

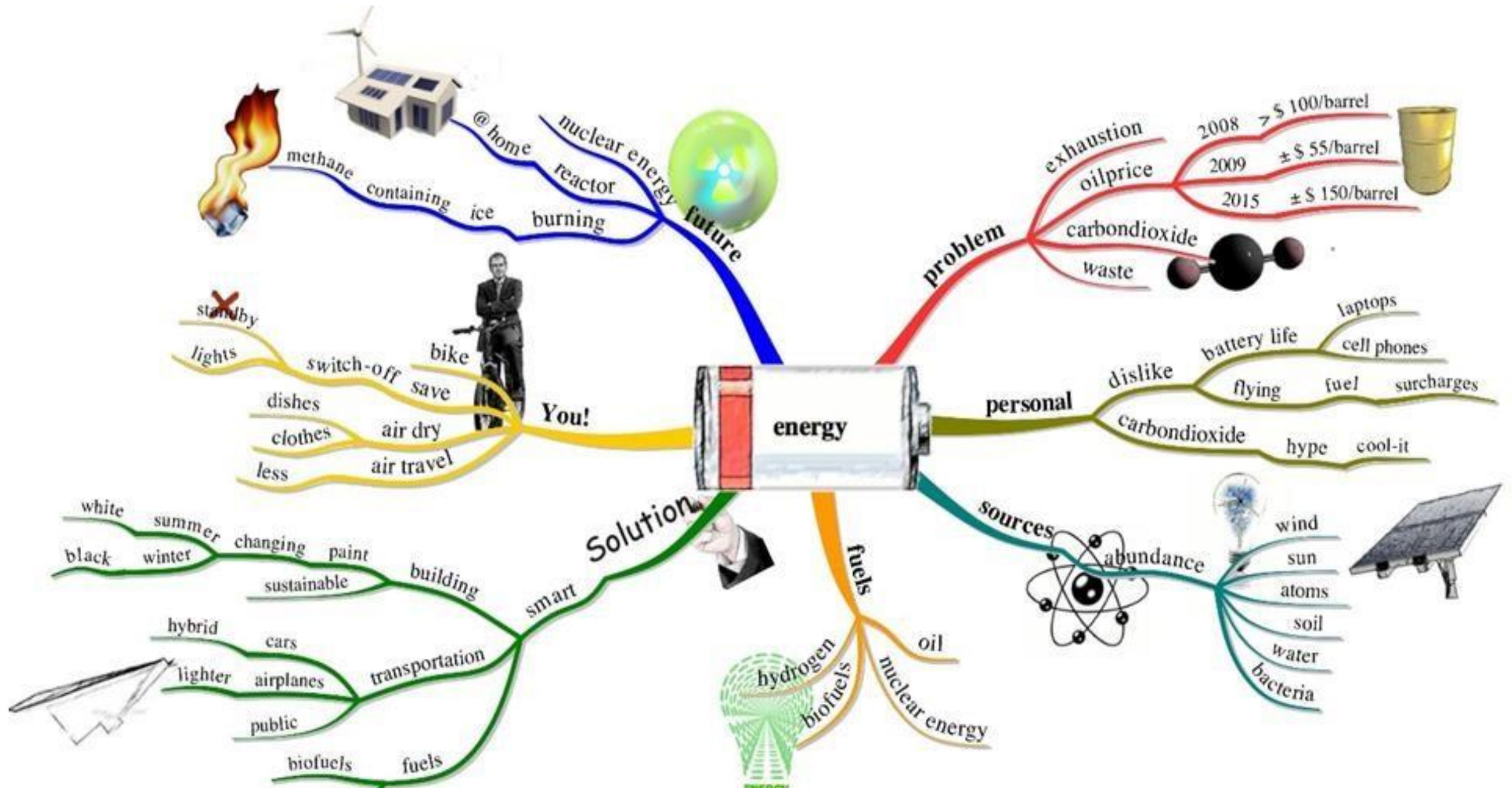
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# **Introduction to Environmental Science**

**Renewable Energy Resources**

**Dr. Emmanuel Amankwah**

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# **Renewable Energy Resources**

## ***What is energy?***

Energy is defined as the capacity to do work. Energy can neither be created nor destroyed. It only changes from one form to another. It is the fuel for life.

## **Mechanical energy:**

***Potential Energy:*** It is the energy possessed by a body by virtue of its position or configuration

***Kinetic energy:*** It is the energy possessed by a body by virtue of its motion.

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20-25% of the chemical energy in gasoline is converted to mechanical energy. The rest is lost into the environment as low quality heat energy.

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5% of electricity is changed into u



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low-quality heat

## **Harnessing Energy Sources**

Energy source has greatly influenced the development of civilization.

- Human or muscle power – eg. Cheap labour
- Animal power
- Steam engine – using firewood
- Coal – to power steam engines, industrial application, electricity production, etc.

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- Fossil fuel (oil, gas and coal) – current energy sources
- Renewable energy for the future

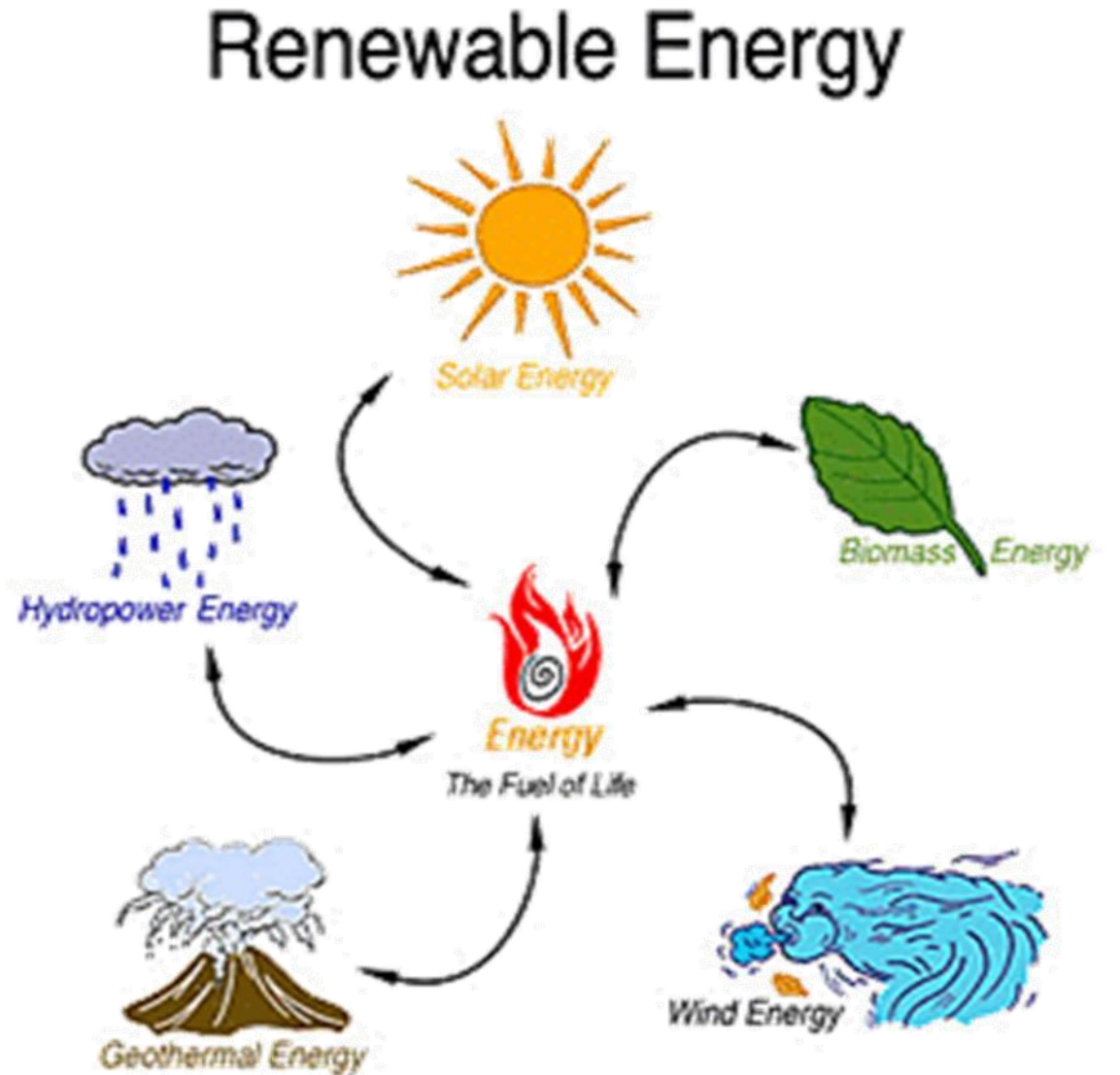
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# **Types of Energy**



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## Renewable energy resources



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They are mostly biological in nature:

- Biomass energy from plants
- Solar energy
- Wind energy
- Hydropower energy
- Geothermal energy

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## **Renewable Resources**

Renewable energy is supposed to be sustainable over time but

Overexploitation of the soil, forest, etc. will affect its availability

Poor management is also a key factor.

