

Paper-1 General Aspects of Energy Management and Energy Audit

Chapter -1

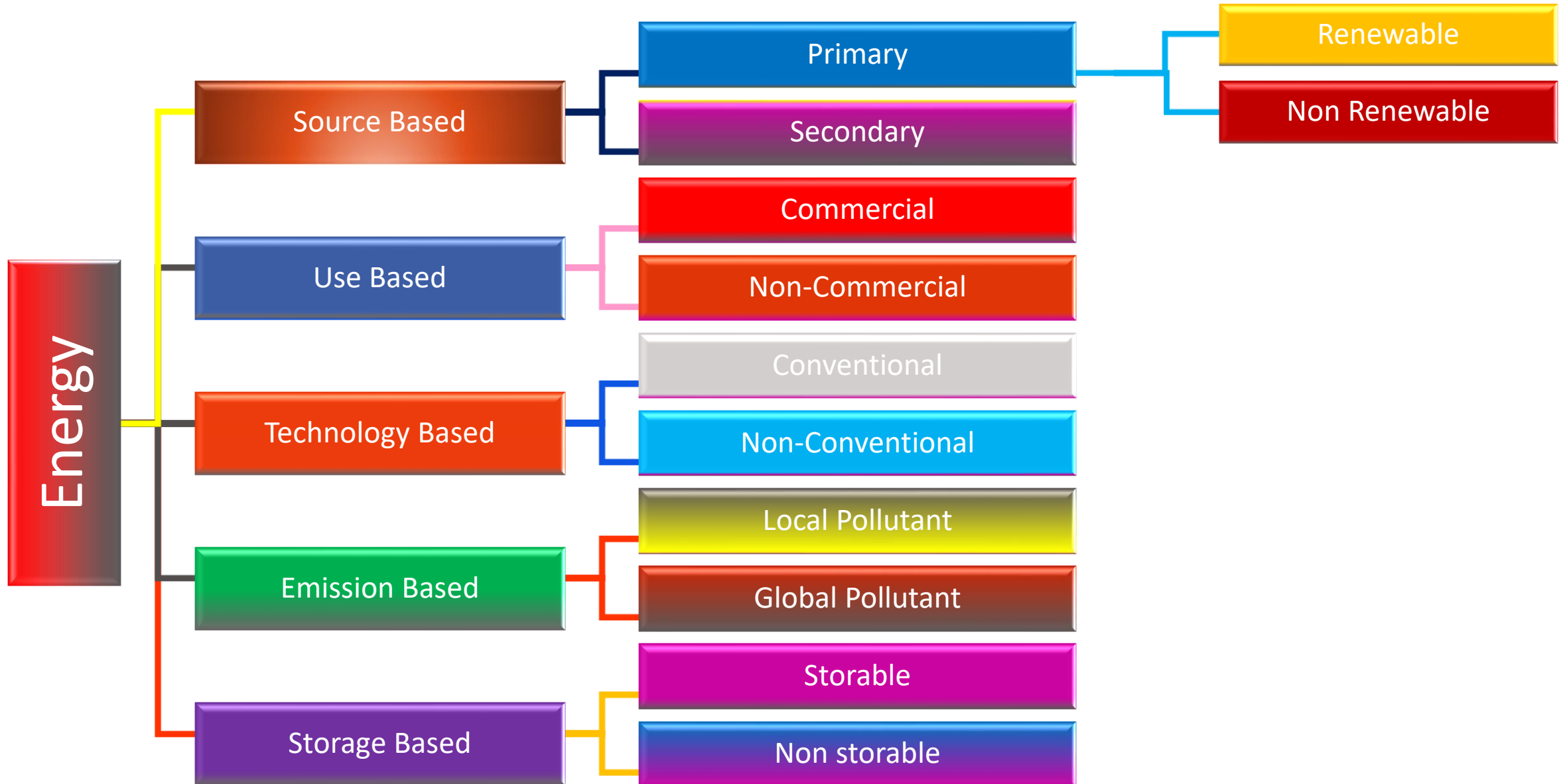
ENERGY SCENARIO

Renjith P C - Certified Energy Auditor –CEA 35069

