

ENERGY CONSERVATION AND AUDIT

Course Code: BEE755B

MODULE 1: ENERGY SCENARIO AND MANAGEMENT

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MODULE 1: ENERGY SCENARIO AND MANAGEMENT

This module introduces students to the global and Indian energy scenario, energy resources classification, energy-economy linkages, environmental implications, conservation policies, and strategic energy management. After studying this module, students will be able to:

1. Distinguish between commercial and non-commercial energy sources and their roles.
2. Analyse primary energy resources and global/Indian production trends.
3. Relate energy consumption patterns to economic development.
4. Evaluate the need for energy conservation and restructuring of the energy sector.
5. Understand India's Energy Conservation Act-2001 and its key provisions.
6. Explain the linkages between energy use, air pollution, and climate change.
7. Describe strategies for long-term energy security and sustainability.

1. Energy Scenario: Commercial and Non-Commercial Energy

Energy is the lifeblood of modern economies. The global demand for energy continues to rise, driven by population growth, urbanisation, and industrial expansion. Understanding the nature, sources, and consumption patterns of energy is fundamental to managing it efficiently.

1.1 Classification of Energy Sources

Energy sources are broadly classified as follows:

Table 1.1 – Classification of Energy Sources

Basis	Commercial Energy	Non-Commercial Energy
Definition	Energy bought and sold in the market with a definite price	Energy obtained freely from nature, not traded in organised markets
Examples	Coal, petroleum, natural gas, electricity, LPG	Firewood, agricultural residues, animal dung, solar (traditional)
India's share (approx.)	~65% of total energy consumption	~35% of total energy consumption
Primary users	Industry, transport, urban households	Rural households, small-scale agriculture
Metering/accounting	Measured and accounted in national statistics	Often not captured in official energy statistics
Environmental impact	High CO ₂ and pollutant emissions (fossil fuels)	Indoor air pollution from biomass combustion

1.1.1 Commercial Energy

Commercial energy refers to energy commodities that are available to users at a competitive price. They are produced, transported, and sold in established energy markets. Key points:

- Coal remains the dominant commercial fuel in India, contributing nearly 44% of primary energy supply.
- Petroleum products account for approximately 29% of India's commercial energy.
- Natural gas contributes around 6%, with a growing role under the National Gas Grid expansion.
- Nuclear energy contributes a small but strategic share (~1–2%) of electricity generation.
- Renewable electricity (hydro, wind, solar) is the fastest-growing commercial energy segment.

1.1.2 Non-Commercial Energy

Non-commercial energy, also called traditional biomass energy, remains critical for rural India. Key characteristics:

- Approximately 700 million Indians still rely on biomass (firewood, cow-dung cakes, agricultural waste) for cooking.
- The combustion of these fuels in inefficient chulhas causes severe indoor air pollution — a leading cause of respiratory diseases.
- National programmes like the Pradhan Mantri Ujjwala Yojana (PMUY) aim to replace traditional biomass with LPG, reducing health and environmental burdens.
- Recognising non-commercial energy in policy planning is essential for achieving universal energy access (SDG-7).

2. Primary Energy Resources

Primary energy resources are those extracted or captured directly from natural sources before any conversion or transformation. They are classified into:

Table 2.1 – World Proved Reserves of Primary Energy Resources (approximate, 2023 data)

Resource	Proved Reserves	Reserve-to-Production Ratio	Top Holders
Coal	~1,074 Billion tonnes	~139 years	USA, Russia, Australia, China, India
Petroleum (crude oil)	~1,732 Billion barrels	~54 years	Venezuela, Saudi Arabia, Canada, Iran, Iraq
Natural Gas	~188 Trillion m ³	~49 years	Russia, Iran, Qatar, USA, Turkmenistan
Uranium (nuclear)	~6.1 Million tonnes (recoverable)	~130 years (at current use)	Kazakhstan, Australia, Namibia, Canada
Hydropower potential	~15,000 TWh/yr (economically exploitable)	Renewable (inexhaustible)	China, Brazil, Canada, India, Russia

2.1 India's Primary Energy Scenario

India is the world's third-largest energy consumer (after China and the USA). Key facts:

- India's total primary energy supply was approximately 906 Mtoe (Million tonnes of oil equivalent) in 2022.

