

ENERGY and Environmental Engineering

Subject Code: **EG110**
B.Tech. I , Semester – II



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Energy: B Tech I Year Syllabus Detailing and Course Materials

SYLLABUS	
BASICS OF ENERGY AND ITS CONSERVATION Classification of Energy Sources, Global and National Energy Scenario. Fossil and alternate fuels and its characterization, General aspects of energy conservation and management; Energy Conservation Act, Energy Policy of Company; Need for Energy Standards and Labelling; Energy Building Codes.	(7 hours)
INTRODUCTION TO ENERGY CONVERSION SYSTEMS Energy conversion systems: Working Principle, Basic Components, General functioning and normal rating specification of various energy conversion systems like Power Plant, Pump, Refrigerator, Air-conditioner, Internal Combustion Engine, Solar PV Cell, Solar Water Heating System, Biogas Plant. Wind Turbine, Fuel cells. Energy storage in Batteries. Types of Batteries; Electric Vehicles	(8 hours)
Total:	15 hours

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat

B.Tech. I (ME) Semester – I ENERGY AND ENVIRONMENTAL ENGINEERING EG110	Scheme	L	T	P	Credit
		3	0	2	04

1. Course Outcomes (COs): At the end of the course, students will be able to	
CO1	Explain the components of ecosystems, various biogeochemical cycles and importance of different urban network services
CO2	Differentiate between various types of environmental pollution along with their impacts and regulatory standards
CO3	Examine various global environmental issues and their management
CO4	Discuss the fundamental principles of energy, including classification, conservation and related policy frameworks and regulations.
CO5	Analyse a given energy systems and their components

Content

1. Introduction
2. Need/Aim/Application
3. Classification of Energy Sources
4. Main Energy Sources
5. Energy Scenario

1. Introduction

- Energy Definition
- Brief History
- Forms of Energy
- Laws of Energy
- Terminologies

2. Need/Aim/Application

- Reason for studying ENERGY
- Linked Environment

3. Classification

- Primary and Secondary
- Commercial and Non-commercial
- Renewable and Non-Renewable

4. Main Energy Sources

- Coal
- Oil
- Natural Gas
- Nuclear Power
- Hydropower
- Other Renewable Energy Sources