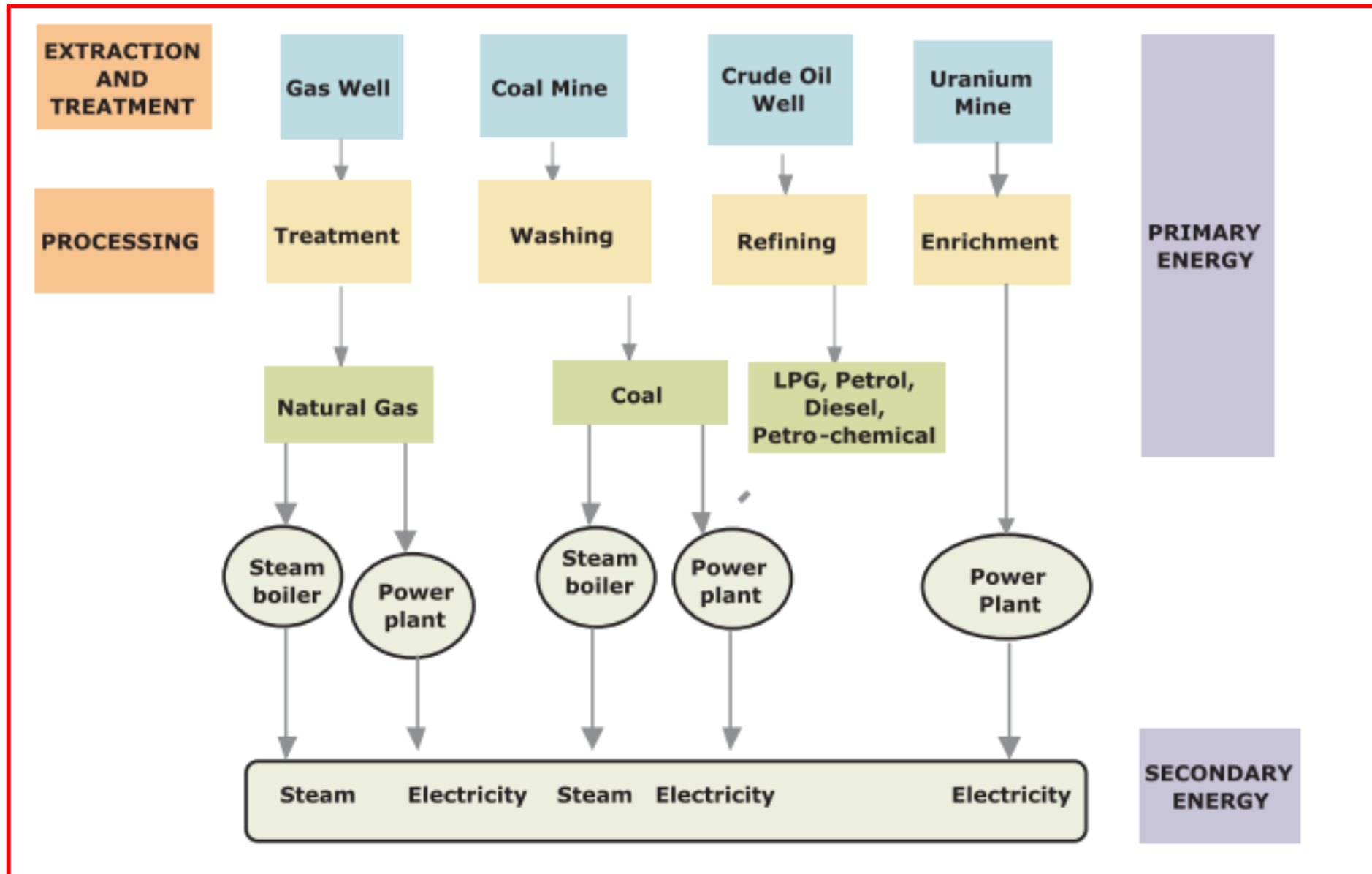
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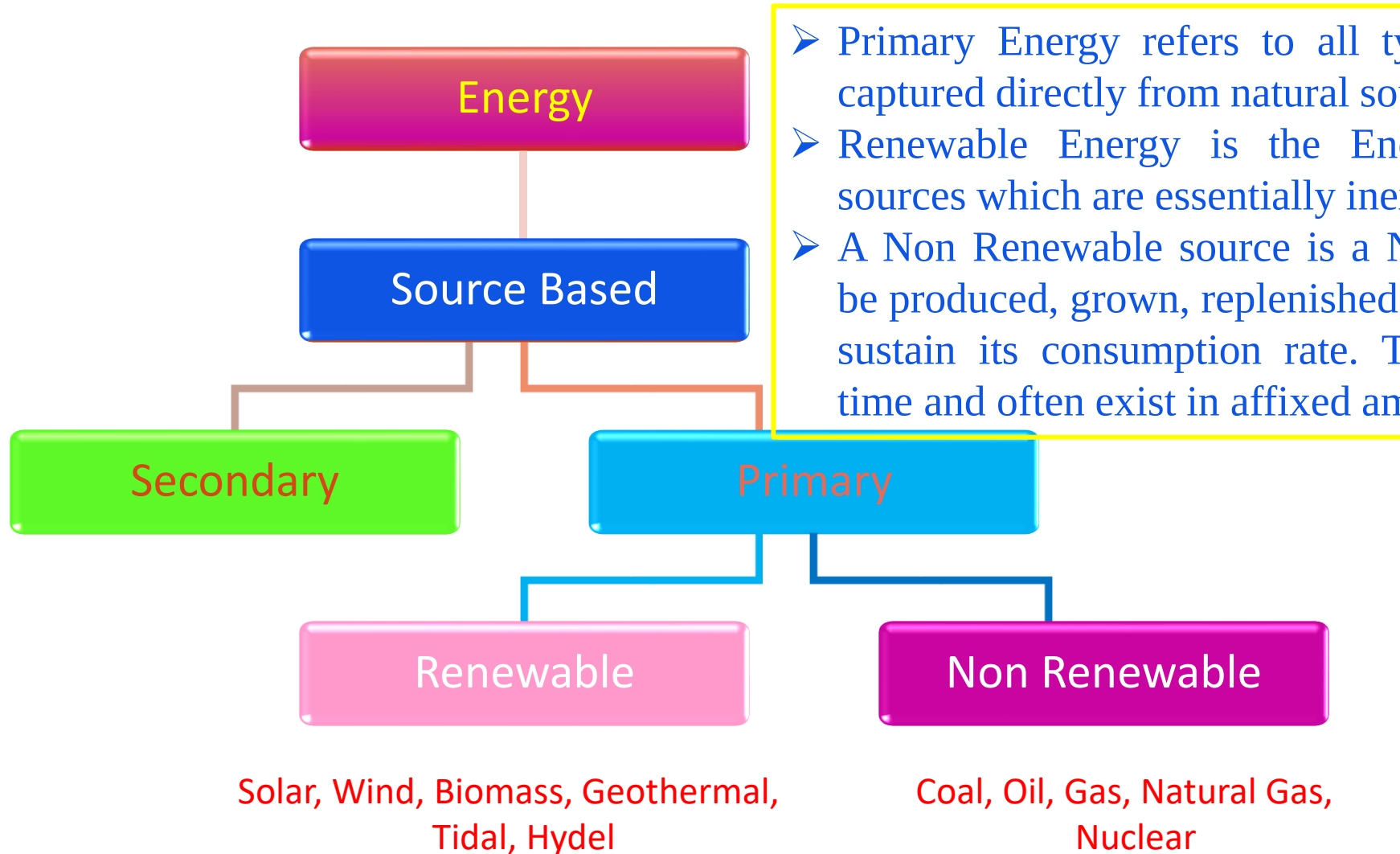
Classification of Energy Sources