- Coal dominates India's energy mix at ~56% of commercial primary energy, owing to abundant domestic reserves (~315 billion tonnes of estimated reserves).
- India imports about 85% of its crude oil requirement — a significant energy security and trade balance vulnerability.
- India has set an ambitious target of achieving 500 GW of non-fossil fuel-based electricity capacity by 2030, and Net-Zero emissions by 2070.

2.2 Renewable vs Non-Renewable Energy

Table 2.2 – Renewable versus Non-Renewable Primary Resources

Criterion	Renewable	Non-Renewable
Availability	Replenished naturally in short cycles	Formed over millions of years; finite stock
Examples	Solar, wind, biomass, hydro, geothermal, tidal	Coal, petroleum, natural gas, nuclear fuel
CO ₂ emission	Near-zero (except biomass combustion)	Significant; major source of GHGs
Energy density	Low to medium; intermittent availability	High; dispatchable on demand
India's status	~42% of installed electricity capacity (2024)	Still ~58% of installed capacity (thermal + nuclear)

3. Commercial Energy Production

Commercial energy production involves the extraction, conversion, and supply of energy commodities through organised industries. In India, this encompasses coal mining, oil & gas extraction, power generation, and refineries.

3.1 Coal Production

- India is the second-largest coal producer in the world.
- Annual coal production reached ~990 million tonnes in FY 2023-24, with a target of 1.5 billion tonnes by 2030.
- Coal India Limited (CIL) accounts for nearly 80% of domestic coal production.
- However, the calorific value and quality of Indian coal is relatively lower (2,500–4,500 kcal/kg) compared to Australian or South African coal (5,500–7,000 kcal/kg).

3.2 Oil & Natural Gas Production

- India produced approximately 29.2 million tonnes of crude oil in 2022-23.
- ONGC and Oil India Limited are the primary domestic producers.
- Natural gas production is about 35 billion cubic metres per year.
- Due to the gap between domestic production and demand, India imports ~85% of crude oil requirements, primarily from the Middle East, Russia, and USA.

3.3 Electricity Generation

Table 3.1 – India's Installed Electricity Generation Capacity (as of March 2024)

Source	Installed Capacity (GW)	% of Total
Thermal (Coal + Gas + Oil)	~237 GW	~57%
Hydroelectric	~47 GW	~11%
Nuclear	~7.5 GW	~2%
Solar	~82 GW	~20%
Wind	~45 GW	~11%
Others (Biomass, Small Hydro)	~11 GW	~3%
TOTAL	~430 GW	100%

Key note: India's total electricity generation in FY 2023-24 was approximately 1,734 TWh. The peak demand crossed 243 GW in May 2024, reflecting growing economic activity.

4. Final Energy Consumption

Final energy consumption refers to the energy consumed by end-users (industry, transport, agriculture, domestic sector) after accounting for losses in conversion, transmission, and distribution.

Table 4.1 – Sector-wise Final Energy Consumption in India (approximate, FY 2022-23)

Sector	Energy Consumed (Mtoe)	Share (%)	Dominant Fuel
Industry	~210	~38%	Coal, electricity
Transport	~125	~23%	Diesel, petrol, ATF
Residential / Domestic	~110	~20%	LPG, biomass, electricity
Agriculture	~50	~9%	Electricity, diesel
Commercial	~55	~10%	Electricity, diesel
TOTAL	~550 Mtoe	100%	—

Important observation: India's per-capita primary energy consumption (~637 kgoe in 2022) is significantly lower than the world average (~1,900 kgoe) and developed nations (USA: ~6,700 kgoe), indicating large headroom for growth and simultaneously a huge potential for efficiency improvements.

4.1 Energy Intensity

Energy intensity is defined as the energy consumed per unit of GDP (kgoe / USD of GDP). It measures the energy efficiency of an economy.

