

# **ELECTRICAL ENERGY CONSERVATION AND AUDITING**

## **MODULE 1: ENERGY SCENARIO**

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Subject Code: BEE755B

August 2025

# MODULE OVERVIEW

Module 1 explores the global and Indian energy scenario, covering energy types, consumption patterns, and conservation frameworks. This foundational knowledge establishes the context for understanding electrical energy conservation and auditing practices.

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## Learning Objectives

- 1 Understand energy fundamentals and classifications
- 2 Analyze global and Indian energy resources (2025)
- 3 Examine energy consumption patterns
- 4 Evaluate energy pricing and sector reforms
- 5 Study environmental impacts of energy use
- 6 Comprehend Energy Conservation Act 2001

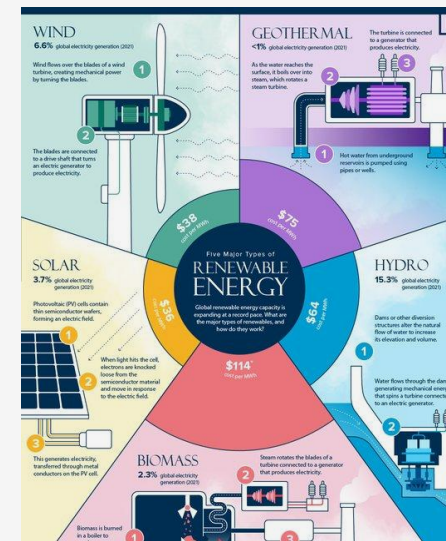
# ENERGY FUNDAMENTALS

Energy is the physical ability to do work. According to the Law of Conservation of Energy, energy cannot be created or destroyed - it can only be transferred or converted from one form to another.

Energy management is essential to balance generation and consumption, reduce greenhouse effects, and achieve cost savings.

Energy Classification:

1. Primary & Secondary Energy
2. Commercial & Non-Commercial Energy
3. Renewable & Non-Renewable Energy



# PRIMARY ENERGY RESOURCES

Global reserves of primary energy resources continue to evolve with updated 2025 data showing significant concentrations in specific regions.

## Coal

- Global reserves: 107 trillion tons
- Major holders: USA (25.4%), Russia (16.7%), China (16.2%), India (15.4%)
- India's R/P ratio: 230 years

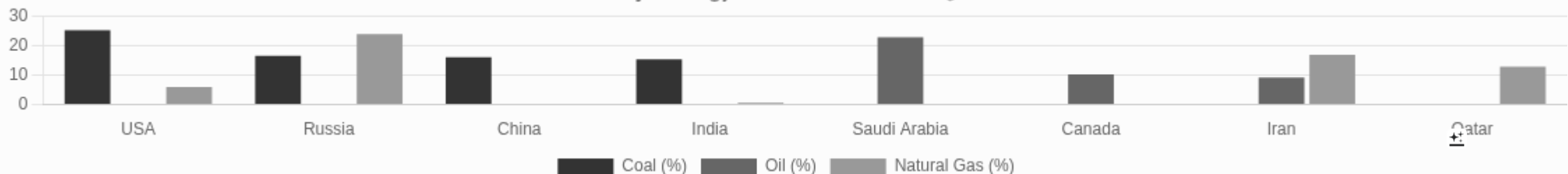
## Oil

- Global reserves: 1,750 billion barrels
- Major holders: Saudi Arabia (23%), Canada (10.3%), Iran (9.3%)
- India's share: 0.3%, 90% import dependent

## Natural Gas

- Global reserves: 210 trillion cubic meters
- Major holders: Russia (24%), Iran (17%), Qatar (13%)
- India's share: 0.6% (1.3 tcm)

Major Energy Resource Holders (2025)



# COMMERCIAL VS. NON-COMMERCIAL ENERGY

## Commercial Energy

Energy sources that can be bought or sold in the market for a definite price. They form the basis of industrial, agricultural, transport and commercial development in the modern world.

- Coal and Lignite
- Petroleum Products (Petrol, Diesel)
- Natural Gas
- Electricity

Commercial energy accounts for over 75% of total energy consumption globally as of 2025, with

## Non-Commercial Energy





Energy sources that are traditionally gathered and not bought at a price. Often used in rural households and frequently ignored in energy accounting.