5. Energy Scenario

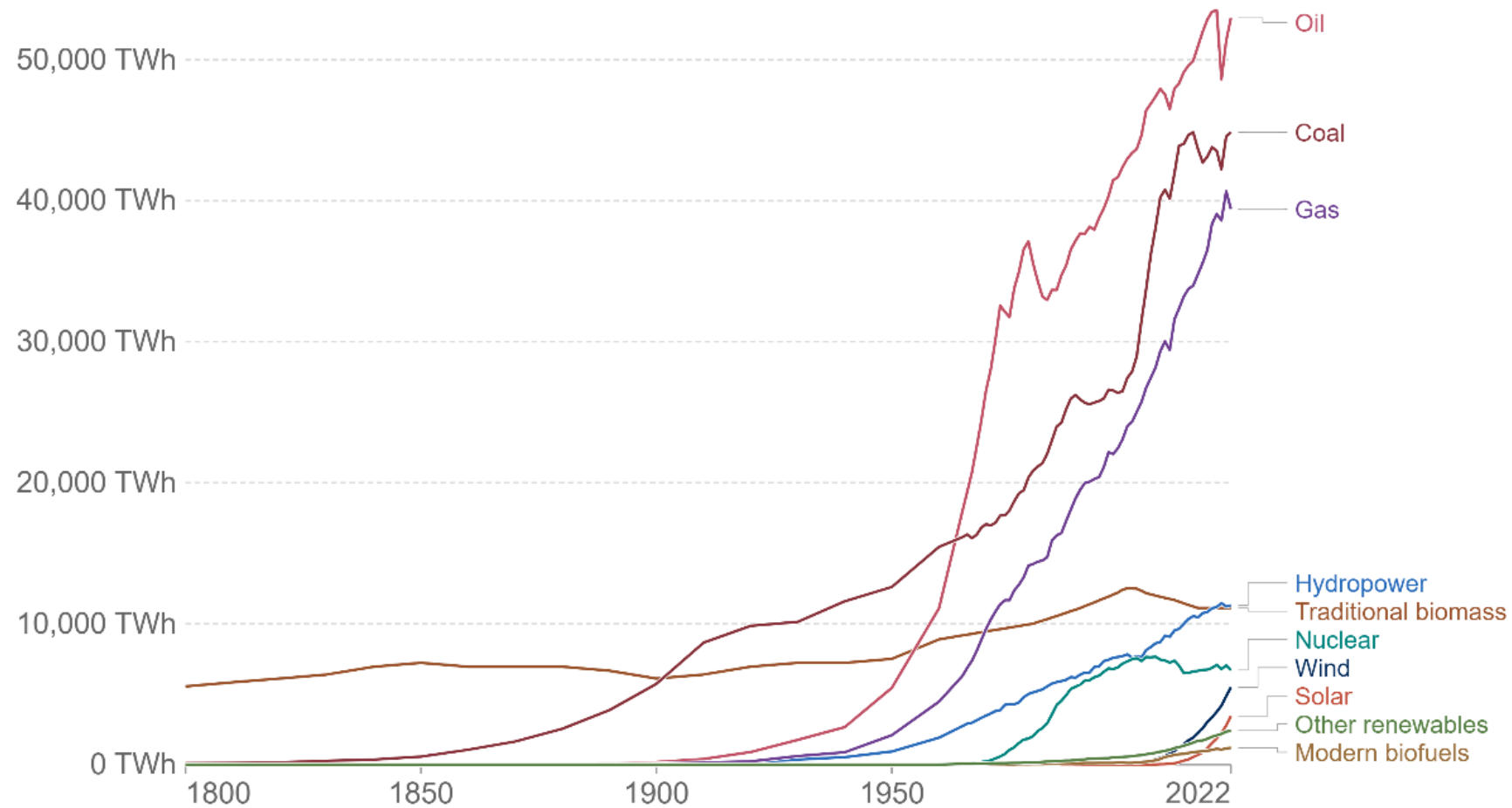
% energy consumption

	Pre-covid (2014)		Post Covid (2024)	
Energy Source	National	Global	National	Global
Coal	54.5	30	45.9	25.1
Oil	29.5	33	24.0	29.6
Natural Gas	7.8	24	5.1	22.0
Nuclear Power	1.2	4.0	1.2	3.75
Hydropower	5.0	7.0	1.5	6.32
Other Renewable Energy	2.0	2.0	22.3	13.23

Global primary energy consumption by source

Global primary energy consumption here is measured by the 'substitution' method which takes account of the inefficiencies of fossil fuel production.