- India's energy intensity: approximately 0.10–0.11 kgoe per USD (2015 PPP basis, 2022).
- India's energy intensity has been declining due to efficiency improvements, but remains higher than many advanced economies.
- The Bureau of Energy Efficiency (BEE) targets a 4–5% per year reduction in energy intensity under the National Mission for Enhanced Energy Efficiency (NMEEE).

5. Energy Needs of a Growing Economy

Energy and economic growth are tightly coupled. As an economy grows, its demand for energy typically rises to support industrialisation, urbanisation, transportation, and improved living standards.

5.1 Energy-GDP Nexus

- Empirical evidence shows a strong correlation between per-capita energy consumption and per-capita GDP.
- Developing nations like India require a 6–8% annual growth in energy supply to sustain a GDP growth rate of 7–8%.
- Historical analysis shows India's commercial energy consumption grew from ~175 Mtoe in 2000 to ~775 Mtoe in 2022, nearly mirroring economic expansion.
- The concept of 'energy elasticity of GDP' (ratio of % change in energy demand to % change in GDP) typically lies between 0.7 and 1.2 for developing economies.

5.2 Sectoral Energy Needs and Drivers

Table 5.1 – Key Drivers of Energy Demand in India

Sector	Growth Driver	Energy Challenge
Industry	'Make in India', PLI schemes, infrastructure push	High energy intensity; need for efficiency
Transport	Rising vehicle fleet; freight movement	Petroleum import dependence; EV transition needed
Residential	Rising incomes, electrification, appliance ownership	Peak demand management; space cooling loads
Agriculture	Irrigation, mechanisation, cold chain	Subsidised power leads to inefficiency
Services / IT	Rapid expansion; data centre growth	Cooling and round-the-clock reliable power

6. Long-Term Energy Scenario

Long-term energy scenarios are projections of how the energy system may evolve over the next 20–30 years, considering policy choices, technology trends, and climate commitments.

6.1 India's Projected Energy Demand

- India's total primary energy demand is projected to reach ~2,100–2,500 Mtoe by 2047 (India@100), nearly 3× the 2022 level.
- Electricity demand is expected to reach approximately 5,000–6,000 TWh/year by 2047.
- The share of natural gas in the energy mix is targeted to increase from ~6% to 15% by 2030 under the National Gas Grid Policy.
- Oil demand is expected to peak around 2035 before declining with EV penetration.

6.2 Renewable Energy Targets

Table 6.1 – India's Long-Term Renewable Energy Targets

Target	Deadline	Status / Goal
500 GW non-fossil capacity	2030	Committed under NDC update (COP26)
50% electricity from renewables	2030	Part of updated NDC submitted to UNFCCC
Reduce emission intensity of GDP by 45%	2030	Over 2005 baseline — updated NDC
Net-Zero emissions	2070	Announced at COP26 (Glasgow, 2021)
National Hydrogen Mission	2030	Target: 5 MMT green hydrogen production

7. Energy Pricing

Energy pricing refers to the mechanisms by which the cost of energy is determined and passed on to consumers. Appropriate pricing is critical for efficient resource allocation, investment signalling, and demand management.

7.1 Principles of Energy Pricing

- Cost-reflective pricing: prices should reflect the true economic cost of production, transmission, distribution, and externalities.
- Long-run marginal cost (LRMC) pricing: a theoretically optimal approach where price equals the cost of serving the next unit of demand.
- Subsidised pricing: used for social equity reasons but can distort consumption and reduce incentives for efficiency.
- Time-of-use (ToU) pricing and peak pricing: differential pricing to flatten the load curve and signal congestion periods.