The Major Primary & Secondary Energy Sources



On the basis of Source



- Primary Energy refers to all types of Energy extracted or captured directly from natural sources. Classified in to Two.
- Renewable Energy is the Energy obtained from natural sources which are essentially inexhaustible
- A Non Renewable source is a Natural Source, which cannot be produced, grown, replenished, or used on a scale which can sustain its consumption rate. These resources deplete with time and often exist in affixed amount.

The Primary Energy Content of all fuel is expressed in terms of **toe**

Renewable Energy

Renewable energy is created through the use of naturally occurring resources that replenish themselves over time.



Solar
Energy



Wind
Energy



Hydroelectric
Energy



Geothermal
Energy

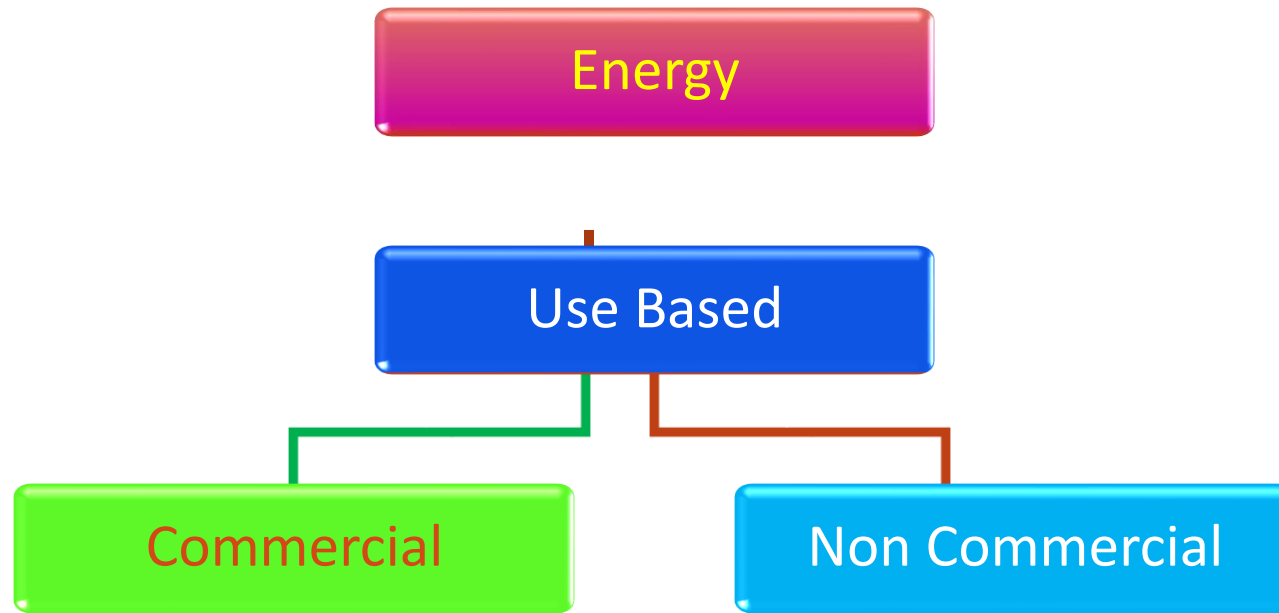


Biomass
Energy



Marine
Energy

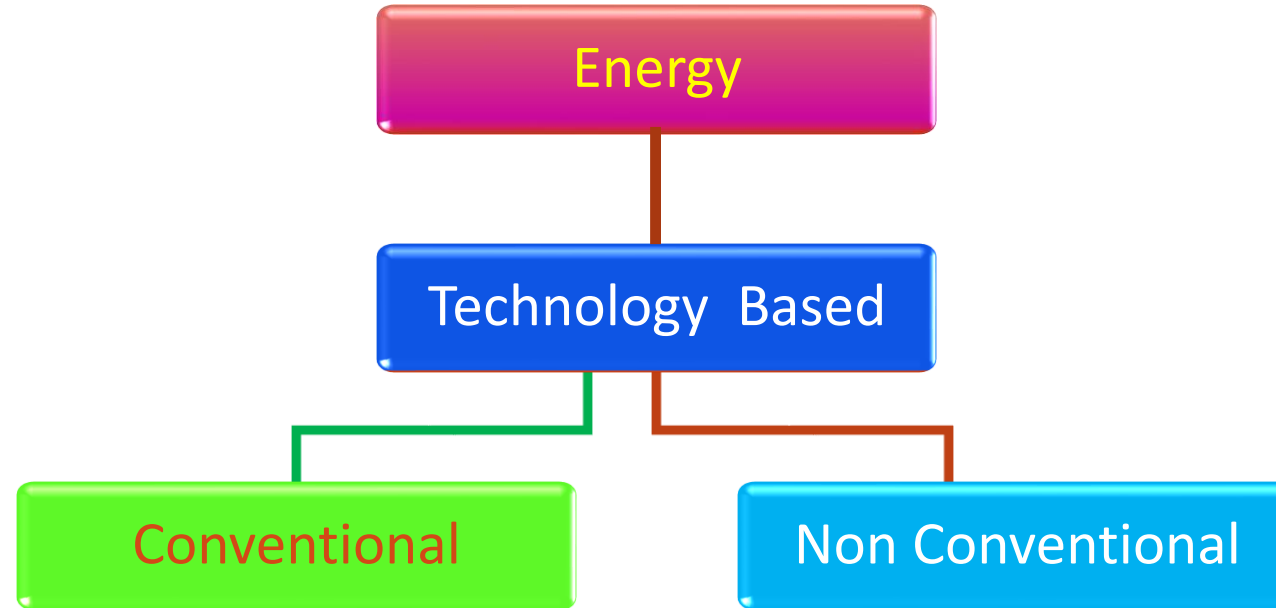
On the basis of Use



Energy that is available in the Market for a definite price is known as Commercial Energy i.e. Any form of Energy used for Commercial Purposes
Eg. Coal, Refined Petroleum, Natural Gas

Any kind of Energy which is sourced within a community and its surrounding area, and which is not normally traded in the commercial market is termed as non Commercial Energy.
Eg. Firewood, Cattle feed and Agricultural wastes