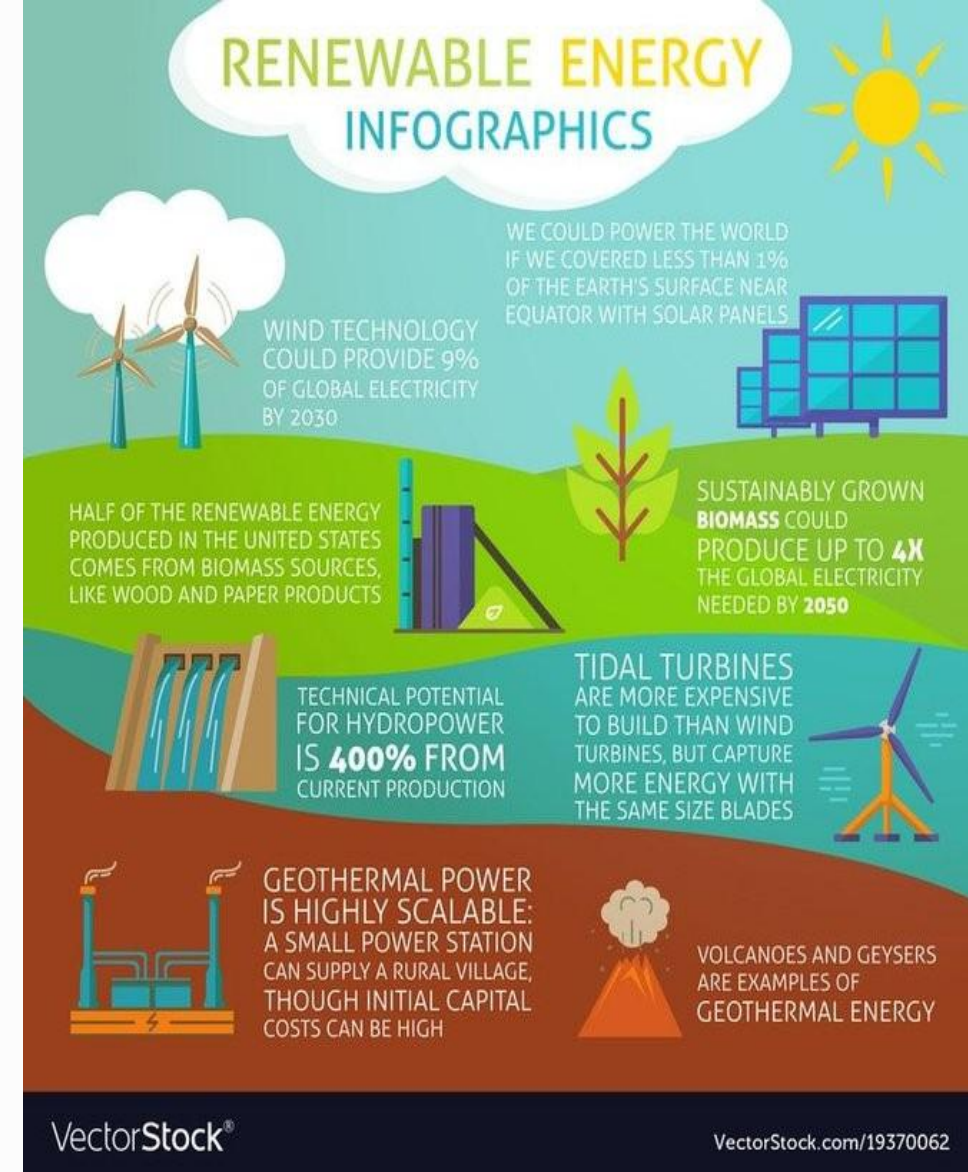
- Firewood
- Agricultural Waste
- Animal Dung Cake
- Charcoal

In rural India, non-commercial energy still constitutes about 30% of total energy consumption, though this percentage has declined from 50% in 2000 as

# RENEWABLE VS NON-RENEWABLE ENERGY

India has made significant strides in renewable energy adoption, with clean energy sources now comprising 46.3% of total installed capacity in 2025.