7.2 Energy Pricing Issues in India

Table 7.1 – Energy Pricing Issues in India

Energy Form	Current Issue	Reform Direction
Electricity	Cross-subsidies; below-cost tariffs for agriculture	SERC-based cost-reflective tariff revisions
LPG	Direct Benefit Transfer (DBT) partially implemented	Targeted subsidy for BPL households via PMUY
Petrol / Diesel	Deregulated since 2010/2014; linked to global crude	Dynamic pricing; EV transition to reduce demand
Coal	Nominally market-priced; captive linkages below market	Auction-based linkage; commercial mining entry
Natural Gas	Administered Pricing Mechanism (APM) for older fields	Moving to market-linked pricing for new discoveries

Note: Perverse subsidies have historically led to wasteful energy consumption, suppressed investment in the energy sector, and strained government finances. The International Energy Agency (IEA) estimates that global fossil fuel subsidies reached a record USD 7 trillion in 2022 (explicit + implicit), with India being one of the largest subsidisers in absolute terms.

8. Energy Sector Reforms

Energy sector reforms are structural changes aimed at improving efficiency, attracting investment, ensuring competition, and aligning pricing with costs. India has undertaken significant reforms since the 1990s.

8.1 Electricity Sector Reforms – Key Milestones

Table 8.1 – Key Milestones in India's Power Sector Reform

Year	Legislation / Policy	Key Reform
1991	Policy Liberalisation	Private sector entry into power generation; IPPs allowed
1998	Electricity Regulatory Commission Act	Establishment of independent State Electricity Regulatory Commissions (SERCs)
2003	Electricity Act 2003	Unbundling of SEBs; open access; delicensing of generation; competition
2014	UDAY Scheme (2015)	Ujwal DISCOM Assurance Yojana — financial restructuring of DISCOMs
2022	Electricity Amendment Bill 2022	Expanding open access; multiple supply licensees; promoting renewables

8.2 Oil & Gas Sector Reforms

- NELP (New Exploration Licensing Policy, 1997): opened E&P to private and foreign companies.
- Natural Gas market development: PNGRB (Petroleum and Natural Gas Regulatory Board) established in 2006.
- Discovered Small Field policy (2016): bid rounds for small discovered fields to fast-track production.
- Open Acreage Licensing Policy (OALP, 2017): revenue-sharing model; continuous acreage offer.

9. Energy and Environment

The production and consumption of energy — particularly from fossil fuels — is the single largest contributor to global environmental problems including air pollution and climate change. Understanding these linkages is central to energy planning.

9.1 Air Pollution from Energy Use

Table 9.1 – Major Air Pollutants from Energy Combustion and Their Effects

Pollutant	Primary Source	Health/Environmental Effect	Standard (India, CPCB)
SO ₂	Coal-fired power plants, industries	Acid rain, respiratory diseases	80 µg/m ³ (annual)
NO _x	Transport vehicles, thermal plants	Smog, ozone formation, lung damage	80 µg/m ³ (annual)
PM2.5	Combustion (vehicles, biomass, coal)	Deep lung penetration; cardiovascular & pulmonary disease	40 µg/m ³ (annual) NAAQS 2009
PM10	Industries, road dust, construction	Respiratory irritation	60 µg/m ³ (annual)
CO	Incomplete combustion in vehicles	Reduces oxygen carrying capacity of blood	2 mg/m ³ (8-hr average)
CO ₂	All fossil fuel combustion	Greenhouse gas; climate change	No ambient standard (GHG not a criteria pollutant)

Key facts on air pollution and energy:

- India has some of the most polluted cities in the world; of the 30 most polluted global cities by PM2.5 (IQAir 2023 World Air Quality Report), 22 are in India.
- The energy sector (power generation + industry + transport) contributes ~70% of India's total air pollutant emissions.
- The Government has notified stringent emission norms for thermal power plants (SO₂, NO_x, mercury, PM) under the Environment Protection Act.

9.2 Climate Change

Climate change refers to long-term shifts in global temperature and weather patterns, largely driven since the mid-20th century by human activities, especially the burning of fossil fuels.

9.2.1 Greenhouse Gas (GHG) Emissions

- CO₂ is the most significant anthropogenic GHG, responsible for about 75% of the warming effect.
- Methane (CH₄), with 80× the 20-year global warming potential of CO₂, leaks from natural gas systems and coal mines.
- N₂O, HFCs from refrigeration and air conditioning, and black carbon are other important GHGs from the energy sector.