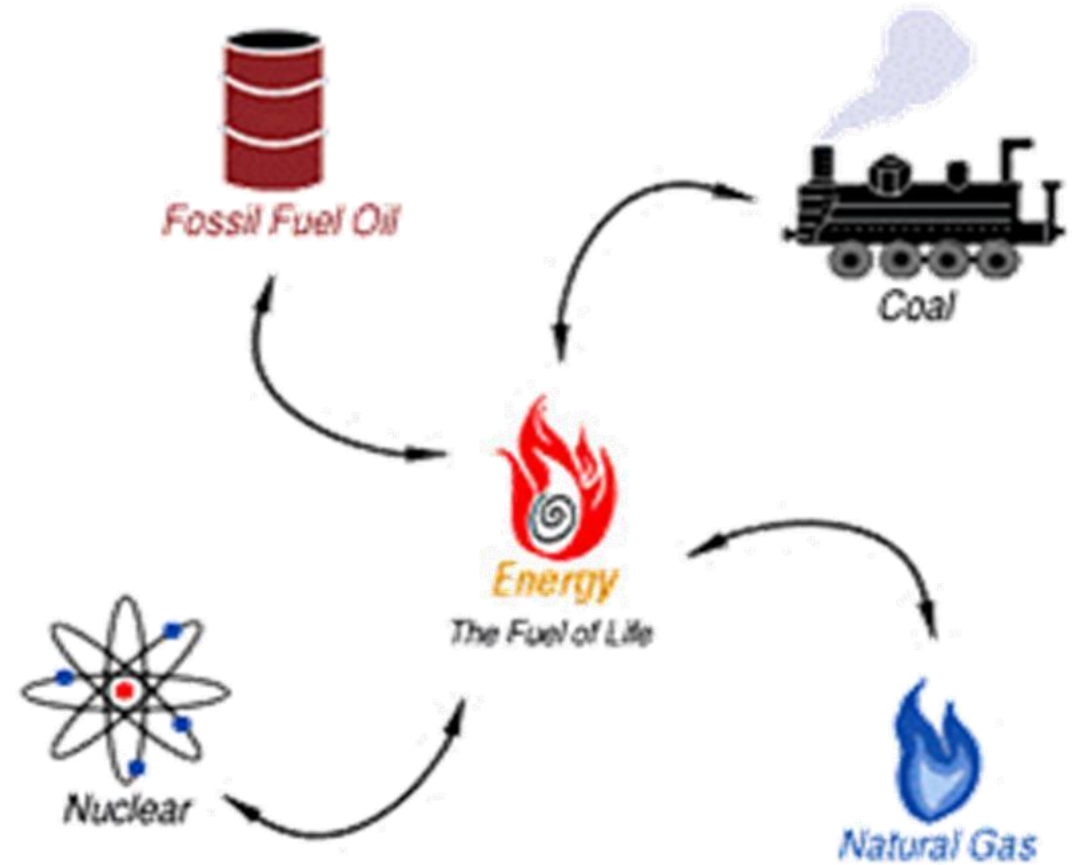
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# **Types of Energy**

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## Non-renewable energy resources

## Non-Renewable Energy



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These are physical resources such as:

➤ Fossil fuels

- Coal

- Oil

- Natural gas

➤ Nuclear energy

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## **Non-Renewable Resources**

Resource that exists in a fixed amount formed millions to billions of years.

Examples are gold, bauxite, copper, aluminum, iron, salt, clay, coal, and oil.

Any potentially renewable resource can become non-renewable if used improperly

Theoretically, they never get exhausted due to economic feasibility for extracting.

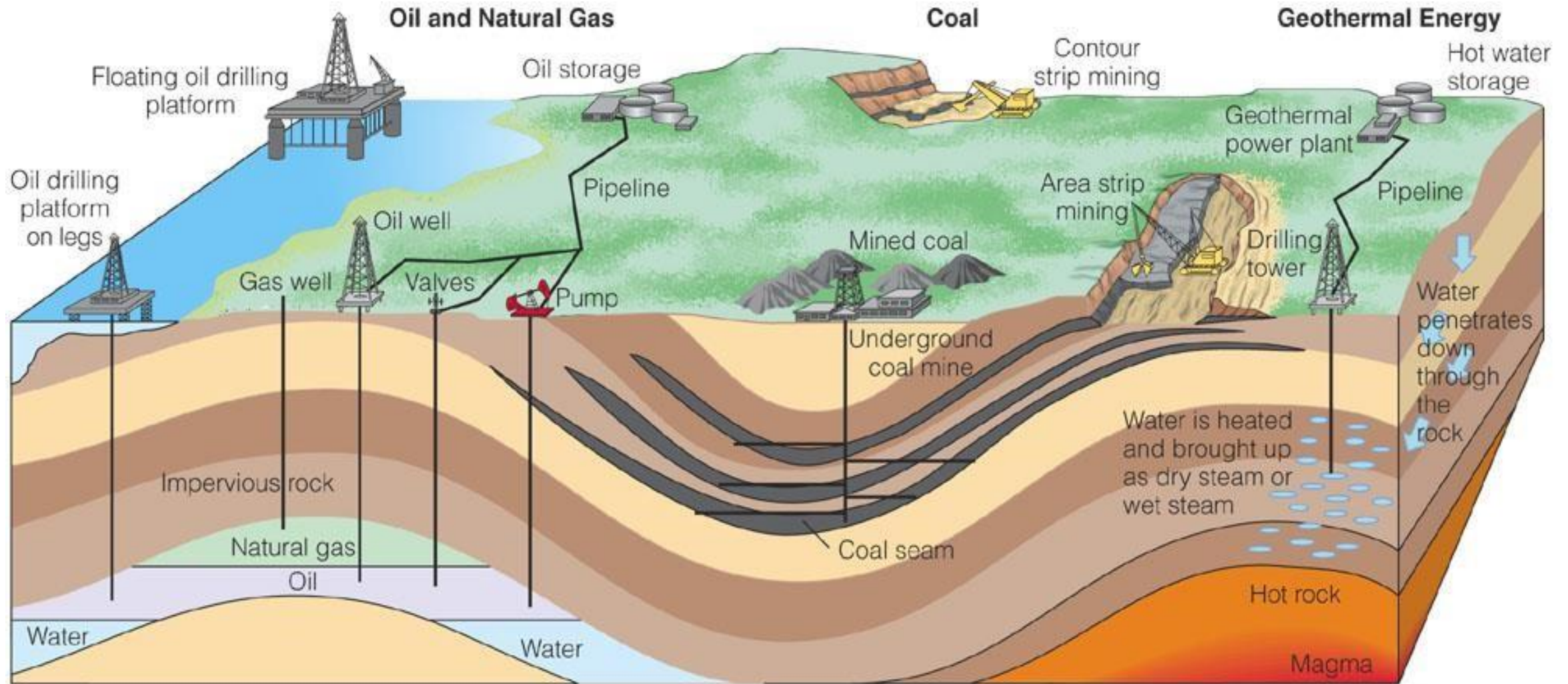
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# **Overview of Nonrenewable Energy Sources**

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## **2. Fossil fuels**

### ***i. Coal***

- Present through out the world
- $2,730 \times 10^6$  tons are extracted every year
- Estimated mining 300 - 850 years