Our World
in Data

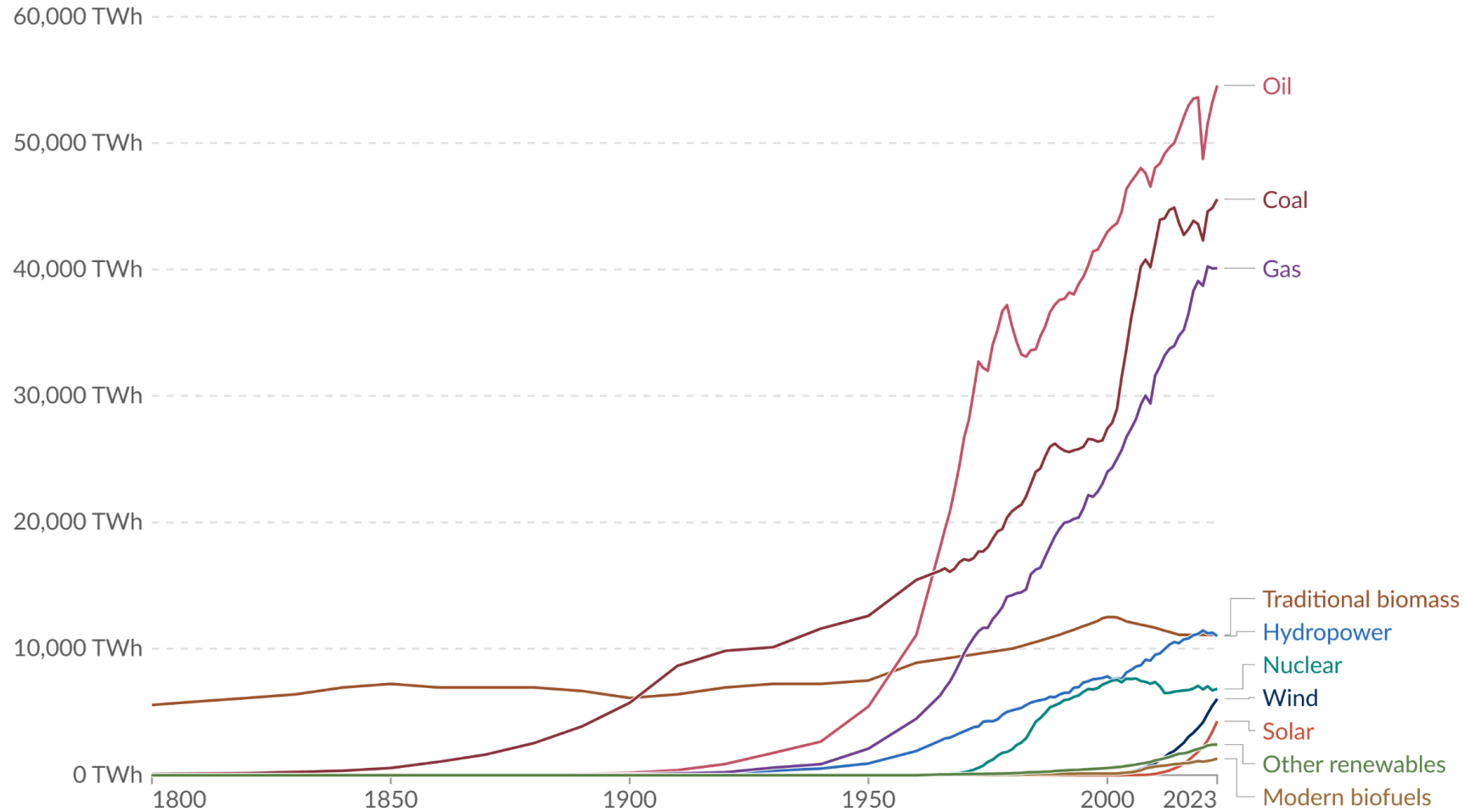


Source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)
OurWorldInData.org/energy • CC BY

Global primary energy consumption by source

Our World
in Data

Primary energy¹ consumption is measured in terawatt-hours², using the substitution method³.



Data source: Energy Institute - Statistical Review of World Energy (2024); Smil (2017)

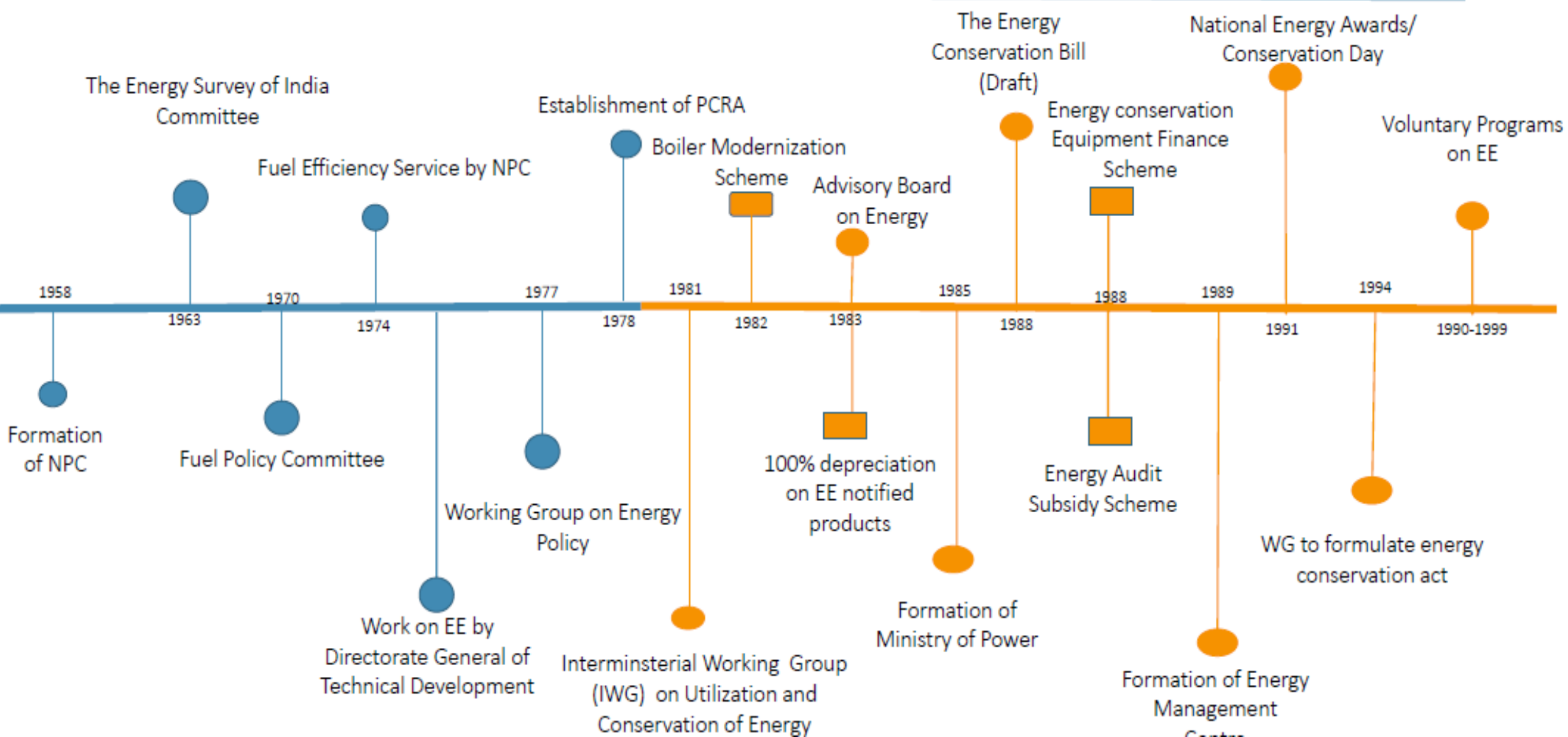
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Note: In the absence of more recent data, traditional biomass is assumed constant since 2015.