- India's total GHG emissions are approximately 3.4 Gt CO₂e/year (2022), making it the third-largest emitter after China and the USA. However, India's per-capita emissions (~2.4 tCO₂e) are well below the world average (~6.3 tCO₂e).

Table 9.2 – Key Greenhouse Gases and their Global Warming Potential (GWP-100)

Gas	GWP-100 (vs CO ₂)	Primary Energy-related Source
CO ₂	1 (baseline)	Fossil fuel combustion, cement, deforestation
CH ₄ (Methane)	~27 (AR6, IPCC 2021)	Natural gas leaks, coal mines, landfills
N ₂ O (Nitrous Oxide)	~273	Combustion, agriculture, chemical plants
SF ₆ (Sulphur hexafluoride)	~25,200	High-voltage switchgear in electricity systems

9.2.2 IPCC Findings (AR6, 2021–2023):

- Global surface temperature has already increased by 1.1°C above the 1850–1900 average.
- To limit warming to 1.5°C (Paris Agreement), global CO₂ emissions must reach net-zero by around 2050.
- Even with current pledges, the world is on track for ~2.5–3°C of warming this century.
- Impacts include sea-level rise, extreme weather events, agricultural disruptions, and biodiversity loss — all with disproportionate effects on developing nations including India.

10. Energy Security

Energy security is defined as the uninterrupted availability of energy sources at an affordable price. It is a multidimensional concept encompassing availability, accessibility, affordability, and acceptability (the 4 A's framework).

10.1 Dimensions of Energy Security

Table 10.1 – Four Dimensions of Energy Security

Dimension	Description	India's Challenge
Availability	Physical existence of sufficient energy resources	Oil import dependence; finite coal reserves
Accessibility	Ability to physically access and transport energy	Supply chain disruptions; evacuation infrastructure gaps
Affordability	Reasonable cost to consumers and the economy	High oil import bill (USD 140 bn/yr); subsidies burden
Acceptability	Environmentally and socially acceptable supply	Balancing growth with climate and pollution commitments

10.2 Strategies for Energy Security in India

- Diversification of energy sources: increasing the share of domestic renewables, nuclear, and reducing dependence on imported oil.
- Strategic Petroleum Reserve (SPR): India has built strategic reserves of ~5.3 million metric tonnes at three underground caverns (Visakhapatnam, Mangaluru, Padur).
- International energy partnerships: long-term supply agreements with oil-producing nations; equity oil partnerships through OVL (ONGC Videsh).
- Domestic oil exploration: OALP rounds and incentivising E&P through HELP (Hydrocarbon Exploration and Licensing Policy).
- Energy efficiency: reducing demand growth through efficiency standards (BEE star ratings, PAT scheme) reduces import dependence.
- Technology development: fostering indigenous technology in solar, batteries, green hydrogen to reduce strategic vulnerabilities.

11. Energy Conservation and Its Importance

Energy conservation refers to the reduction of energy consumption through improved practices, behavioural changes, and technological measures without compromising output or comfort. It is often described as 'the fifth fuel' after coal, oil, gas, and nuclear energy — because conserving one unit of energy at the consumer end saves 2–3 units of primary energy input due to conversion efficiencies.

11.1 Why is Energy Conservation Important?

Table 11.1 – Multiple Rationales for Energy Conservation

Rationale	Explanation
Economic	Reduces energy bills; frees capital; improves industrial competitiveness; reduces subsidy burden on government
Environmental	Fewer emissions of CO ₂ , SO ₂ , NO _x , particulate matter; helps meet NDC and net-zero targets
Energy Security	Reduces dependence on imported fuels; extends life of domestic reserves
Infrastructure Deferral	Conserved energy reduces the need for new power plants and transmission lines — saving enormous capital expenditure
Employment	Energy efficiency projects and industries create skilled jobs (e.g., LED manufacturing, insulation, ESCO sector)
Social Equity	Lower energy costs benefit poorer households and small businesses disproportionately