### ***ii. Natural gas***

- CH<sub>4</sub> is major constituent
- Lower sulphur content
- Least polluting of all energy sources

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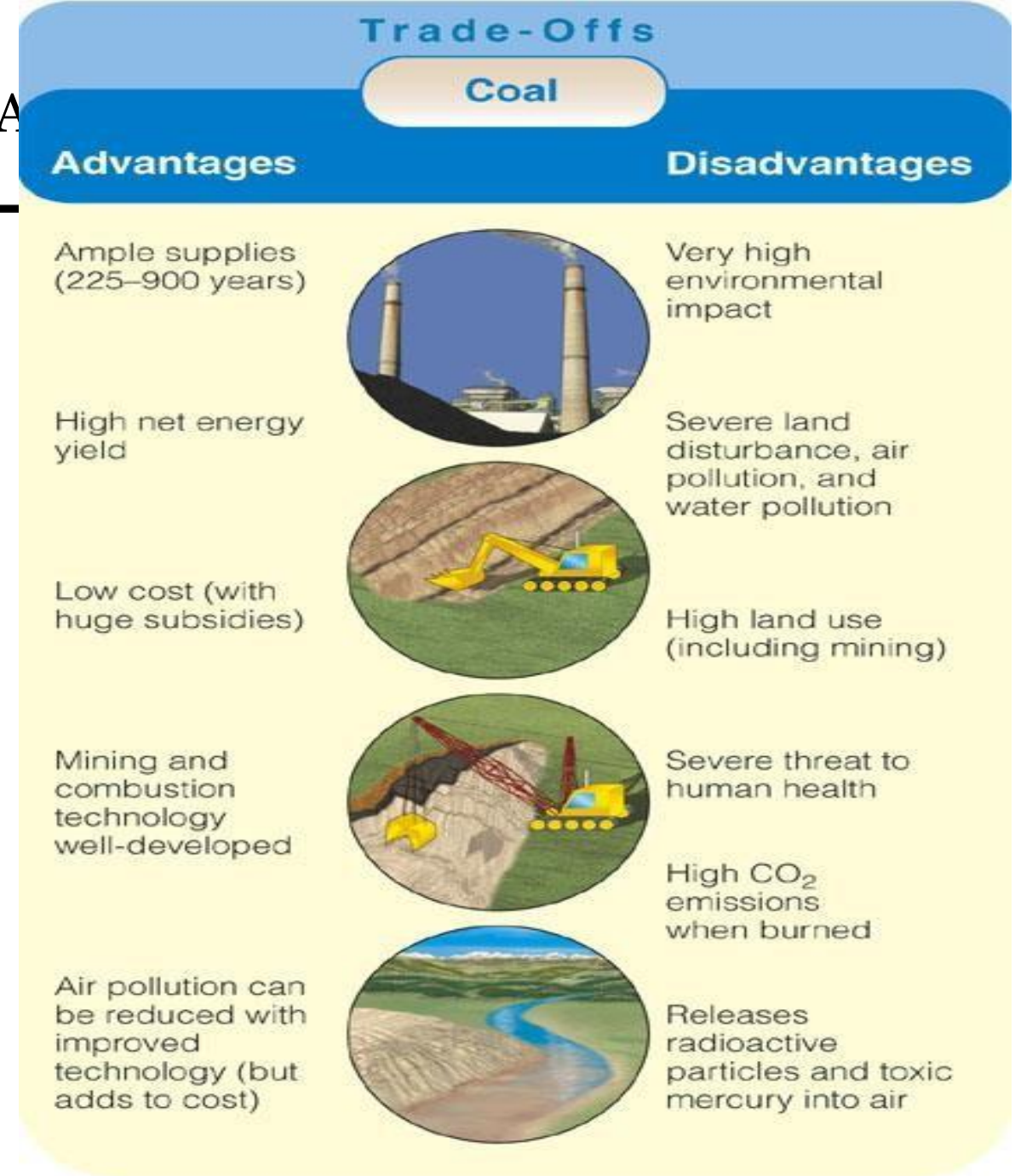
### *iii. Oil*

- Has high energy content; major constituents Petrol, kerosene, diesel, naphtha

# Coal: Trade-offs

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- World's most abundant fossil fuel
- Mining and burning coal has a severe environmental impact
- Accounts for over 1/3 of the world's CO<sub>2</sub> emissions

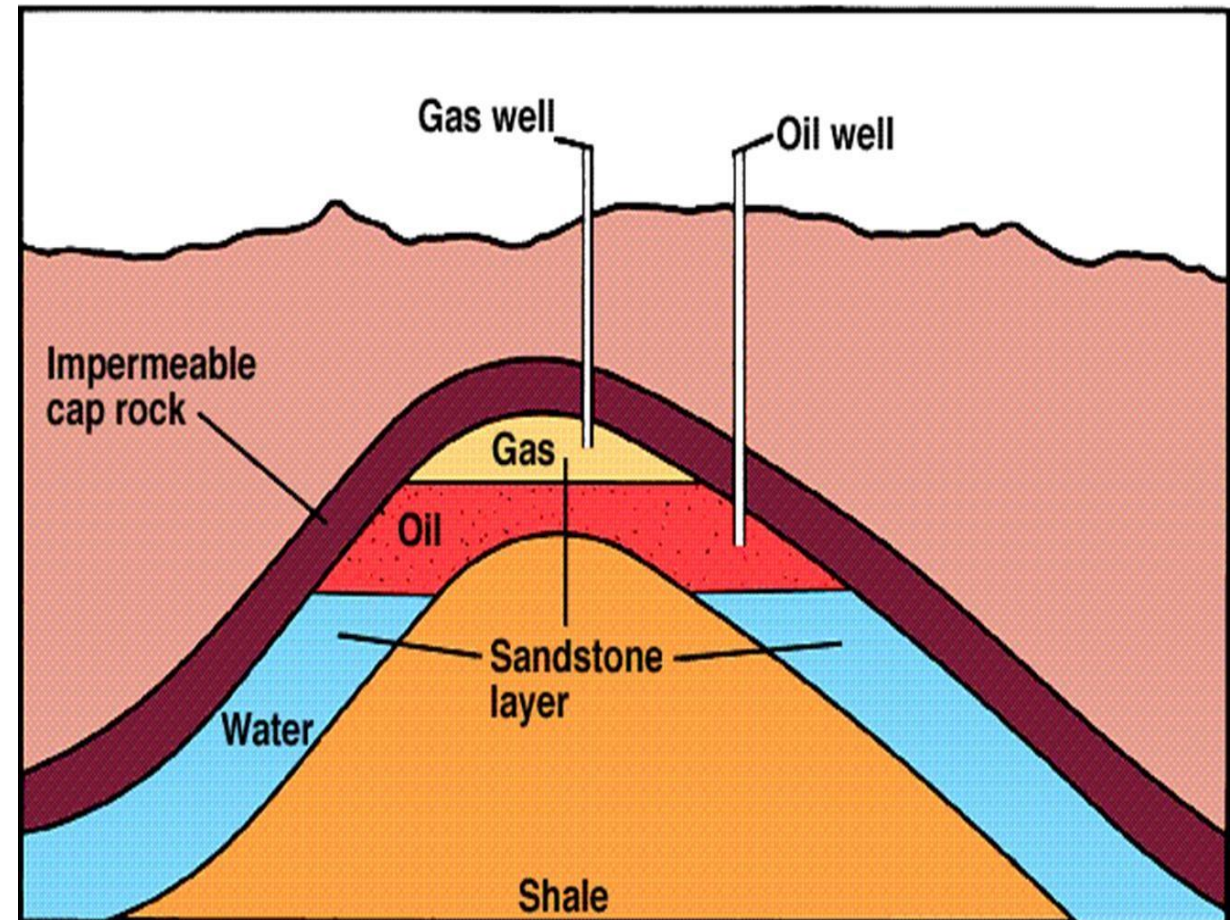




## ii. Crude Oil and Natural Gas

- Accumulations of dead marine organisms on the ocean floor were covered by sediments.
- Muddy rock gradually formed rock (shale) containing dispersed oil.
- Sandstone formed on top of shale, thus oil pools began to form.
- Natural gas often forms on top of oil.

