes of generation plants.
- Easily combustible, and burns at low temperatures, making coal-fired boilers cheaper and simpler than fossil fuels.
- Abundant in quantity and can be easily transported to many areas of the world.

PRODUCTION OF COAL TAR PITCH



Courtesy of Koppers Industries, Inc.

Trade-Offs

Coal

Advantages

Ample supplies in many countries

High net energy yield

Low cost when environmental and health costs are not included

Disadvantages

Severe land disturbance and water pollution

Fine particle and toxic mercury emissions threaten human health

Emits large amounts of CO_2 and air pollutants when produced and burned

NUCLEAR POWER

- Nuclear energy is the energy in the nucleus, or core, of an atom. Atoms are tiny units that make up all matter in the universe. Energy is what holds the nucleus together. There is a huge amount of power in an atoms dense nucleus. In fact, the power that holds the nucleus together is officially called the "strong force.
- Nuclear energy can be used to create electricity, but it must first be released from the atom. In nuclear fission, atoms are split to release the energy.

- A nuclear reactor, or power plant, is a series of machines that can control nuclear fission to produce electricity. The fuel that nuclear reactors use to produce nuclear fission is pellets of the element uranium. In a nuclear reactor, atoms of uranium are forced to break apart. As they split, the atoms release tiny particles called fission products. Fission products cause other uranium atoms to split, starting a chain reaction. The energy released from this chain reaction creates heat.

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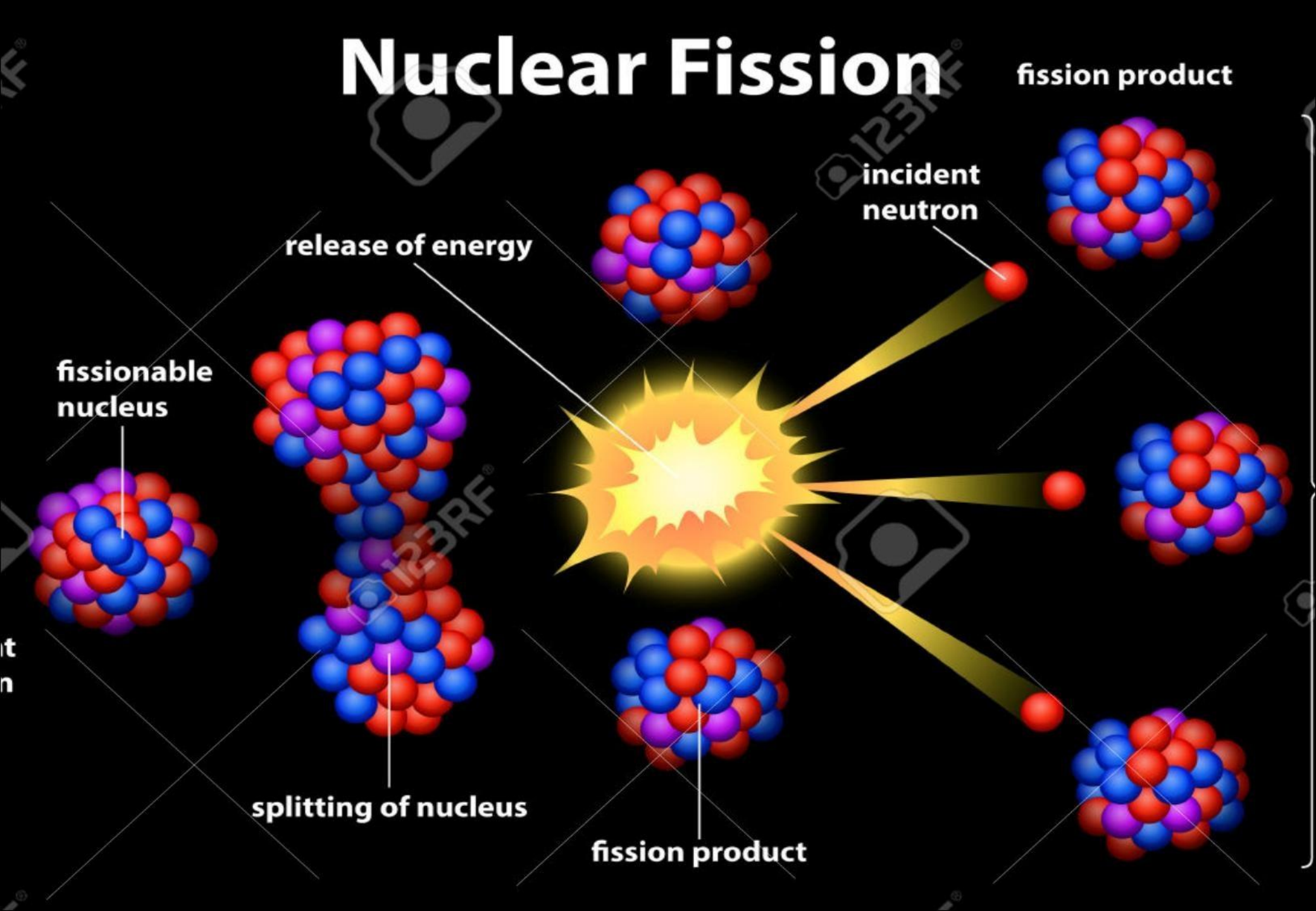
WHO DESCOVERED NUCLEAR FISSION