11.2 Potential for Energy Conservation in India

- India's electrical T&D losses are approximately 20–22%, among the highest in the world (global average: 8%). Reduction to 12% alone could save ~100 TWh/year.
- The BEE estimates India's total energy savings potential at about 25–30% of current consumption through cost-effective measures.
- PAT (Perform, Achieve and Trade) scheme covered 887 designated consumers (DCs) in Cycle I-II, achieving savings of 45.2 Mtoe against a target of 11.5 Mtoe.
- LED lighting programme (UJALA): distribution of 368 million LED bulbs by 2022 saves approximately 47.65 billion kWh/year, reducing peak demand by ~9,500 MW.

12. Restructuring of the Energy Supply Sector

Restructuring the energy supply sector involves fundamental changes in ownership, governance, market structure, and regulatory frameworks to make the sector more efficient, competitive, and financially viable.

12.1 Rationale for Restructuring

- Historically, India's energy sector was characterised by State Electricity Boards (SEBs) that were vertically integrated monopolies engaged in generation, transmission, and distribution — leading to cross-subsidisation, commercial losses, and operational inefficiency.
- By 2000, the cumulative losses of SEBs had crossed INR 26,000 crore, threatening fiscal stability of states.
- The Electricity Act 2003 mandated unbundling of SEBs into separate entities for generation (GENCO), transmission (TRANSCO), and distribution (DISCOM), with independent regulation through SERCs.

12.2 Elements of Energy Sector Restructuring

Table 12.1 – Elements of Energy Supply Sector Restructuring

Element	Description
Unbundling	Separation of generation, transmission, distribution into distinct legal entities with separate accounts
Independent Regulation	SERCs and CERC determine tariffs and open access; reduce political interference
Privatisation	Private participation in generation (IPPs) and distribution (e.g., Delhi, Mumbai privatisation)
Open Access	Large consumers can buy power from any generator using the common grid infrastructure for a wheeling charge
Competitive Markets	Power exchanges (IEX, PXIL) enable short-term trading; renewable energy certificates
DISCOM Reform	AT&C loss reduction targets; feeder separation; smart metering; privatisation of distribution

13. Energy Strategy for the Future

A future-oriented energy strategy for India must balance the imperatives of economic development, environmental sustainability, energy security, and social equity. The strategy rests on five pillars:

- 1. Rapid Renewable Energy Deployment:** Achieve 500 GW non-fossil capacity by 2030; accelerate solar, wind, and green hydrogen at scale.
- 2. Energy Efficiency Across All Sectors:** Strengthen PAT scheme; expand BEE star-labelling; implement building energy codes (ECBC); mandate industrial energy audits.
- 3. Clean Cooking and Universal Energy Access:** Complete the LPG transition under PMUY; promote biogas and solar cooking solutions in rural areas.
- 4. Smart Grid and Digitalisation:** Deploy Advanced Metering Infrastructure (AMI); adopt Demand Response (DR) programmes; integrate storage and EVs as grid assets.
- 5. Green Hydrogen Economy:** Develop a domestic green hydrogen supply chain for fertiliser, steel, refinery decarbonisation, and export opportunities under the National Green Hydrogen Mission (NGHM).

Table 13.1 – India's Energy Strategy: Key Programmes and Goals

Programme	Objective	Target / Status
NMEEE (PAT, MTEE, MEPS)	Industrial energy efficiency	Savings >45 Mtoe in PAT Cycle I-II
UJALA (LED programme)	Efficient lighting in households	368 million LEDs; ~47.65 BU savings/year
NGHM (Green Hydrogen)	Decarbonise hard-to-abate sectors	5 MMT production target by 2030
FAME II (EV promotion)	Reduce oil dependency in transport	INR 10,000 crore; 1 million EV incentives
ECBC (Building codes)	Reduce cooling/heating energy in buildings	Savings of 300 BU/year potential by 2047

14. Energy Conservation Act-2001 and Its Features

The Energy Conservation Act-2001 (EC Act) was enacted by the Government of India with the objective of providing for efficient use of energy and its conservation. It is the cornerstone legal framework for energy efficiency in India, and was significantly amended in 2022 (Energy Conservation (Amendment) Act, 2022).