### Crude Oil and Natural Gas Pool



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- Primary component of natural gas is methane

## **Crude-Oil Reserves and Production**

Oil reserves implies an estimated guess of the world's oil which can only be realized upon exploration.

After several drilling exploration to hit the oil field, an accurate estimation could be made to determine how much oil could be exploited economically which becomes the actual reserve. NB: 1 barrel of oil = 42 gallons

The oil is then extracted (produced) as crude oil for further process. Oil extraction comes with a deposit of gas which is extracted for commercial purposes or flare off.

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It is estimated that about 140 trillion m<sup>3</sup> of natural gas is recoverable and can last for over 70 year.

Natural gas is has less environmental impact than oil and coal. However, alternative sources such as solar, wind, hydro, etc. are being exploited.

## **Petroleum (crude oil)**

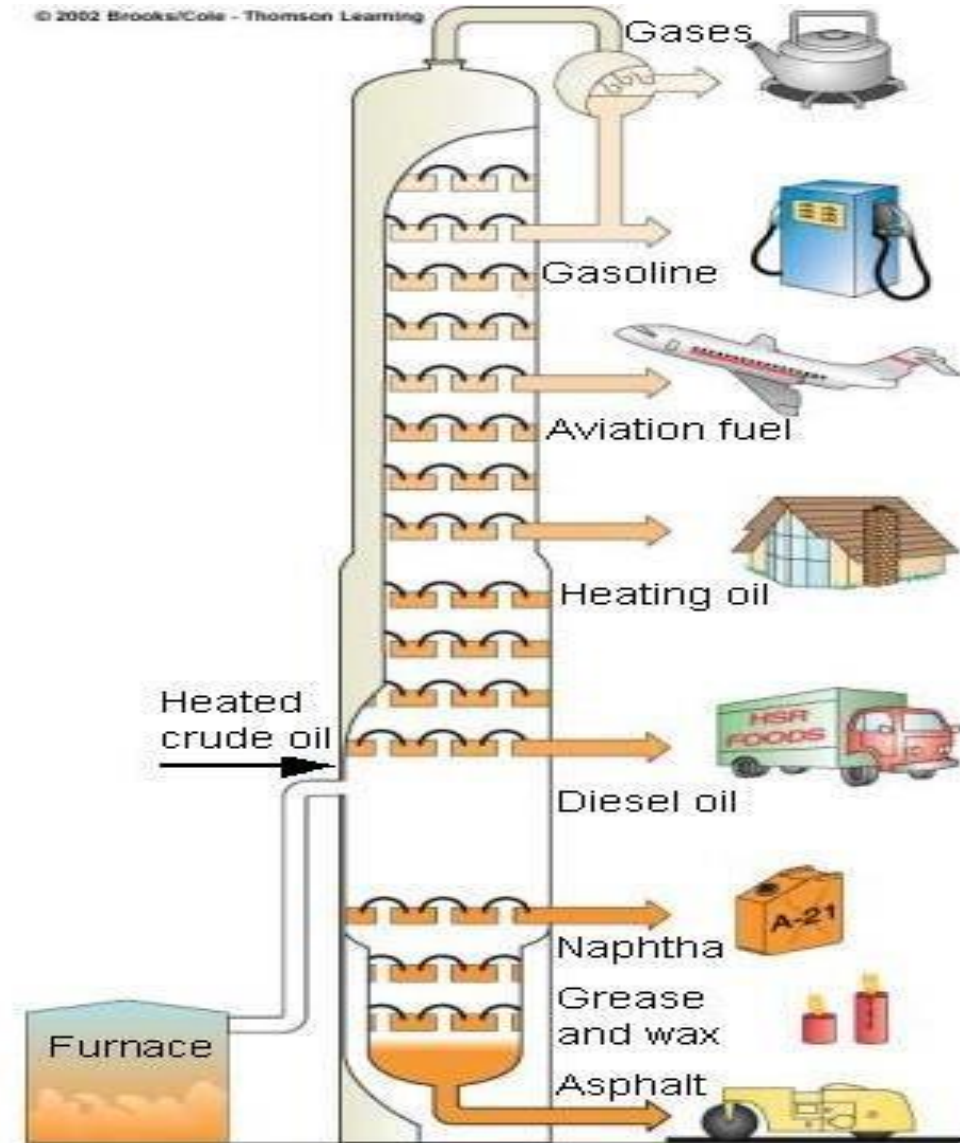
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- **Costs:**

- Recovery
- Refining
- Transporting
- Environmental
  - Highest risks are in transportation

- **Refining yields many products**

- Asphalt
- Heating oil
- Diesel
- Petrochemicals
- Gasoline, etc.





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**Conventional Oil**

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### **Advantages**

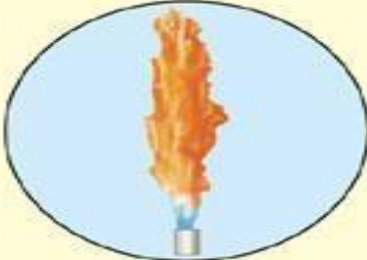
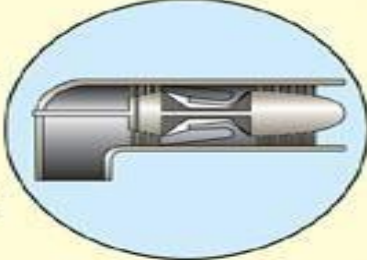
- Relatively low cost
- High net energy yield
- Efficient distribution system

### **Disadvantages**

- Running out (42-93 years)
- Low prices encourage waste
- Air pollution and
- greenhouse gases
- Water pollution

### iii. Natural Gas

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Trade-Offs		
Conventional Natural Gas		
Advantages		Disadvantages
Ample supplies (125 years)		Nonrenewable resource
High net energy yield		Releases CO <sub>2</sub> when burned
Low cost (with huge subsidies)		Methane (a greenhouse gas) can leak from pipelines
Less air pollution than other fossil fuels		Difficult to transfer from one country to another
Lower CO <sub>2</sub> emissions than other fossil fuels		Shipped across ocean as highly explosive LNG
Moderate environmental impact		Sometimes burned off and wasted at wells because of low price
Easily transported by pipeline		
Low land use		

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- 50-90% methane
- Cleanest of fossil fuels
- Approximate 200 year supply
- Advantages and disadvantages

## **Environmental effects of oil and natural gas recovery**

1. Disruption of the land during construction of pipelines, storage sites, roads, etc.

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2. Pollution of land and water bodies from oil spillage, broken pipe and leakages.
3. Accidental release of air pollutants such as hydrocarbons and hydrogen sulfides (toxic gas)
4. Loss or damage to the ecosystem
5. Release of drilling muds during exploration

## **Non- Conventional sources of energy**

The non-conventional energy source is less polluting, environmentally clean, socially relevant and can be used as alternatives to conventional source.

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## Non conventional energy sources

- Solar energy
- Hydro energy
- Wind energy
- Tidal energy
- Geothermal energy
- Biomass energy

**Solar energy**

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The Sun energy is the source of almost all lives' processes globally.

