

Fossil Fuel, Types, Policies, Significance, Challenges, Examples

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Fossil Fuels are carbon rich energy resources formed through anaerobic decomposition of the buried remains of prehistoric plants, animals and micro-organisms under high temperature and pressure over millions of years within the Earth's crust. These fuels, mainly Coal, Petroleum and Natural Gas, are extracted and burned to generate heat, electricity and mechanical energy. Their combustion releases energy but also produces carbon dioxide, a major greenhouse gas driving global warming and climate change.

Fossil Fuel Types

Fossil Fuels are classified into major categories based on their physical state, origin and composition, each with distinct formation processes and applications.

- **Primary Types:** Coal, Petroleum and Natural Gas are the three major Fossil Fuels formed from terrestrial plants or marine organisms under pressure and heat over millions of years.
- **Secondary Forms:** Derivatives like Kerosene, Diesel, Gasoline, LPG and Petrochemicals such as plastics and synthetic resins are produced through refining and processing of crude Fossil Fuels.

- **Other Sources:** **Shale Gas** and Oil Sands represent unconventional Fossil Fuels extracted using advanced technologies like hydraulic fracturing due to deeper and complex geological formations.

Coal

Coal is a solid Fossil Fuel mainly composed of carbon, formed from terrestrial plant material buried in swampy environments and transformed through Coalification over millions of years.

- **Types of Coal:** Anthracite contains 80-90% carbon and is hardest; bituminous holds 60-80% carbon; lignite has 40-60% carbon and higher moisture; peat is the earliest stage with lowest carbon content.
- **Formation Process:** Coal forms when dense vegetation in wetlands gets buried under sediments and undergoes compression and heating, gradually transforming into higher carbon forms through geological time.
- **Distribution:** China holds about 12% of global reserves; USA is second largest; India ranks third with Gondwana Coal dominating regions like Jharkhand, Odisha and West Bengal.
- **Uses:** Coal is used in electricity generation, industrial fuel, metal smelting and production of coke, Coal tar and Coal gas for various industrial applications.

Petroleum

Petroleum is a liquid Fossil Fuel formed from marine organisms buried under sediments and transformed into hydrocarbons through heat and pressure, commonly called “Black Gold”.

- **Formation:** Dead marine organisms settled on seabeds, got buried under sediments and converted into crude oil under high pressure and temperature over millions of years.
- **Refining Process:** Crude oil is refined into products like petrol, diesel, lubricating oil, paraffin wax and petrochemicals through fractional distillation in refineries.
- **Global Distribution:** Major reserves exist in Middle East regions like Saudi Arabia, Iraq and Iran; also in USA, Russia and Venezuela due to ancient marine conditions.
- **Indian Scenario:** Oil discovered in Digboi (1869); ONGC established in 1956; major fields include Bombay High, Gujarat, Assam and Krishna-Godavari Basin.

Natural Gas

Natural Gas is a clean, gaseous Fossil Fuel primarily composed of methane, formed alongside Petroleum or independently in sedimentary rock formations.

- **Composition:** Methane is the dominant component, making Natural Gas efficient and relatively less polluting compared to Coal and Petroleum based fuels.
- **Formation:** Marine micro-organisms form organic rich mud, which transforms into kerogen and later into gas under temperatures of 90-160°C through geological processes.
- **Distribution:** Major global reserves are in Russia, Iran and USA; in India, reserves are around 450 billion cubic metres mainly in Bombay High, Assam and KG Basin.

- **Uses:** Used in electricity generation, transportation as CNG, domestic cooking and as a raw material for fertilizers and chemical industries.

Shale Gas

Shale Gas is an unconventional Fossil Fuel found in sedimentary rocks, extracted using advanced techniques like hydraulic fracturing.

- **Nature:** It is trapped in fine grained shale rocks and requires artificial fracturing to release hydrocarbons, making extraction technologically complex and costly.
- **Extraction Method:** Hydraulic fracturing (fracking) creates cracks in rock layers, allowing gas to flow to the surface for collection and processing.
- **Distribution in India:** Potential reserves exist in Cambay Basin, Gondwana formations, Krishna-Godavari Basin, Cauvery Basin and Assam-Arakan region.
- **Significance:** Provides additional energy security but raises environmental concerns due to water use, chemical exposure and methane leakage risks.

Fossil Fuel Policies

Policies related to Fossil Fuels aim to balance energy security, economic growth and environmental sustainability amid rising global concerns about climate change.

- **International Frameworks:** Paris Climate Agreement and United Nations **Sustainable Development** Goal 7 promote reduction in Fossil Fuel use and transition to clean energy sources globally.
- **Energy Transition:** International Energy Agency recommended no new Fossil Fuel extraction projects to meet climate targets and limit global warming impacts in its 2021 report **Net Zero by 2050**.
- **Indian Context:** India imports about 85% of crude oil, creating policy challenges related to energy security, **Atma Nirbharta** and diversification of energy sources.

Fossil Fuel Challenges

Fossil Fuels face multiple environmental, economic and structural challenges due to their widespread use and associated impacts.

- **Environmental Impact:** Burning releases CO₂, contributing over 70% of greenhouse gas emissions, leading to global warming, ocean acidification and **climate change**.
- **Pollution Effects:** Air pollution from Fossil Fuels costs about 3% of global GDP and causes millions of deaths due to particulate matter and toxic gases.
- **Resource Depletion:** Being non-renewable, reserves are depleting rapidly compared to formation rate, creating long term energy security concerns.
- **Economic Dependency:** Countries like India depend heavily on imports, exposing economies to price volatility and geopolitical risks, especially in Middle East regions.

Fossil Fuel Significance

Fossil Fuels have been central to global development, industrial growth and modern lifestyle due to their high energy density and versatility.

- **Energy Production:** Provide 77% of global energy and over 60% electricity, powering industries, households and infrastructure across the world.
- **Industrial Development:** Enabled Industrial Revolution through steam engines, internal combustion engines and large scale manufacturing processes.
- **Transportation:** Petroleum fuels power automobiles, railways and aircraft, forming the backbone of global trade and mobility systems.
- **Agricultural Support:** **Natural Gas** based fertilizers support nearly 50% of global food production, making Fossil Fuels essential for food security and **Green Revolution** advancements.

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