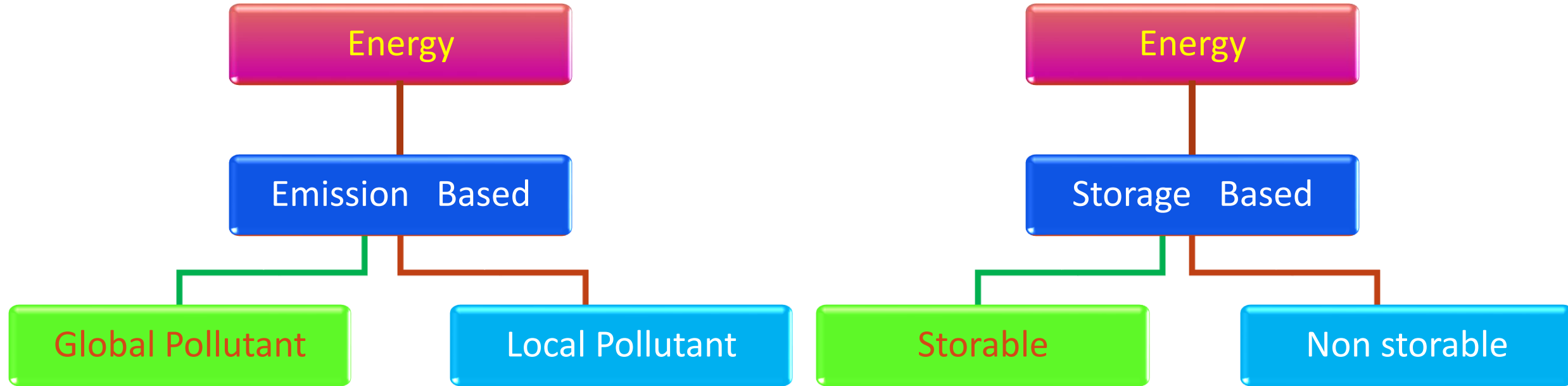
On the basis of Technology



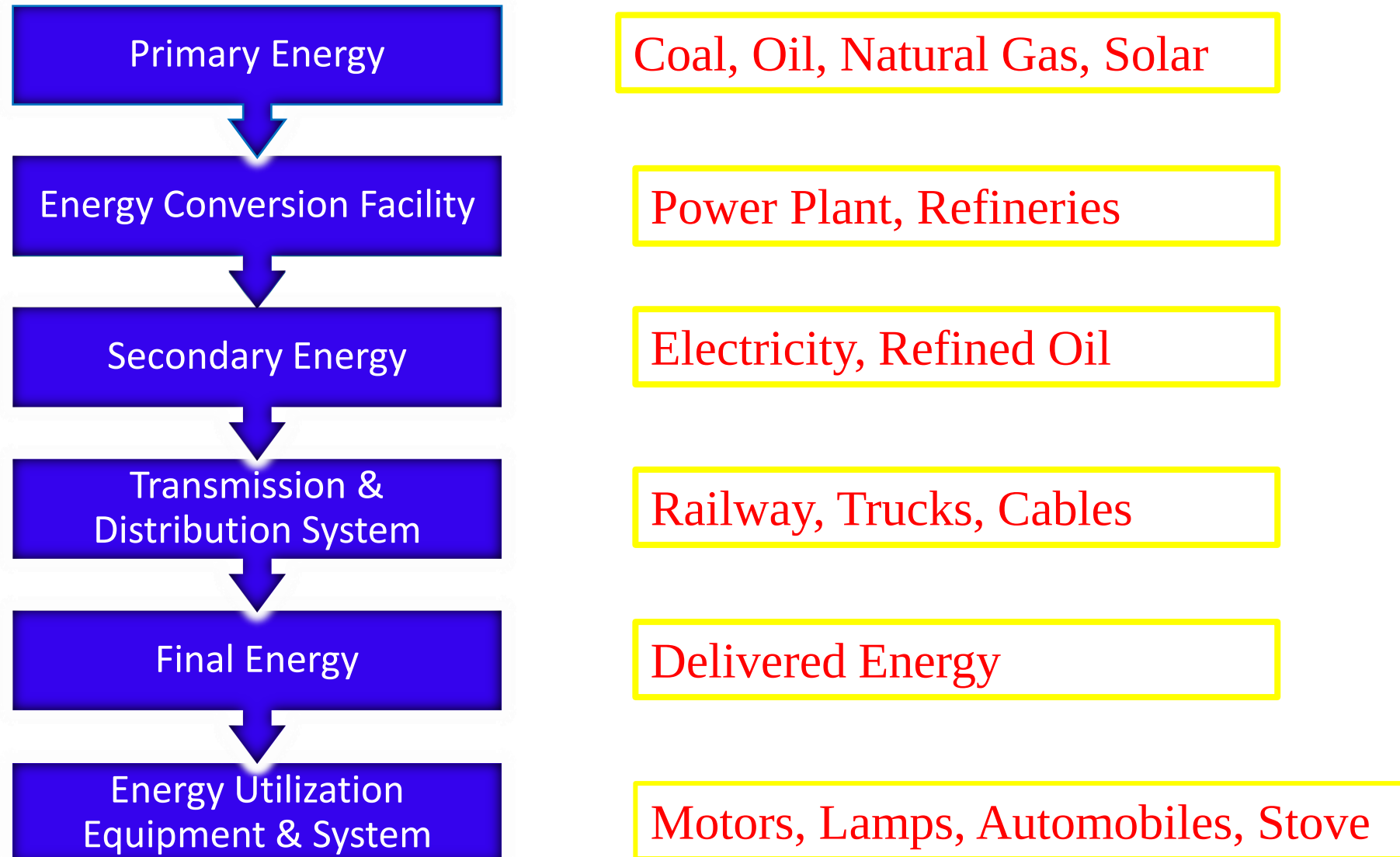
Technology used to capture or harness energy sources are existing and conventional
For example : Hydro

Technology used to capture or harness energy sources are new and novel.
For example : Ocean Tidal

On the basis of Emission & Storage Based



Energy Flow Diagram



Units of Energy

- Energy is measured in various units depending on the system of measurement.
- Common units include Joules (J), Calories (cal), kilowatt-hours (kWh), and British Thermal Units (BTU).

Joule

- Basic Unit of Energy System
- Standard Unit

Calorie

- Amount of heat required to raise Temp of 1 gram of Water by 1 degree Celsius

Btu

- Widely used in the United States for heating and cooling systems.