- It provides continuous supply of energy that exceeds demand
- The remaining enormous amount of energy is available to life on Earth
- Amount of energy received from Sun each day is 600 times greater than the amount of energy produced each day by all the other sources taken together

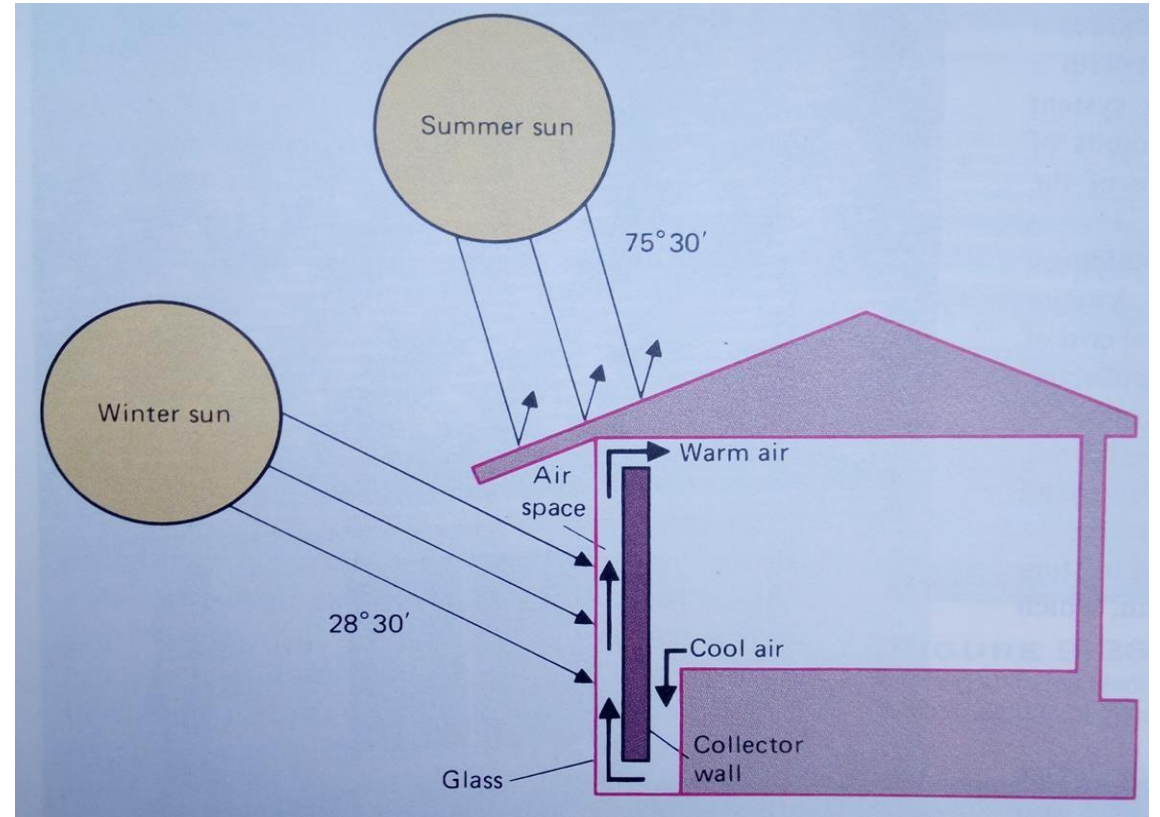
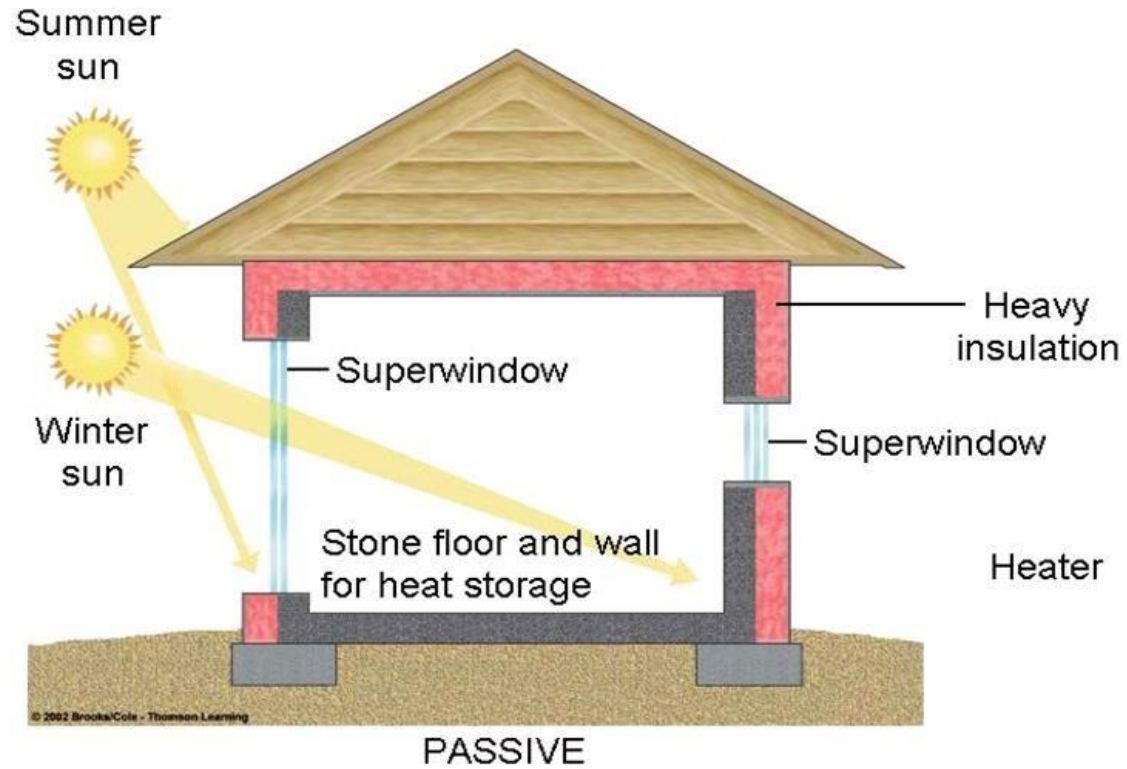
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## **Passive solar heating systems**

1. In a passive heating system, the solar energy is converted directly to heat for use at the site of collection



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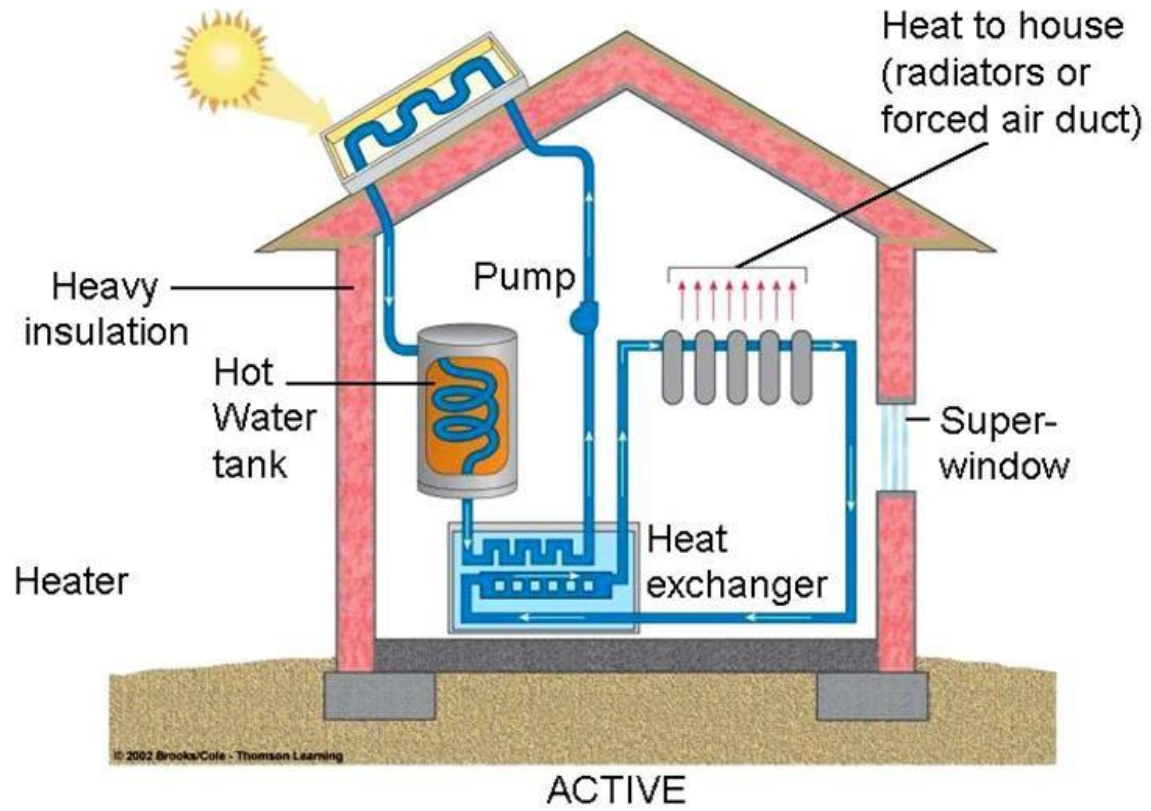


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## **Active solar heating systems**

In an active heating system, the solar energy is converted into heat, but the heat energy must be transferred from the region of collection to the place of use

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**Hydroelectr**



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Obtained from water flow

Most conventional renewable source of energy

Mechanical energy of down flowing water is harnessed to generate electricity

## **Electricity production**

Production of electricity as a secondary power depend on the use of primary energy sources to power generators to produce electricity.