-  **Solar: 110.9 GW** - Nearly 39x growth since 2014 (2.82 GW)
-  **Wind: 51.6 GW** - India ranks 4th globally in onshore wind capacity
-  **Non-renewable: 53.7%** - Thermal (coal, gas): 50.5%, Nuclear: 1.8%
-  **Global milestone:** Clean power exceeded 40% of global electricity in 2024



# GLOBAL ENERGY CONSUMPTION PATTERNS (2025)

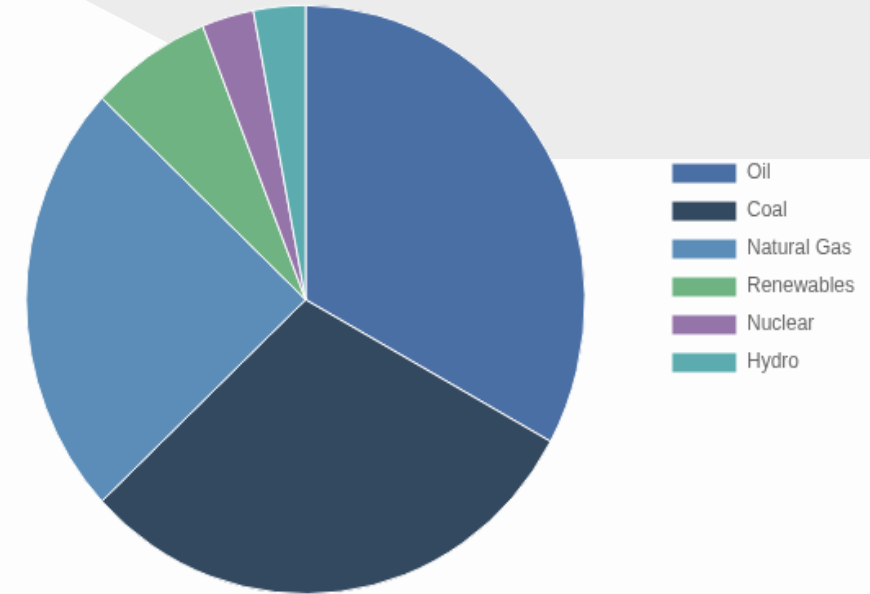
Global primary energy consumption in 2025 is equivalent to **9,741 million tonnes** of oil equivalent. The distribution shows:

- **Oil (33%)**: Dominates transportation
- **Coal (30%)**: Major electricity source
- **Natural Gas (24%)**: Growing industrial use
- **Others (13%)**: Renewables, nuclear, hydro

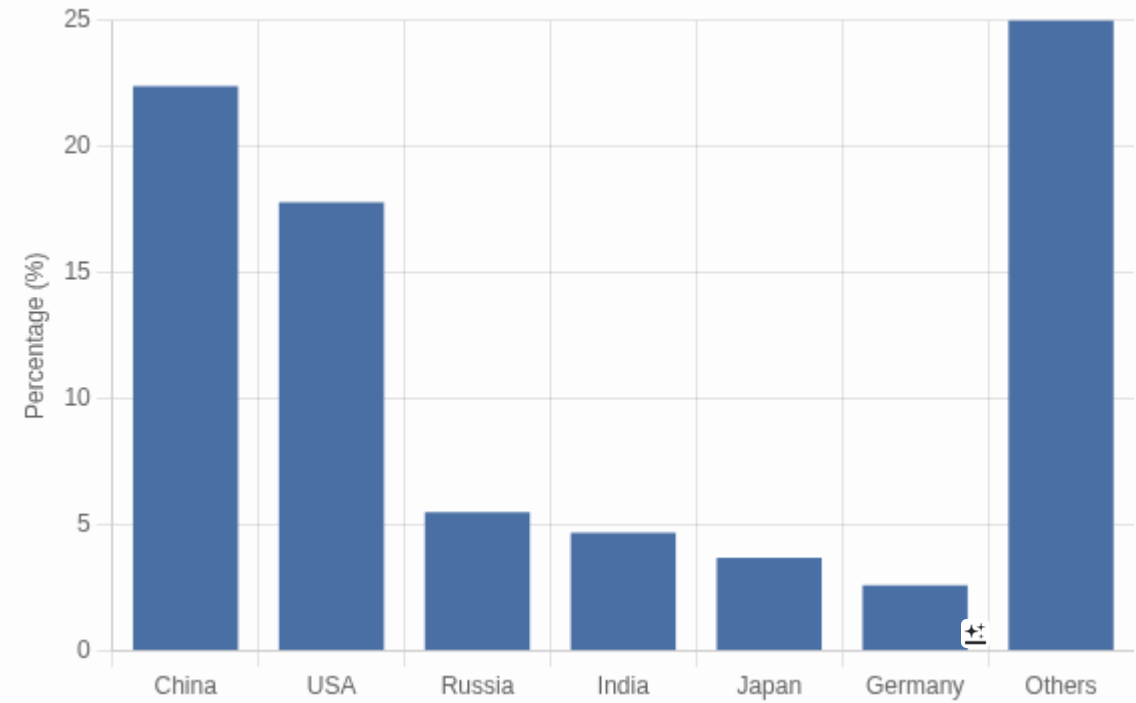
Major consuming countries:

- China: 22.4%
- USA: 17.8%
- Russia: 5.5%

Global Energy Consumption by Source (2025)



Energy Consumption by Country (2025)



# INDIA'S ENERGY SCENARIO 2025

India's energy landscape has evolved significantly with a total installed capacity of 490 GW as of July 2025. The country is witnessing rapid growth in renewable energy adoption while still relying on coal for baseline power generation.