- 1 BTU is the amount of energy required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Kwh

- The kilowatt-hour is a standard unit of electricity production and consumption.

Conversion of Units of Energy

$$1 \text{ Btu} = 252.164 \text{ Calories}$$

$$1 \text{ Btu} = 1055.06 \text{ J}$$

$$1 \text{ Calorie} = 4.187 \text{ J}$$

$$1 \text{ KWh} = 860 \text{ Kcal}$$

$$1 \text{ KWh} = 3.6 \times 10^6 \text{ J}$$

$$1 \text{ KWh} = 3412 \text{ Btu}$$

Conversion of Commercial Unit to Scientific Unit

Tonnes of Oil Equivalent (toe): One ton of oil equivalent (toe) is, unit of energy, based on the amount of energy released by burning one tonne of oil

$$1 \text{ toe} = 1 \times 10^7 \text{ Kcal} = 11630 \text{ KWh} = 41858 \text{ MJ}$$

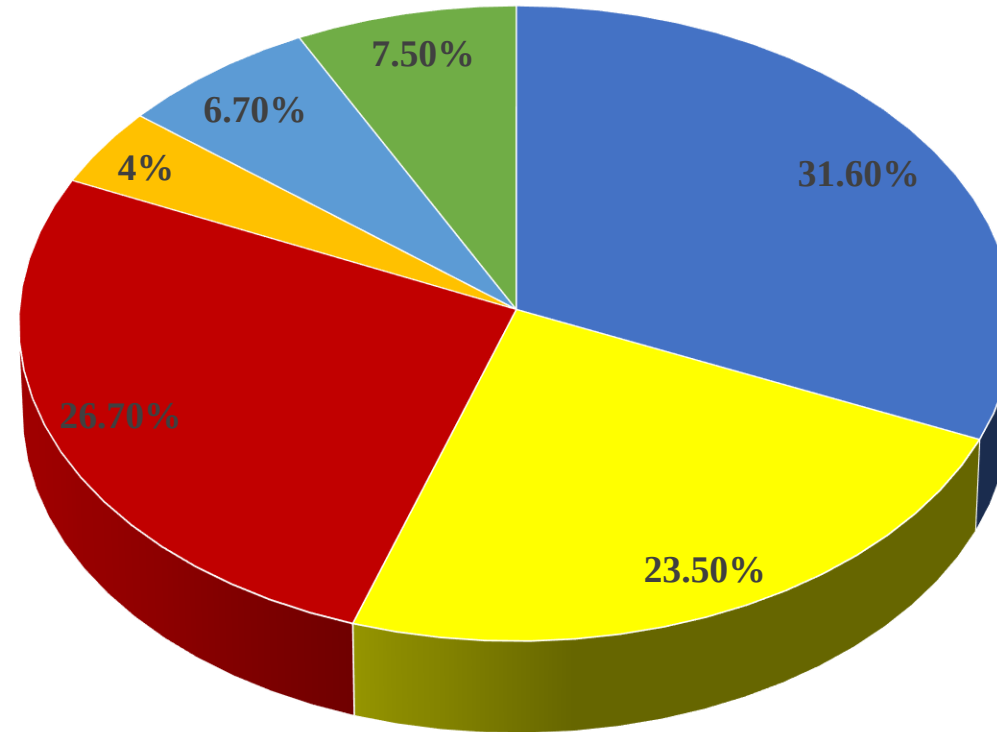
iii. Gross Calorific Values of Common Fuels for calculation of toe