Hydro energy involves the turning of turbines by the flow of water to convert kinetic energy into electrical energy.

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Energy from electricity is widely used for electrical appliances, lighting homes and streets, running equipment in industries including computers, etc.

## **Conditions that favour generation of hydroelectricity**

1. Uneven topography which leads to development of powerful water currents

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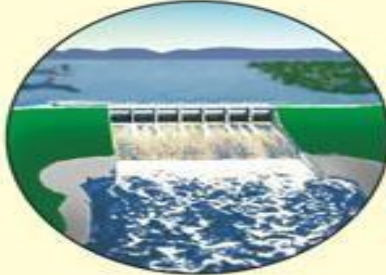

2. Perennial river droughts
3. Presence of forest regulates rainfall and prevent soil erosion
4. Availability of knowhow in technology
5. Funds to meet capital requirement



# Producing Electricity from Moving Water

- Large-scale hydropower
- Small-scale hydropower
- Tidal power plant
- Wave power plant

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Trade-Offs		
Large-Scale Hydropower		
Advantages		Disadvantages
Moderate to high net energy		High construction costs
High efficiency (80%)		High environmental impact from flooding land to form a reservoir
Large untapped potential		High CO <sub>2</sub> emissions from biomass decay in shallow tropical reservoirs
Low-cost electricity		Floods natural areas behind dam
Long life span		Converts land habitat to lake habitat
No CO <sub>2</sub> emissions during operation in temperate areas		Danger of collapse
May provide flood control below dam		Uproots people
Provides water for year-round irrigation of cropland		Decreases fish harvest below dam
Reservoir is useful for fishing and recreation		Decreases flow of natural fertilizer (silt) to land below dam



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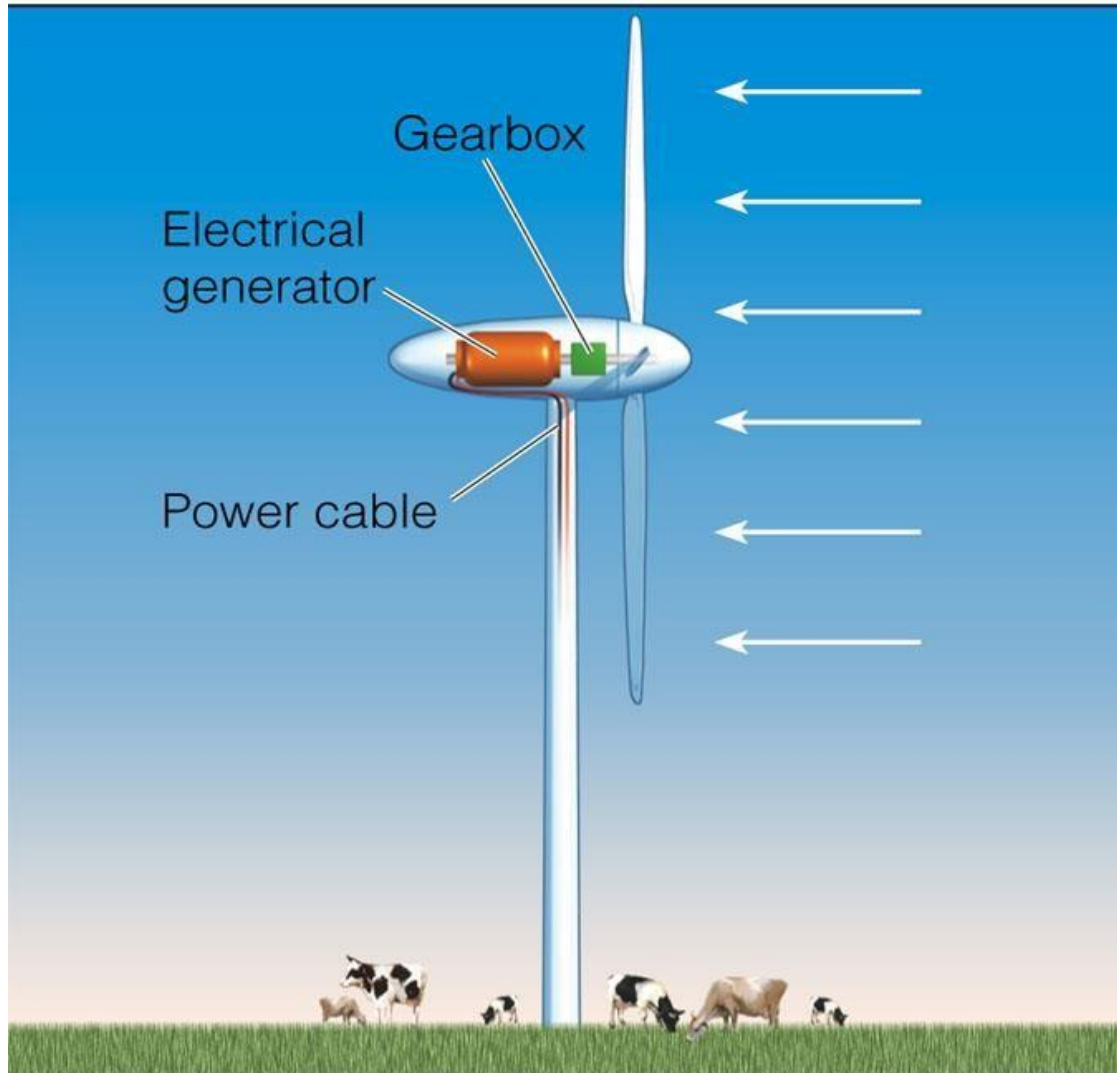
## **Wind Energy**

How can wind be used to generate electricity?

When wind has higher speed (5-10 m/s) it can be converted to electrical energy by attaching a wind-electric generator to the axle of the wind mill

➤ **Check Ghana issues**

# Producing Electricity from Wind



**Wind turbine**

© 2005 Brooks/Cole - Thomson

## Trade-Offs

### Wind Power

#### Advantages

- Moderate to high net energy
- High efficiency
- Moderate capital cost
- Low electricity cost (and falling)
- Very low environmental impact
- No CO<sub>2</sub> emissions
- Quick construction
- Easily expanded
- Can be located at sea
- Land below turbines can be used to grow crops or graze livestock

#### Disadvantages

- Steady winds needed
- Backup systems needed when winds are low
- High land use for wind farm
- Visual pollution
- Noise when located near populated areas
- May interfere in flights of migratory birds and kill birds of prey



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# **Wind farm for energy production**

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## **Geothermal Energy**

How can hot materials within Earth's crust be used to provide power to electrical generators?

The Earth's core is very hot. When the hot material is close enough to the surface, they heat the ground water and form steam.

Geysers and hot springs are the natural openings through which steam and hot water come up to the surface.

In the areas where the steam is trapped underground, geothermal energy can be tapped by drilling wells to obtain steam. This steam can be used to provide power to electrical generators.