Nuclear fission of heavy elements was discovered on December 17, 1938 by German Otto Hahn and his assistant Fritz Strassmann, and explained theoretically in January 1939 by Lise Meitner and her nephew Otto Robert Frisch.

WORKING OF NUCLEAR FISSION

When an atom of nuclear fuel (uranium) absorbs a neutron, the uranium will **fission** into two smaller atoms (waste) and release one to three neutrons. The kinetic energy of the waste is used to heat the water for the steam turbine. The neutrons are used to **fission** the next lot of uranium atoms and the process continues.


Nuclear Fission
fission product
incident neutron
release of energy
fissionable nucleus
splitting of nucleus
fission product

NUCLEAR FUSION

Fusion power is the generation of energy by nuclear fusion.Fusion reactions are high energy reactions in which two lighter atomic nuclei fuse to form a heavier nucleus. This major area of plasma physics research is concerned with harnessing this reaction as a source of large scale sustainable energy.

Nuclear Fusion

If light nuclei are forced together, they will fuse with a yield of energy because the mass of the combination will be less than the sum of the masses of the individual nuclei. If the combined nuclear mass is less than that of iron at the peak of the binding energy curve, then the nuclear particles will be more tightly bound than they were in the lighter nuclei, and that decrease in mass comes off in the form of energy according to the Einstein relationship. For elements heavier than iron, fission will yield energy.

For potential nuclear energy sources for the Earth,

the deuterium-tritiumfusion reaction contained by some kind of magnetic confinement seems the most likely path. However, for the fueling of the stars, other fusion reactions will dominate.

Advantages:

Large nameplate capacity per plant, typically around 1 GW. Typically 90% capacity factor, maximizing output from the nameplate capacity.

Small fuel transportation volumes as the fissionable material just isn't that big or heavy compared to equivalent fossil fuel BTU sources.

Low CO2 per MWH on a full life cycle basis. ~12 grams which is only slightly more than wind / solar. This is a reason nuclear is a much better source for one of the major pressing problems of today than fossil fuels: global warming.

No particulate matter pollution.

No sulfur dioxide or other chemical pollution.

Low fatalities per TWH. Nuclear is higher than renewables according to current statistics, but much, much lower than fossil fuel generation.

Disadvantages:

Nuclear power is costly power. The EIA puts the wholesale cost at 11 to 13 cents USD per KWH for new nuclear full lifecycle. The US Vogtle example is running 11 cents USD per KWH unless more delays and problems drive that cost