Solid Fuels (kcal/kg)	
Name	Range/ Around
Coal (Indian)	2800-5000
Lignite	2500-3000
Coal (Indonesian)	5500
Coal (South African)	6000
Pet Coke	7500-8500
Rice Husk	3200
Bagasse	1900-2100
Wood	3400 (depending on moisture)
Liquid Fuels (kcal/kg)	
Name	Range/ Around
Furnace Oil	10000-10500
Diesel	10000
Kerosene	11100
LDO	10700
LSHS	10600
LPG	11600-12500
Naptha	10050
HSD	11840
Petrol	11200
Gaseous Fuels (kcal/NM3)	
Name	Range/ Around
Natural Gas	8600-10500
Propane	22200
Butane	28500

Global Primary Energy Sources & Commercial Energy Production

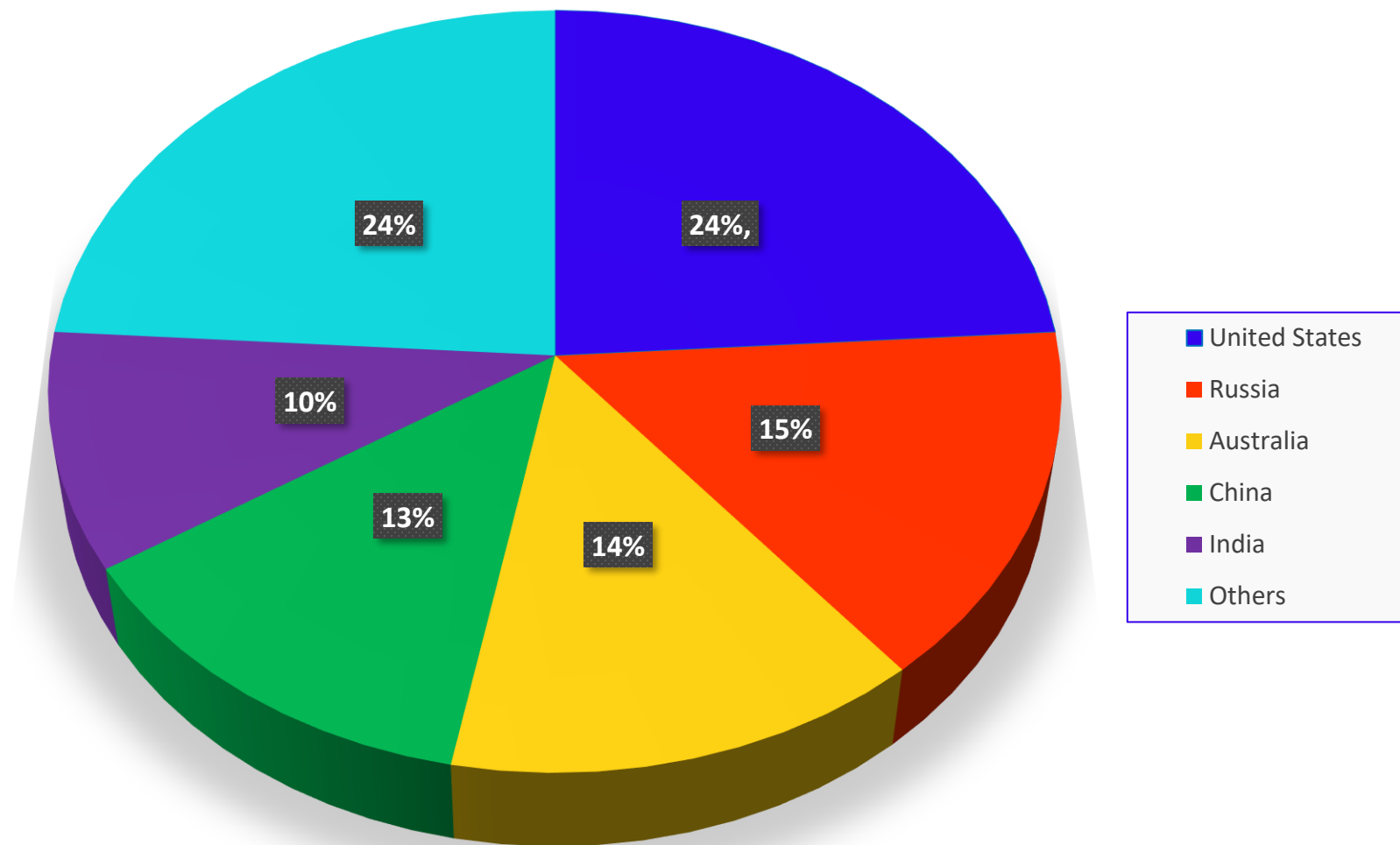
Primary Global Energy Consumption

Global Energy Consumption 2022 (as per 2023 Statistical review)