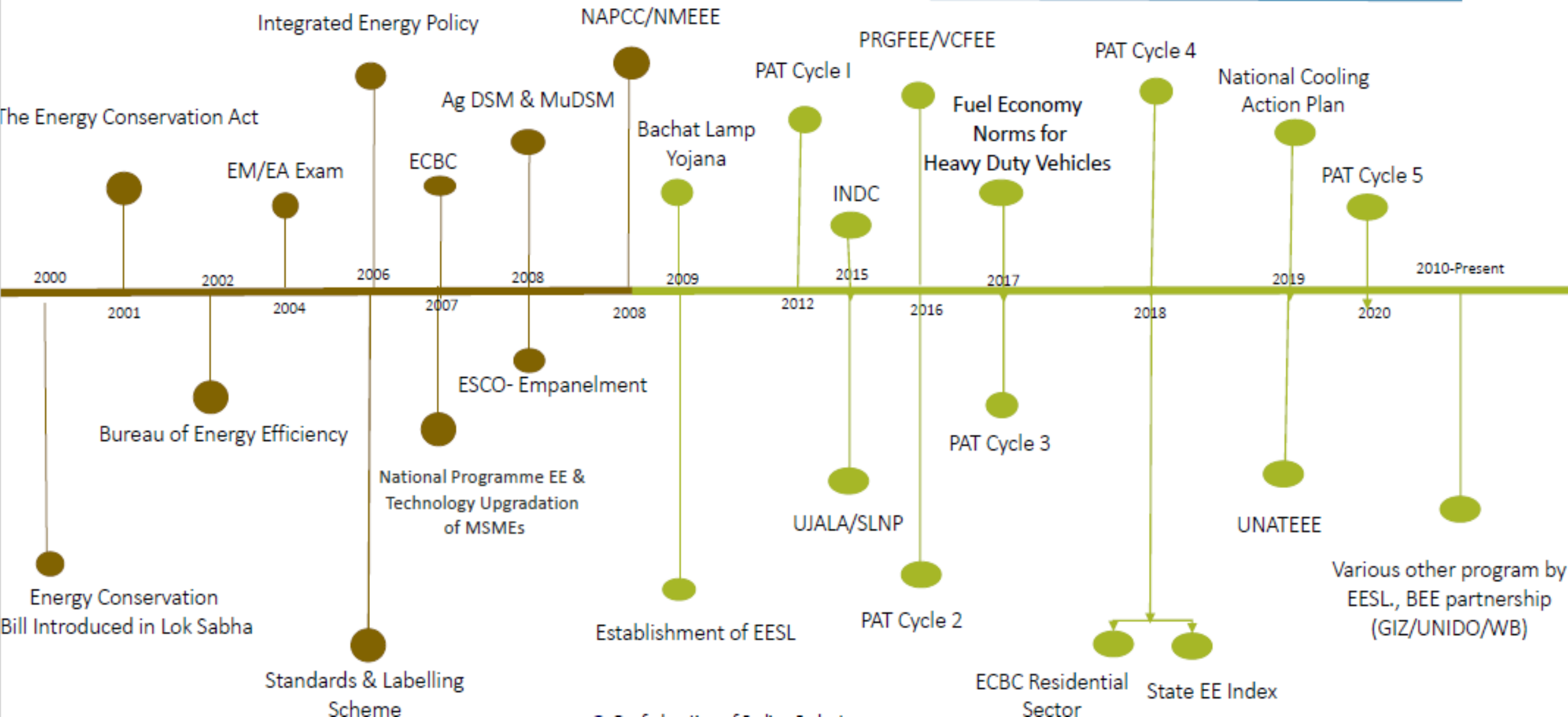
STEPS TAKEN BY INDIA TOWARDS ENERGY EFFICIENCY

Year	Steps taken	Year	Steps taken
1958	National Productivity Council, (NPC)	2012	PAT Cycle 1
1963	The Energy Survey of India Committee	2013	National Electric Mobility Mission Plan
1970	Fuel Policy Committee	2015	Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME India)
1982	Boiler Modernization Scheme	2015	UJALA (Unnat Jyoti by Affordable LEDs for All):
1983	Advisory Board on Energy	2016	MeITY’s Phased Manufacturing Programme
1988	The Energy Conservation Bill (Drafted)	2016	PAT Cycle 2
1991	National Energy Awards/Conservation Day	2017	PAT Cycle 3
2001	The Energy Conservation Act	2018	PAT Cycle 4
2002	Bureau of Energy Efficiency, (BEE)	2019	National Mission on Transformative Mobility and Battery Storage
2006	Standards and Labelling, (S & L)	2020	PAT Cycle 5
2007	Energy Conservation Building Code, ECBC	2023	National Green Hydrogen Mission
2008	National Action Plan on Climate Change (NAPCC)	2024	PM E-drive scheme (Electric mobility promotion)
2009	Bachat Lamp Yojana	2024	Renewable Energy Expansion