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## **Biomass Energy**

Biomass is accumulation of organic materials produced by living things

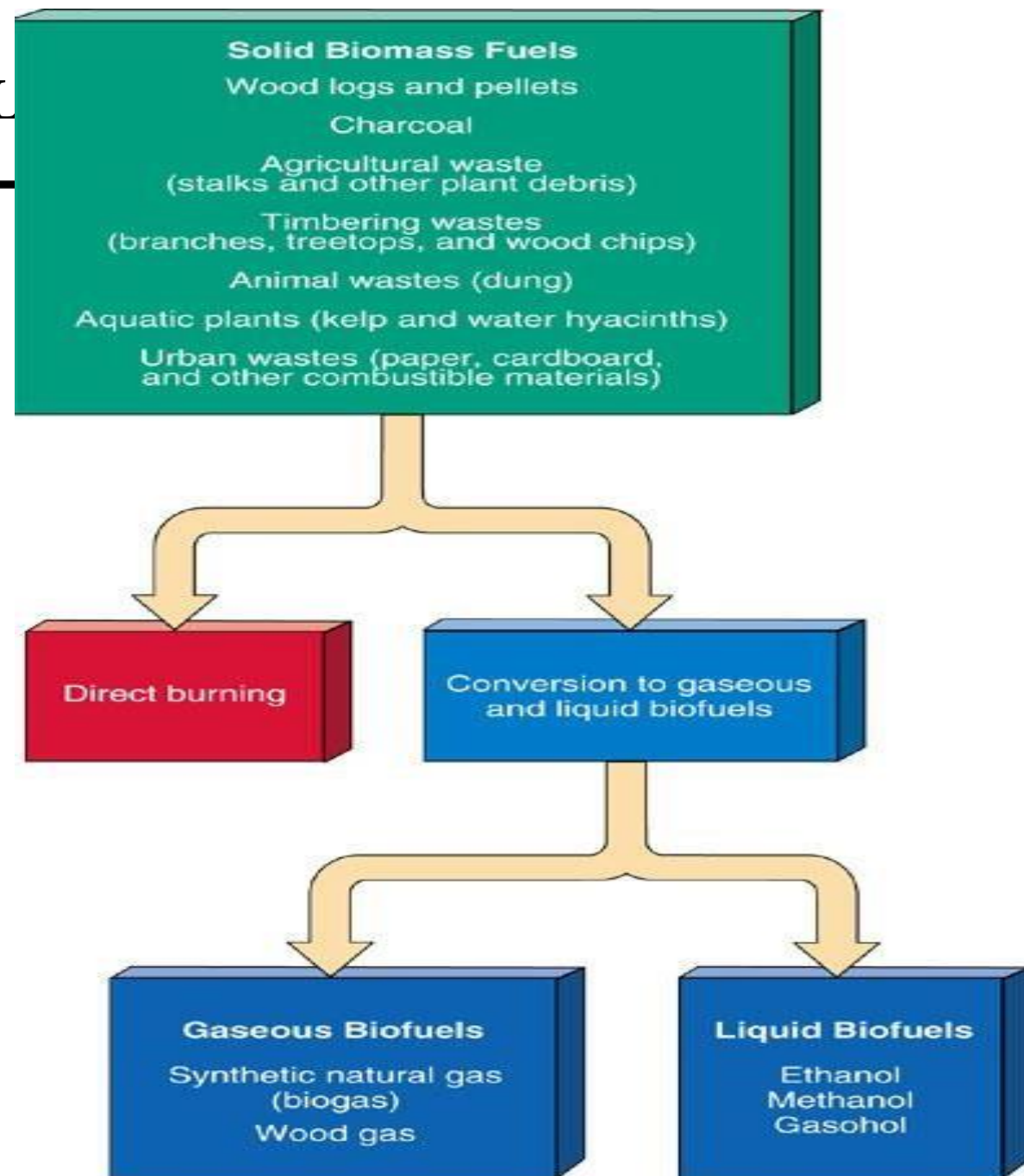
New plant growth, residues and wastes, herbaceous plants, fresh water algae, aquatic plants, agricultural and forest residues and wastes. How can biogas be a solution to the energy crisis in rural areas?

Bagasse a waste of sugar mills, is a good source for energy generation. They produce 2,000 MW of surplus electricity. 40 % of that is being used by sugar mills for power and the remaining used for irrigation etc.



# Producing Energy from Biomass

- Biomass and biofuels
- Biomass plantations
- Crop residues
- Animal manure
- Biogas
- Ethanol
- Methanol



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# Hybrid and Fuel Cell Cars

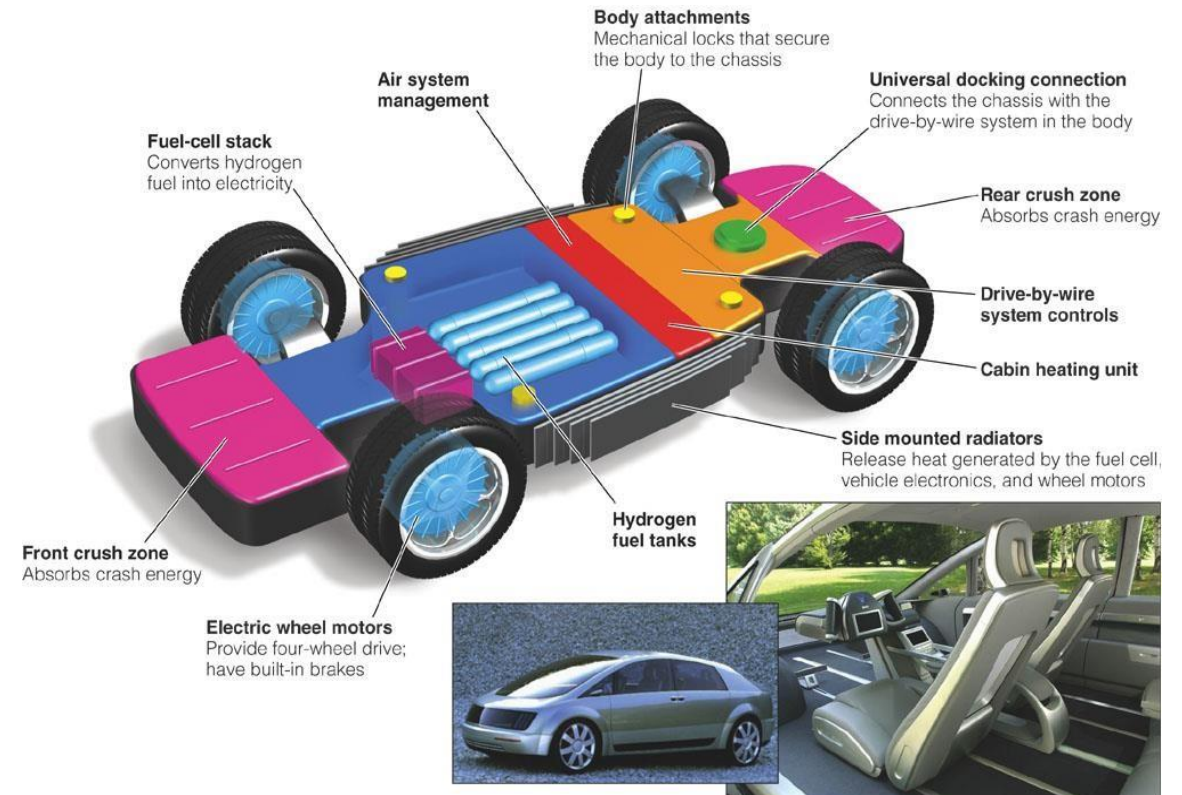
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Hybrid cars still use traditional fossil fuels

- Energy otherwise wasted charges battery which assists acceleration and hill climbing
- More efficient than internal combustion engine alone, but still uses nonrenewable resources

Fuel cell cars not yet available

- Hydrogen gas is fuel
- Very efficient

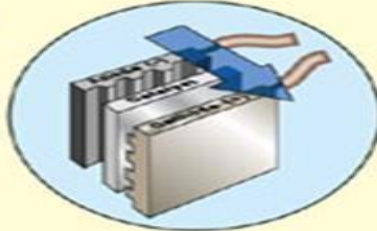






- Low pollution
- Major infrastructure change needed for fueling stations

## The Hydrogen Revolution

- Environmentally friendly
- Extracting hydrogen efficiently
- Storing hydrogen
- Fuel cells