■ Oil ■ Natural Gas ■ Coal ■ Nuclear Energy ■ Hydro Electric ■ Renewables

Global Coal Reserve



Global Coal Reserves

- The proven global coal reserve is 1000 Billion tonnes
- The USA had the largest share of the global reserve (24%) followed by Russia (15%), Australia (14%), China (13%),
- India is 4th in the list with 10% reserve.
- Global coal reserve is expected to last up to 133 Years .
- China is top producer of coal in world having 47.4% share in global production, India produces 650.1 MT and its share in global production is just 5.9

Oil Reserves

- The global proven oil reserve was estimated to be 1730 billion barrels (One barrel of oil is approximately 160 litres) out of which 48% are in middle east.
- Venezuela has the largest share of the reserve with almost 18.2% followed by 16.2% of Saudi Arabia.
- USA is Eleventh in oil reserve but First in production .
- Saudi Arabia second in the the list of oil production followed by Russia.
- India has 0.29% oil reserve which is sufficient for 17.5 years.
- India with annual production of 47 MT has share of 1% in global oil production

Natural Gas Reserves

- The global proven gas reserve was estimated to be 186 trillion cubic meters .
This is equal to 55 years at the rate of current production .
- Russia (24.3%) has the largest share of the reserve followed by Iran (17.3%) and Qatar(12.5%)
- India has only 0.7% of global natural gas reserve .
- US (21.7%) is largest consumer of natural gas followed by Russia 12.4%, other top consumers are China, Iran etc.

Reserve/Production

- Reserves/Production (R/P) - If the reserves remaining at the end of the year are divided by the production in that year, the result is the length of time that the remaining reserves would last if production were to continue at that level.
- At current R/P ratio , World oil and gas reserves are estimated at just 53 and 55 years, respectively. Coal is likely to last a little over 133 years