**6-6.5%**

Annual energy consumption  
growth

**9%**

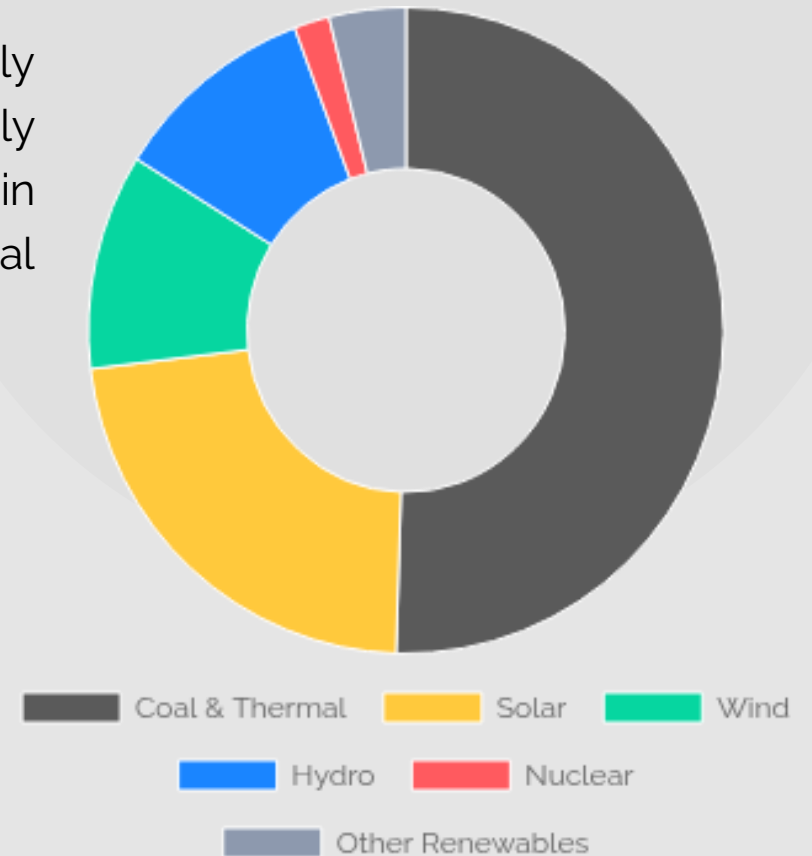
Electricity demand growth  
rate

**90%**

Oil import dependency

**22 GW**

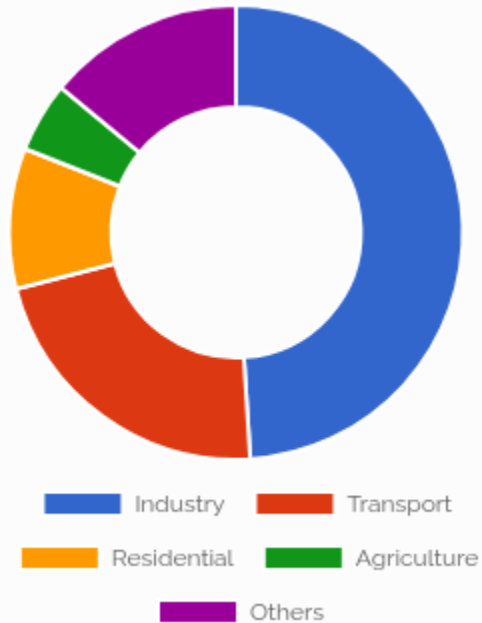
Renewable capacity added



India's Installed Power Capacity Mix (490 GW, July 2025)