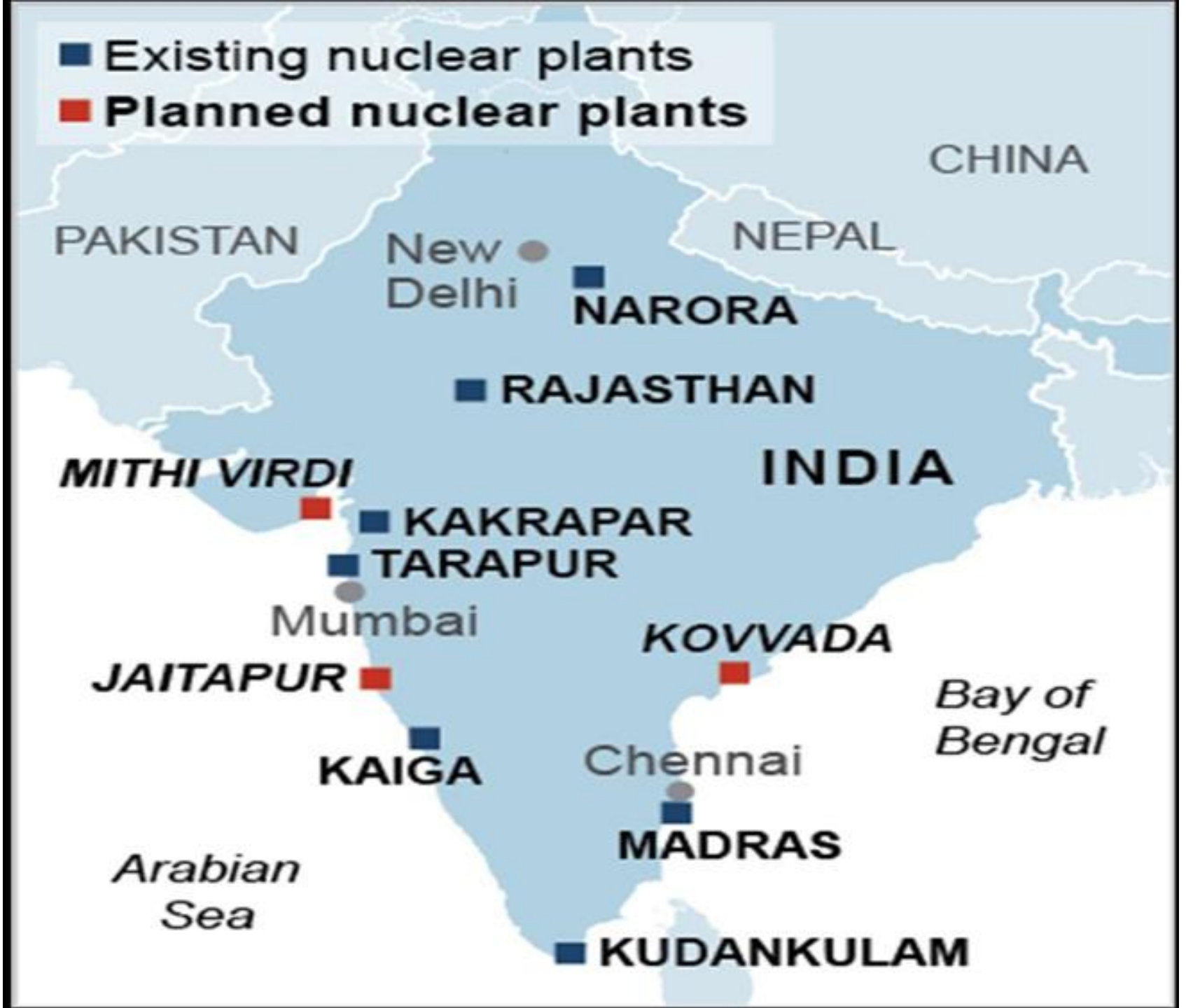
Nuclear armaments proliferation. Most nuclear generation technologies lend themselves to easier nuclear armament manufacturing, especially through the fuel cycle.

Nuclear has very large potential economic liabilities. Fukushima is trending toward a total cost of one trillion USD with cleanup, long-term loss of 150 square kilometres of productive land, displacement, lawsuits, utility bankruptcies and bailouts, GDP impacts and the cost of replacement fossil fuels. While the probability of another Fukushima isn't high, every generation has had its nuclear disaster.

Poor social license. There have been about 70 years of movies out of Hollywood, Japan and other nations which have typically made everyone terrified of radiation. Nuclear energy has been demonized. It's the work of a generation to reverse that globally. This is crucial as politicians rule at the pleasure of their citizens. Fighting for nuclear is usually a no-win situation

High cool water needs. Nuclear plants are thermal generation plants which require large volumes of relatively cool water to operate. In areas of drought and increasing water temperatures, some nuclear plants are already on reduced generation capacity and are threatened with shutdowns. Some nuclear generation assets may be completely inoperable in the future.


Nuclear power plants in India


Existing nuclear plants
Planned nuclear plants
CHINA
PAKISTAN
NEPAL
New Delhi
NARORA
RAJASTHAN
INDIA
MITHI VIRDI
KAKRAPAR
TARAPUR
Mumbai
KOVVADA
JAITAPUR
Bay of Bengal
KAIGA
Chennai
MADRAS
Arabian Sea
KUDANKULAM

NuclearReactor Accidents

The accidents at the Three Mile Island (TMI) and Chernobyl nuclear reactors have triggered particularly intense concern about radiation hazards. The TMI accident, in Pennsylvania in 1979, resulted from a combination of deficient equipment and operator errors. Even though there was severe damage to the nuclear fuel within the reactor, very little radioactivity escaped into the outside environment. The effectiveness of the large concrete containment building that surrounded the reactor contributed to this relatively small release. Subsequent studies concluded that the maximum dose received by any member of the public was under 1 mSv (100 mrem). The collective off- site dose is estimated to have been about 20 person-Sv. Under the standard low-dose assumption, this corresponds to one eventual cancer fatality in the neighboring population of 2 million people. (This population receives an annual collective dose of about 6000 person-Sv from natural sources.)

International Atomic Energy Agency (IAEA)

- A nuclear and radiation accident is defined by the International Atomic Energy Agency (IAEA) as "an event that has led to significant consequences to people, the environment or the facility." Examples include lethal effects to individuals, large radioactivity release to the environment, or reactor core melt."[4] The prime example of a "major nuclear accident" is one in which a reactor core is damaged and significant amounts of radioactivity are released, such as in the Chernobyl disaster in 1986.