Energy Efficiency (1960-2000)



Energy Efficiency (2001-Present)



1958 NPC

The objectives of NPC:

1. Productivity Enhancement
2. Quality Improvement
3. Benchmarking and Best Practices
4. Training and Capacity Building
5. Research and Development
6. Consultancy Services
7. International Cooperation
8. Policy Advocacy
9. Productivity Awards

1963: The energy Survey of India Committee

Key **objectives** of "The Energy Survey of India Committee" were:

1. Energy Resource Assessment
2. Energy Demand Estimation
3. Energy Policy Formulation
4. Energy Efficiency Promotion
5. Renewable Energy Potential
6. Infrastructure Development
7. Data Collection and Analysis

1970: Fuel Policy Committee

Some key aspects include:

1. Energy Diversification
2. Promotion of Renewable Energy
3. Subsidy and Pricing Mechanism
4. Energy Efficiency and Conservation
5. Economic Impact
6. Oil and Gas Exploration
7. Environmental Regulations

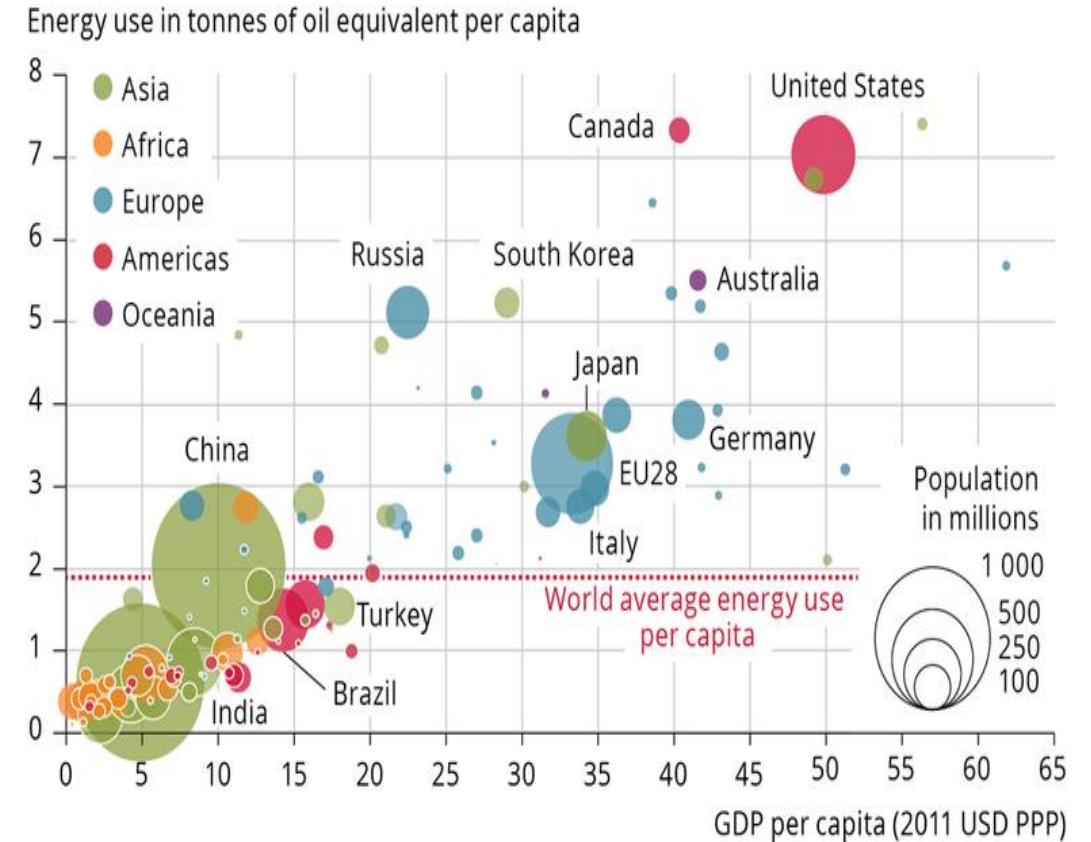
1982: Boiler Modernization Scheme

- Upgrading Technology
- Use of Cleaner Fuels
- Energy Efficiency Measures
- Emission Reduction
- Financial Incentives
- Capacity Building