14.1 Background and Need

- Prior to the EC Act, India had no mandatory legal framework for energy efficiency in industry or buildings.
- Energy intensity of Indian industry was 20–30% higher than that of comparable industries in developed nations.
- The Act was a proactive response to rising energy import bills, environmental commitments, and the need to improve industrial competitiveness.

14.2 Bureau of Energy Efficiency (BEE)

- BEE was established on 1 March 2002 under the Ministry of Power as the statutory body under the EC Act.
- BEE is responsible for policy recommendations, standards and labelling, energy auditor accreditation, and public awareness.
- BEE is governed by a Governing Council chaired by the Minister of Power, with representation from industry, science, and state governments.

14.3 Key Provisions of the Energy Conservation Act-2001

Table 14.1 – Key Provisions of the EC Act 2001

S.No.	Provision	Description
1	Designated Consumers (DC)	Large energy-consuming units in notified sectors (steel, aluminium, cement, textile, fertiliser, pulp & paper, chlor-alkali, railways, ports, railways, commercial buildings) are designated as DCs and are legally mandated to comply with EC provisions
2	Energy Audits	Mandatory energy audits by accredited energy auditors at prescribed intervals for designated consumers; results to be submitted to BEE
3	Energy Managers	Designated consumers must appoint a certified energy manager (with prescribed qualifications); responsible for implementing energy conservation measures and filing annual reports
4	Standards and Labelling	BEE to prescribe energy consumption norms and standards for equipment/appliances; star-labelling programme (1 to 5 stars) for appliances such as ACs, refrigerators, fans, geysers, TVs, motors
5	Energy Conservation Building Codes (ECBC)	Mandatory performance standards for new commercial buildings; state governments may notify ECBC for residential buildings; revised ECBC 2017 targets 50% energy reduction vs baseline
6	Accreditation of Energy Auditors	BEE accredits individuals and firms as energy auditors; conduct of National Certification Examination in Energy Auditing and Energy Management

S.No.	Provision	Description
7	Penalties	Non-compliance by designated consumers attracts penalties: INR 10 lakh per day for first violation; INR 10 lakh per day + 10% of cost of relevant energy consumed for subsequent violations
8	PAT Scheme	Perform, Achieve and Trade scheme is a market-based regulatory mechanism. DCs are given specific energy consumption (SEC) targets; those who over-achieve earn Energy Saving Certificates (ESCs) which can be traded with underperformers

14.4 Energy Conservation (Amendment) Act, 2022 – New Features

The 2022 amendment to the EC Act significantly enhanced India's legal framework for energy efficiency and decarbonisation:

Table 14.2 – Key Additions in the Energy Conservation Amendment Act, 2022

New Provision	Details
Carbon Credit Trading Scheme	Empowers the Central Government to establish a domestic carbon market. Industries can earn and trade carbon credits for exceeding their prescribed GHG reduction targets
Renewable Purchase Obligation (RPO) in EC Act	Obliges designated consumers to procure a minimum percentage of their energy from renewable sources (earlier this was only in the Electricity Act). Failure to comply is penalised
Green Hydrogen Obligation	Certain industries may be obligated to use green hydrogen as feedstock/fuel to support the National Green Hydrogen Mission
Energy Conservation Standards for Vehicles	Empowers the government to prescribe fuel efficiency standards and energy labels for vehicles — extending the scope of the EC Act to the transport sector
Expanded DC list	Residential buildings above a certain size are now included in the Designated Consumer category, making them subject to ECBC compliance
Enhanced penalties	Penalties for non-compliance have been increased to INR 10 lakh/day + 2× the value of the energy used in excess of the prescribed norms

14.5 PAT (Perform, Achieve and Trade) Scheme – Salient Features

Table 14.3 – PAT Scheme Performance Summary (Cycles I & II)