# SECTOR-WISE ENERGY CONSUMPTION IN INDIA



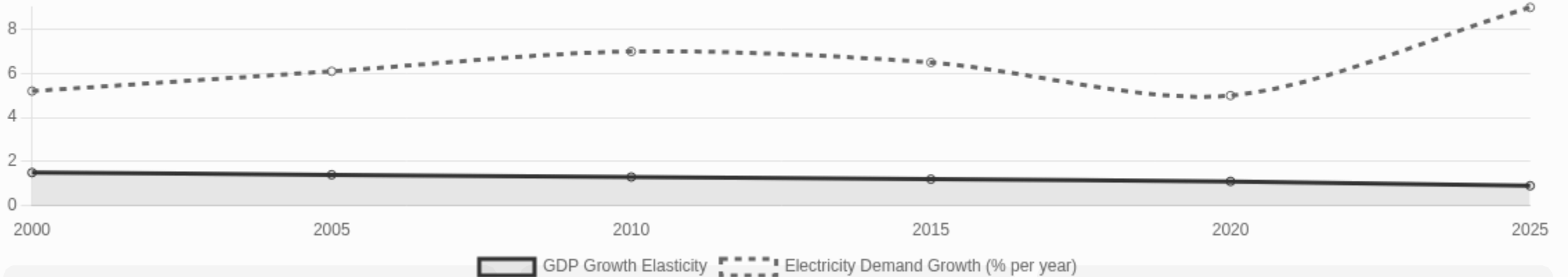
Sector	Share (%)	Key Energy Sources	Major Activities
Industry	49%	Coal, Electricity, Natural Gas	Manufacturing, Construction, Heavy Industries
Transport	22%	Diesel, Petrol, CNG, Electricity (EVs)	Road vehicles, Railways, Aviation
Residential	10%	Electricity, LPG, Biomass	Lighting, Cooling, Cooking, Appliances
Agriculture	5%	Diesel, Electricity (subsidized)	Irrigation pumps, Tractors
Others	14%	Electricity, Natural Gas	Commercial buildings, Services, SMEs

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# ENERGY NEEDS OF A GROWING ECONOMY

Economic growth and energy demand maintain a complex relationship in developing countries like India, with the connection becoming increasingly efficient over time.

GDP-Energy Relationship Over Time (2000-2025)



## GDP Growth

**7.4%**

India's estimated GDP growth (2025)

## Energy Demand

**6.5%**

Annual growth rate (down from historical 9%)

## Electricity Growth

**9.0%**

Annual growth since FY21 (up from 5% decade avg)

# ENERGY STRATEGY FOR THE FUTURE

A comprehensive energy strategy requires immediate actions, medium-term transitions, and long-term vision to ensure sustainable energy security while addressing environmental concerns.

## Immediate-term Strategy

- Fix electricity tariffs to prevent wasteful consumption
- Reduce T&D losses (currently 17% in India, down from 23%)
- Optimize existing infrastructure utilization

## Medium-term Strategy

- Demand-side management and conservation
- Balanced fuel mix (coal, gas, renewables)
- Transportation sector transformation
- Accelerate shift to renewables (22 GW added H1 2025)

## Long-term Strategy

- Next-gen power plant efficiency (ultra-supercritical)
- Smart grid implementation (national target: 100% by 2035)
- Private sector and FDI in energy infrastructure
- Hydrogen economy and storage solutions

# ENERGY PRICING & SECTOR REFORMS

Energy pricing in India remains influenced by political, social, and economic factors rather than true market costs. Subsidies and cross-subsidies have created price distortions, affecting efficiency and conservation efforts. Since 1991, India has gradually implemented energy sector reforms to promote competition, efficiency, and sustainability.

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**Key Challenge:** Balancing affordability for consumers with economic viability for providers while promoting efficient energy use.

## Sector Reforms

### 1 Coal Sector

Private extraction for captive use allowed, imports permitted, competitive environment creation in progress (2025: Bill pending in Parliament).

### 2 Oil & Gas

Liberalized pricing for naphtha and some fuels, New Exploration Licensing Policy (NELP) for domestic exploration, private investment in refineries and LNG facilities.

### 3 Electricity

Electricity Act 2003: Unbundling of generation, transmission, and distribution; established regulatory commissions (CERC/SERCs); open access; renewable purchase obligations; private participation (46.3% renewable capacity by 2025).

# ENERGY AND THE ENVIRONMENT

Energy production and consumption significantly impact our environment through emissions, resource depletion, and climate change effects. Energy accounts for over 73% of global greenhouse gas emissions.