2001: Energy Conservation Act

Objective of EC Act

- India one of the fastest growing economy in the world
- Estimated India's GDP grow at pace of 7% to 9%
- Per Capita Energy Consumption very low in India - ~400 to 450 kg of oil equivalent (Avg. world's per capita energy consumption stands at ~2500 to 3000 kg of oil equivalent)
- Hence, its evident that India's energy consumption is expected to get double / triple in next few decades
- Led to growing imbalance between Supply & Demand
- Gap between Supply & Demand can be fulfilled either by increasing generation or by enhancing the efficiency of energy use
- **Enhancing the efficient use of energy, Reduce gap between supply & demand, Reduce environmental emission**



2001: Energy Conservation Act

- Setting up of Bureau of Energy Efficiency (BEE)
- Energy Conservation Building Codes (ECBC)
- Standard & Labelling Program for Appliances (S&L)
- Energy Consumption Norms for Designated Consumers (DC)
- Certification for Energy Manager / Auditors and Accreditation of Energy Auditing Firm

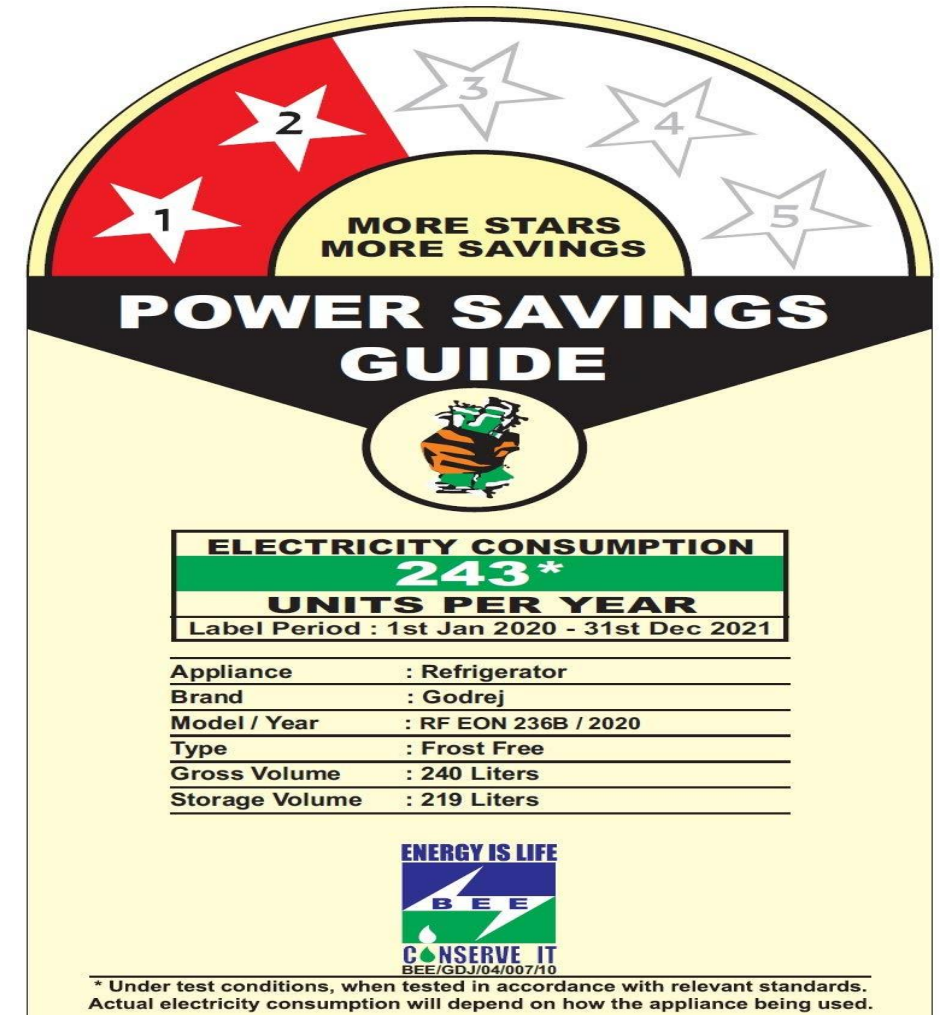
2002: Bureau of Energy Efficiency (BEE)

- Under the provision of EC Act, GOI set up BEE in March 2002
- Objective – Assist GOI in developing policy & strategies for reducing energy intensity of Indian economy
- Role of BEE
 - To prepare standards & labels for Appliance / Equipment (S&L)
 - Develop a list of Designated consumers (DC)
 - Specify certification & accreditation procedure
 - Preparation of Building Code
 - Maintain Energy Conservation Fund
 - Promotional activities in coordination with state & center level agencies
 - Development of energy service company (ESCO)
 - Transforming market for energy efficiency