Parameter	PAT Cycle I (2012–15)	PAT Cycle II (2016–19)
No. of DCs	478	621
Target Saving	6.686 Mtoe/year	8.869 Mtoe/year
Actual Saving	8.67 Mtoe/year (30% over target)	14.08 Mtoe/year (59% over target)
CO₂ reduction	~31.38 Mt CO ₂	~62 Mt CO ₂ equivalent
Sectors covered	8 industrial sectors	11 industrial sectors

15. Module Summary – Key Facts and Figures

Table 15.1 – Quick Reference: Key Figures for BEE755B Module 1

Topic	Key Fact / Figure
India's primary energy supply	~906 Mtoe (2022); 3rd largest consumer globally
India's coal production	~990 MT (FY 2023-24); CIL has ~80% share
India's crude oil imports	~85% of requirement; ~USD 140 bn/year (2022-23)
Installed power capacity	~430 GW (March 2024); ~42% from renewables
Energy Conservation Act	Enacted 2001; BEE established 1 March 2002; amended 2022
PAT Scheme savings	Cycle I: 8.67 Mtoe; Cycle II: 14.08 Mtoe (both exceeded targets)
UJALA LED programme	368 million LEDs; 47.65 BU/year savings; 9,500 MW peak reduction
India's GHG emissions	~3.4 Gt CO ₂ e/year; 3rd globally; per-capita ~2.4 tCO ₂ e
Net-zero target	2070 (announced COP26, Glasgow); 500 GW non-fossil by 2030
T&D losses	~20-22% (national average); reduction to 12% = ~100 TWh savings
EC Act penalty (2022)	Up to INR 10 lakh/day + 2× cost of excess energy consumed
Strategic petroleum reserve	~5.3 MMT; at Visakhapatnam, Mangaluru, Padur
India's energy intensity	~0.10-0.11 kgoe/USD (2015 PPP); declining with efficiency push
ECBC target	50% energy reduction in new commercial buildings vs baseline

16. Review Questions

Short-Answer Questions (4–6 marks)

- Distinguish between commercial and non-commercial energy with suitable examples. Why is non-commercial energy underestimated in national statistics?
- What are the major primary energy resources of the world? Compare India's resource endowment with the global picture.
- Explain the concept of 'energy elasticity of GDP'. How does it relate to energy planning in a developing economy like India?
- Define energy security. Discuss the four dimensions of energy security and India's challenges in each.
- What is energy intensity? How is it linked to industrial competitiveness and environmental performance?
- List the key provisions of the Energy Conservation Act-2001. How does it mandate the role of energy managers and auditors?

Long-Answer Questions (10–15 marks)

14. Discuss India's long-term energy scenario. What are the key targets under India's updated NDCs? How does the energy strategy align with the net-zero commitment?
15. Explain the significance of energy conservation and its importance for India's economy and environment. Discuss at least three major national programmes under energy conservation with quantitative data.
16. Write a comprehensive note on the Energy Conservation (Amendment) Act, 2022. How does the introduction of the Carbon Credit Trading Scheme and RPO obligations under this act change the energy efficiency landscape?
17. Explain the linkages between energy production and consumption, air pollution, and climate change. Discuss relevant standards and policies in India to address these linkages.
18. What is the PAT (Perform, Achieve and Trade) scheme? Discuss its objectives, mechanism, and performance with data from at least two PAT cycles.
19. Describe the restructuring of India's electricity supply sector since 1991. What were the key issues with the SEBs? How has the Electricity Act 2003 addressed them?

End of Module 1 Notes – BEE755B Energy Conservation and Audit

Reference texts: (1) Bureau of Energy Efficiency – Guide Books (1-4) on Energy Efficiency in Industry; (2) IEA World Energy Outlook 2023; (3) Ministry of Power Annual Report 2023-24; (4) Energy Conservation Act 2001 (amended 2022) – Bare Act; (5) IPCC Sixth Assessment Report (AR6), 2021-2023.