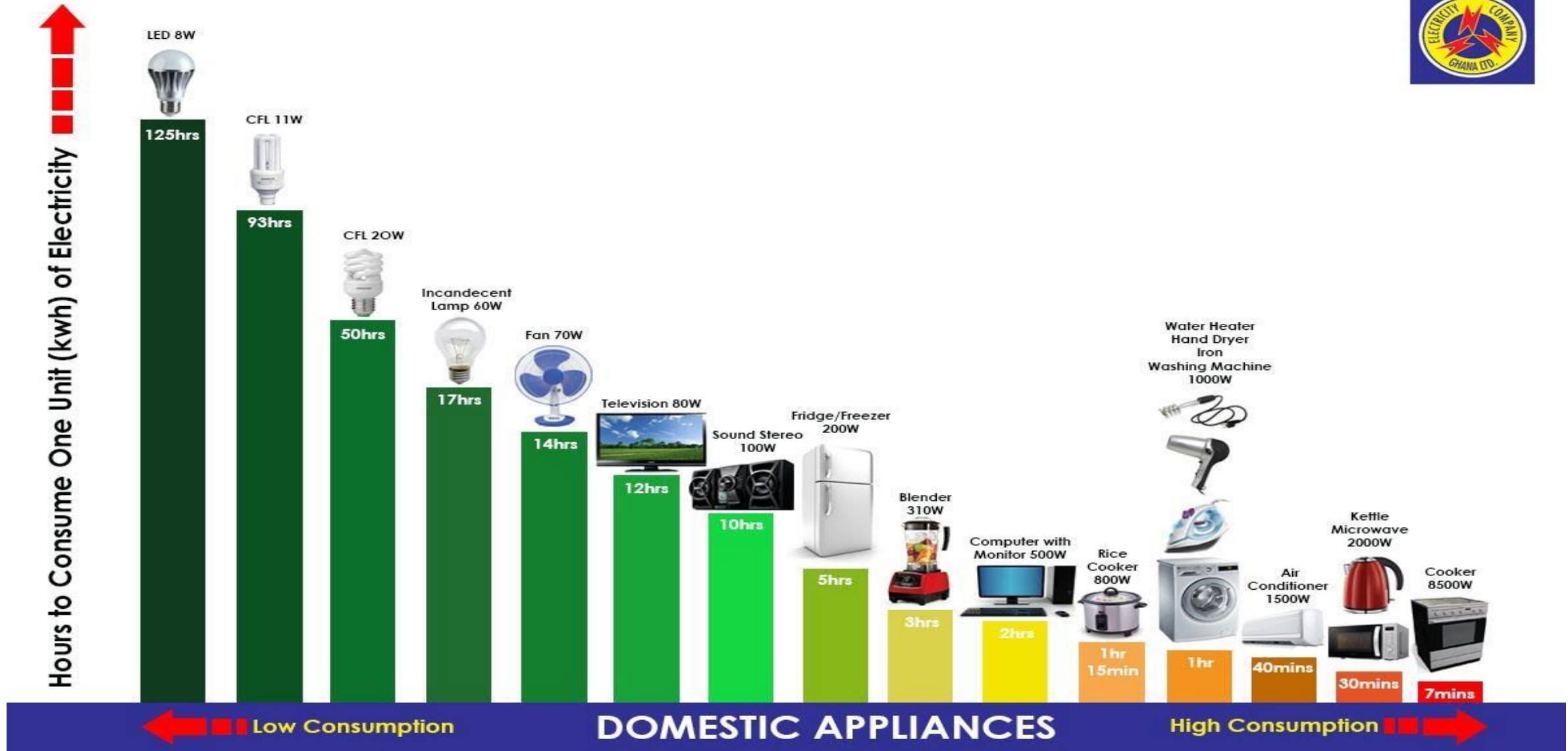
Trade-Offs		
Hydrogen		
Advantages		Disadvantages
Can be produced from plentiful water		Not found in nature
Low environmental impact		Energy is needed to produce fuel
Renewable if produced from renewable energy resources		Negative net energy
No CO <sub>2</sub> emissions if produced from water		CO <sub>2</sub> emissions if produced from carbon-containing compounds
Good substitute for oil		Nonrenewable if generated by fossil fuels or nuclear power
Competitive price if environmental and social costs are included in cost comparisons		High costs (but may eventually come down)
Easier to store than electricity		Will take 25 to 50 years to phase in
Safer than gasoline and natural gas		Short driving range for current fuel cell cars
Nontoxic		No fuel distribution system in place
High efficiency (45–65%) in fuel cells		Excessive H <sub>2</sub> leaks may deplete ozone

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**Energy conservation**

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## **Uses of Energy**

Energy is used for many activities:

1. Transportation
2. Industrial processes
3. Commercial and residential uses
4. Generation of electric powers



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## Improve Energy Efficiency

Increase fuel-efficiency standards for vehicles, buildings, and appliances

Mandate government purchases of efficient vehicles and other devices

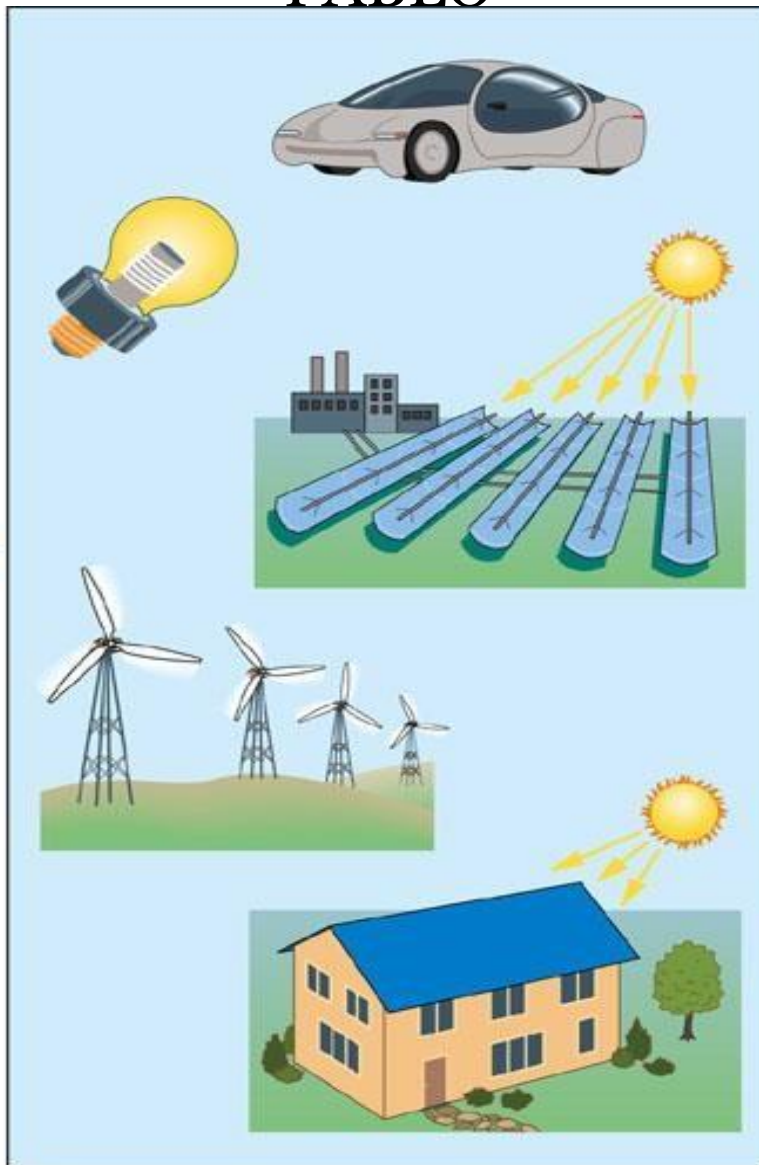
Provide large tax credits for buying efficient cars, houses, and appliances

Offer large tax credits for investments in energy efficiency

Reward utilities for reducing demand for electricity

Encourage independent power producers

Greatly increase energy efficiency research and development



## More Renewable Energy

Increase renewable energy to 20% by 2020 and 50% by 2050

Provide large subsidies and tax credits for renewable energy

Use full-cost accounting and life cycle cost for comparing all energy alternatives

Encourage government purchase of renewable energy devices

Greatly increase renewable energy research and development



## Reduce Pollution and Health Risk

Cut coal use 50% by 2020

Phase out coal subsidies

Levy taxes on coal and oil use

Phase out nuclear power or put it on hold until 2020

Phase out nuclear power subsidies