2006:Standard & Labeling Program (S&L)

- **Objective** – To provide consumer informed choice about the potential energy saving & thereby cost saving potential of relevant product
- Mandatory to display energy performance of high energy consumer equipment or appliances
- S&L program covers **23/34** appliances or equipment's which has high energy end use
 - Mandatory appliances (11) - Air Conditioner, Refrigerator, TFL, Distribution Transformer, Color TV, Electric Geyser, LED Lamps
 - Voluntary appliances (23) – Induction Motors, Pump Sets, Ceiling Fans, LPG Stove, Washing Machine, Computer, DG Sets, Chillers, Microwave Oven, Ballast, Office equipment (Printer, Scanner)



Standard & Labeling Program (S&L)

- Rating on scale of 1 to 5; 5 being most energy efficient level
- To adhere to S&L program appliances / equipment to undergo check testing
- Check testing done in NABL certified labs – If appliances fails to meet the standard; list of those equipment published in newspaper to keep customer informed

Benefit –

S&L program leads to energy saving of ~70 billion unit in 2019-20, which translates into monetary saving of INR 39,000 cr

Table 1: Energy and Cost Saving for 250 liters Frost Free Refrigerator with different Star Ratings

Star Rating	Energy Consumption Per Year (Approx.)	Per Unit Charge (Approx.)	Electricity Cost/year	Total Savings (w.r.t No Star Every Year)	Refrigerator Cost (Approx)	Cost Difference	Pay Back Period
	Units (kWh)	Rs.	Rs.	Rs.	Rs.	Rs.	Years
No Star	1100	2.50	2750	0	14000	0	0
1	977	2.50	2443	308	15000	1000	3.25
2	782	2.50	1955	795	15500	1500	1.89
3	626	2.50	1565	1185	16500	2500	2.11
4	501	2.50	1253	1498	17500	3500	2.34
5	400	2.50	1000	1750	18500	4500	2.57

Source: Bureau of Energy Efficiency

2007:Energy Conservation Building Code (ECBC)

- Real estate sector expected to grow significantly, with favorable GOI policy (PMAY, RERA, GST, Stamp Duty Benefit...), growing demand for e-commerce, healthcare & logistics
- Building sector constitutes ~33% electrical energy consumption in India
- Estimated that energy consumption of real estate sector is expected to increase ~6 to 15 times in couple of decades
- Energy conservation building code launched in 2007 with **objective to enhance energy efficiency level in existing & new residential or commercial establishment**
- Advancement in energy efficient building technology & management practices and also streamlining implementation & compliance process - ECBC Amended in 2017
- Applicable for large residential / commercial building with **connected load of 100 kW and above or 120 kVA and above**
- Focuses on Building envelop, Heating Ventilation & Air Conditioning (HVAC) system, Interior & Exterior lighting system, Electrical system & Renewable energy use

2007:Energy Conservation Building Code (ECBC)

- Star Rating Program for Existing building
- Energy Efficiency Label for Residential Building – In Future
- Building sector incorporated in PAT Cycle 4 (37 hotels) & Cycle 5 (31 hotels)
- Enforcement & Implementation lies with State Gov. ULB & Municipal bodies

Benefit

1. 50% reduction in energy use by 2030 for new commercial building construction leads to energy saving of 300 billion unit
2. Estimated potential saving by labeling program around 388 billion unit by 2030
3. Estimated potential saving of PAT program around 16 million unit by 2022

Designated Consumers (DC)....?

- Energy Intensive Industrial Sector whose consumption is more than threshold consumption classified as Designated Consumer
 - Aluminum – 7,500 MTOE
 - Cement – 30,000 MTOE
 - Chlor Alkali – 12,000 MTOE
 - Fertilizer – 30,000 MTOE
 - Iron & Steel – 30,000 MTOE
 - Pulp & Paper – 30,000 MTOE
- ◊ Railways – 70,000 MTOE for Zonal & 30,000 MTOE for Workshop
 - ◊ Textile – 3,000 MTOE
 - ◊ Thermal Power Station – 30,000 MTOE
 - ◊ Petroleum Refinery – 90,000 MTOE
 - ◊ Electrical Distribution Company – 86,000 MTOE or AT&C loss of 100 MU

Responsibility of Designated Consumers

- Designated Consumers shall designate or appoint energy manager or auditor whose primary responsibility includes conducting energy audit, implementation of energy conservation projects, timely submission of forms etc.
- Designated Consumers to Conduct Energy audits by an Accredited energy auditor within three years with effect from the date of submission of the previous energy audit report
- Furnish details of information on energy consumed & details of action taken on recommendation of accredited energy auditor
- After completion of target year every designated consumers to undergo for Monitoring & Verification study (M&V Study)
- Participation in Escert trading / banking of Escerts
 - DC who has overachieved target can sold Escert
 - DC who shortfall to target can purchase Escert
 - Escert – Tradable Energy Saving Certificates in the Market