## Air Pollution

Combustion of fossil fuels releases SO<sub>x</sub>, NO<sub>x</sub>, CO, particulate matter, leading to smog, acid rain, and respiratory diseases



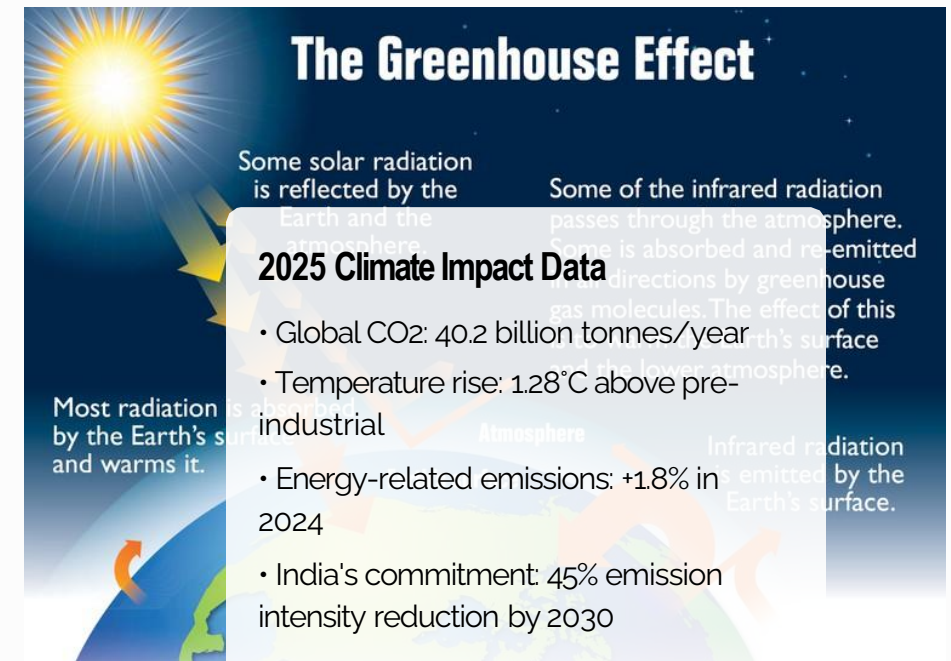
## Climate Change

Energy sector contributes approximately 35 billion tonnes of CO<sub>2</sub> annually, driving global warming, extreme weather events, and sea level rise



## Resource Impact

Energy production affects water resources, biodiversity, and land use patterns, contributing to ecosystem degradation



# ENERGY SECURITY & CONSERVATION

## Energy Import Dependency

India faces significant energy security challenges with high import dependency, particularly for oil.

**90%**

Oil Import Dependency

**₹137B**

Annual Import Bill (2025)

## Energy Security Strategies

- Diversification of energy supply sources
- Building strategic fuel stockpiles

## Benefits of Energy Conservation

Energy conservation provides multiple economic and environmental benefits while enhancing security.

- Reduced energy imports and improved trade balance
- Lower emissions and pollution (CO<sub>2</sub> reduction of 300 MT by 2030)
- Enhanced industrial competitiveness through efficiency
- Extended lifetime of existing resources
- Greater resilience against global price fluctuations

With conservation measures, India aims to reduce its energy intensity by 45% by 2030 compared to 2005 levels. Energy audits have identified potential savings of 20-30%

# ENERGY CONSERVATION ACT, 2001

Passed in 2001 and enacted nationwide, the Act established a comprehensive framework to promote efficient use of energy and its conservation through institutional mechanisms, standards, and regulatory enforcement.



## Bureau of Energy Efficiency

- Established in 2002
- 26-member Governing Council
- Sets standards and enforces efficiency measures
- Manages Energy Conservation Fund



## Standards & Labeling

- Star rating system for appliances
- Mandatory energy performance standards
- Ban on inefficient equipment
- Energy Conservation Building Code



## Designated Consumers

- Energy-intensive industries identified
- Required energy audits & reporting
- Mandatory energy managers
- Compliance with energy consumption norms



## Energy Professionals

- Certification of Energy Managers



## Enforcement & Penalties

- ₹10,000 fine per offense



## 2025 Achievements

- 14,500+ designated consumers

# SUMMARY & KEY TAKEAWAYS

- ✓ India's energy mix is evolving, with renewable capacity reaching **46.3%** (490 GW total) by 2025, including 110.9 GW solar and 51.6 GW wind capacity.
- ✓ Despite progress in renewables, energy security remains challenging with **90%** oil import dependency (record high) and a \$137 billion annual import bill.
- ✓ Energy-economy relationship has evolved: **7.4%** GDP growth now requires only **6-6.5%** energy growth, showing improved efficiency.
- ✓ The Energy Conservation Act 2001 and its 2022 amendments provide a robust framework for energy efficiency through standards, labeling, and mandatory energy management practices.