Certification of Energy Manager / Auditor

- A graduate Engineer (Bachelor of Engineering/Bachelor of Technology) or equivalent with three years of work experience involving use of energy in operation, maintenance, planning, etc.; or
- A post-graduate Engineer (Master of Engineering/Master of Technology) or equivalent with two years of work experience involving use of energy in operation, maintenance, planning, etc.; or
- A graduate Engineer with post-graduate degree in Management or equivalent with two years of work experience involving use of energy in operation, maintenance, planning, etc.; or
- A diploma Engineer or equivalent with six years of work experience involving use of energy in operation, maintenance, planning, etc.; or
- A post-graduate in Physics or Electronics or Chemistry (with Physics and Mathematics at graduation level) with three years of work experience involving use of energy in operation, maintenance, planning, etc.

Certification of Energy Manager / Auditor

Paper No	Name of the Paper	Duration	Max Marks
I.	General Aspects of Energy Management & Energy Audit	3 Hrs	150
II	Energy Efficiency in Thermal Utilities	3 Hrs.	150
III	Energy Efficiency in Electrical Utilities	3 Hrs.	150
IV	Energy Performance Assessment for Equipment and Utility Systems (Open Book Examination)**	2 Hrs.	100

- ◆ The candidate appearing for Energy Manager Examination has to pass THREE papers, viz., Paper-I, Paper-II and Paper-III and obtain a minimum of 50% of the maximum marks in each paper.
- ◆ The candidate appearing for Energy Auditor Examination has to pass all the above FOUR papers viz., Paper-I, Paper-II, Paper-III & Paper-IV and obtain a minimum of 50% of the maximum marks in each paper.
- ◆ Medium of examination ENGLISH
- ◆ Paper-I, Paper-II and Paper-III shall consist of objective and descriptive type questions.

Responsibility of Energy Manager

- Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs
- Establish an energy conservation cell within the firm with management's consent about the mandate and task of the cell.
- Initiate activities to improve monitoring and process control to reduce energy costs.
- Analyze equipment performance with respect to energy efficiency
- Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.

Responsibility of Energy Manager

- Establish a methodology how to accurately calculate the specific energy consumption of various products/services or activity of the firm.
- Develop and manage training programme for energy efficiency at operating levels.
- Create knowledge bank on sectoral, national and inter-national development on energy efficiency technology and management system and information denomination
- Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
- Establish and/or participate in information exchange with other energy managers of the same sector through association

Energy Policy...Why We Need...?



ENERGY POLICY

Tata Motors - Commercial Vehicle Business Unit reaffirms its commitment to minimize the use of energy through continual improvement of its energy performance.

Towards this end it shall strive to:

- Create and establish framework for achieving energy objectives and targets
- Select, purchase and use appropriate energy, efficient equipments, services and eco-friendly technologies
- Evaluate and compare with appropriate benchmark
- Comply with applicable legal and other requirements
- Build awareness on efficient energy use amongst our work force, customers, dealers, vendors and society

This policy has been communicated to all our work force and shall be made available to the public/ stakeholders on request.

Date: September 10, 2012

Ravi Pisharody
Executive Director - Commercial Vehicles



ITC Limited
Pspd Unit : Bhadrachalam
(An ISO 9001, ISO 14001 company)

ENERGY POLICY

We at ITC pspd Unit : Bhadrachalam DIVISION commit ourselves to continuously improve our Energy performance in all our activities, products and services.

To meet above goals we will strive for

- **Maximization of cogeneration**
- **Adopting appropriate energy conservation Technologies to all our projects.**
- **Replacement of energy inefficient equipment with energy efficient equipment.**
- **Conducting conservation studies including audits by engaging external specialists in the respective areas.**
- **Creating awareness among employees and nearby population through campaigns, publicity about the need for energy conservation.**
- **Bench marking of energy consumption levels with the best in class, Internationally.**
- **Recognizing the efforts of employees in energy conservation initiatives and suitably rewarding them.**
- **Closely monitoring and controlling the energy consumption by utilizing effective energy management systems.**
- **Maximizing the recovery of waste energy.**
- **Reducing Specific Energy Consumption at least by 2% annually.**

PRADEEP DHOBALE
Chief Executive

Itc pspd Unit : Bhadrachalam

Energy Policy

- Shows organization commitment to energy conservation & environmental protection
- Foundation for setting objective with short & long term goal
- Integrating energy management into organizations culture & operations
- Helps to develop strategy for achieving short & long term goal
- Shows support from top/senior management of organization