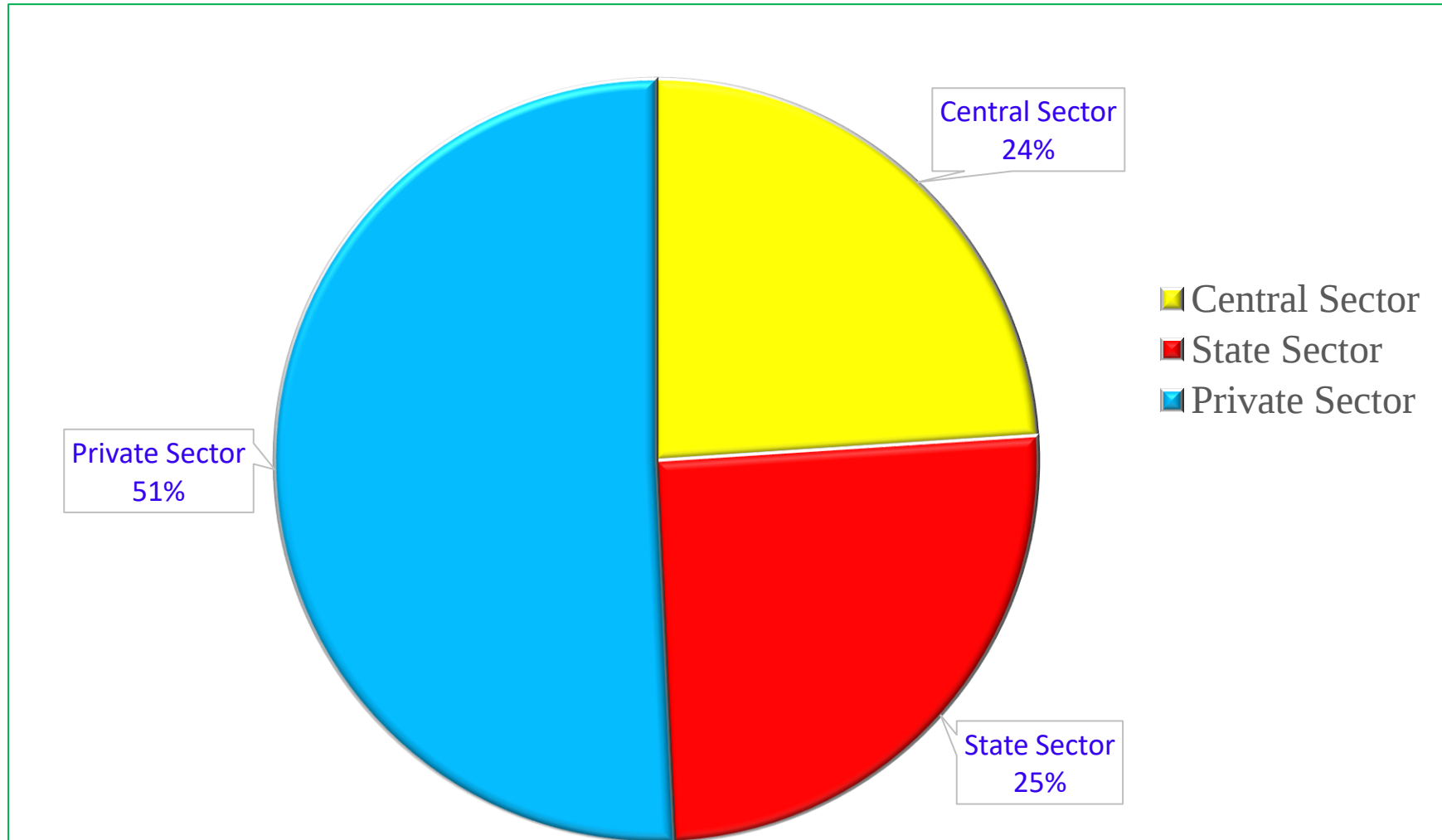
Energy Demand - India

- India rapid growth in energy demand, which rises by more than 3% per year in the STEPS from 2021 to 2030.
- It sees the largest increase in energy demand of any country.
- Coal generation is projected to continue to expand in absolute terms in the STEPS, peaking around 2030, though its share of electricity generation falls from just below 75% to 55%
- Renewables meet more than 60% of the growth in demand for power, and account for 35% of the electricity mix by 2030

Energy Demand - India

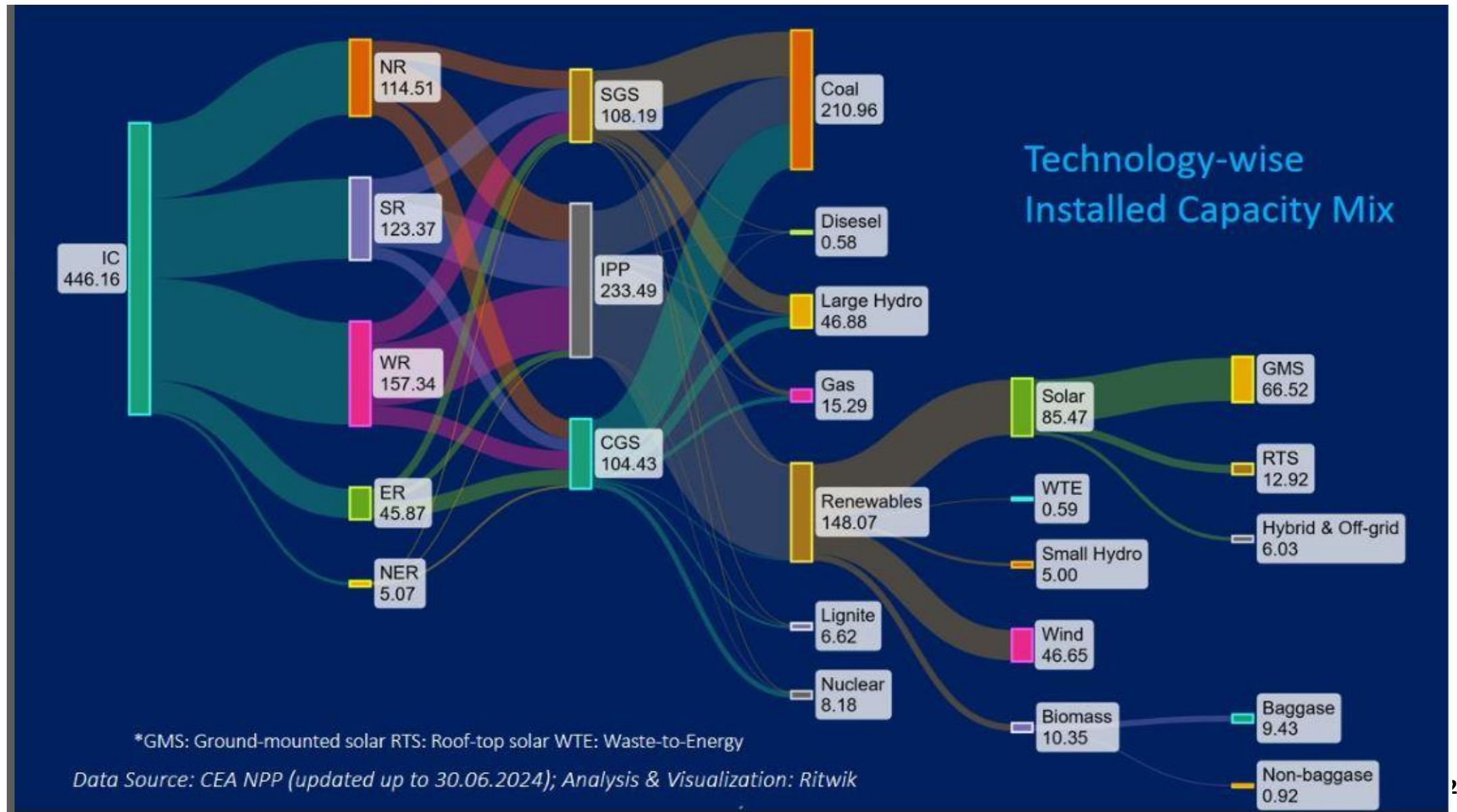
- Solar PV alone accounts for more than 15%. However, coal still meets a third of overall energy demand growth by 2030
- In the APS, more rapid progress in deploying low-emissions alternatives in power, industry and transport sectors in particular puts India on a trajectory in line with its goal of net zero emissions by 2070.

Sector wise Installed Generation Capacity(MW) India

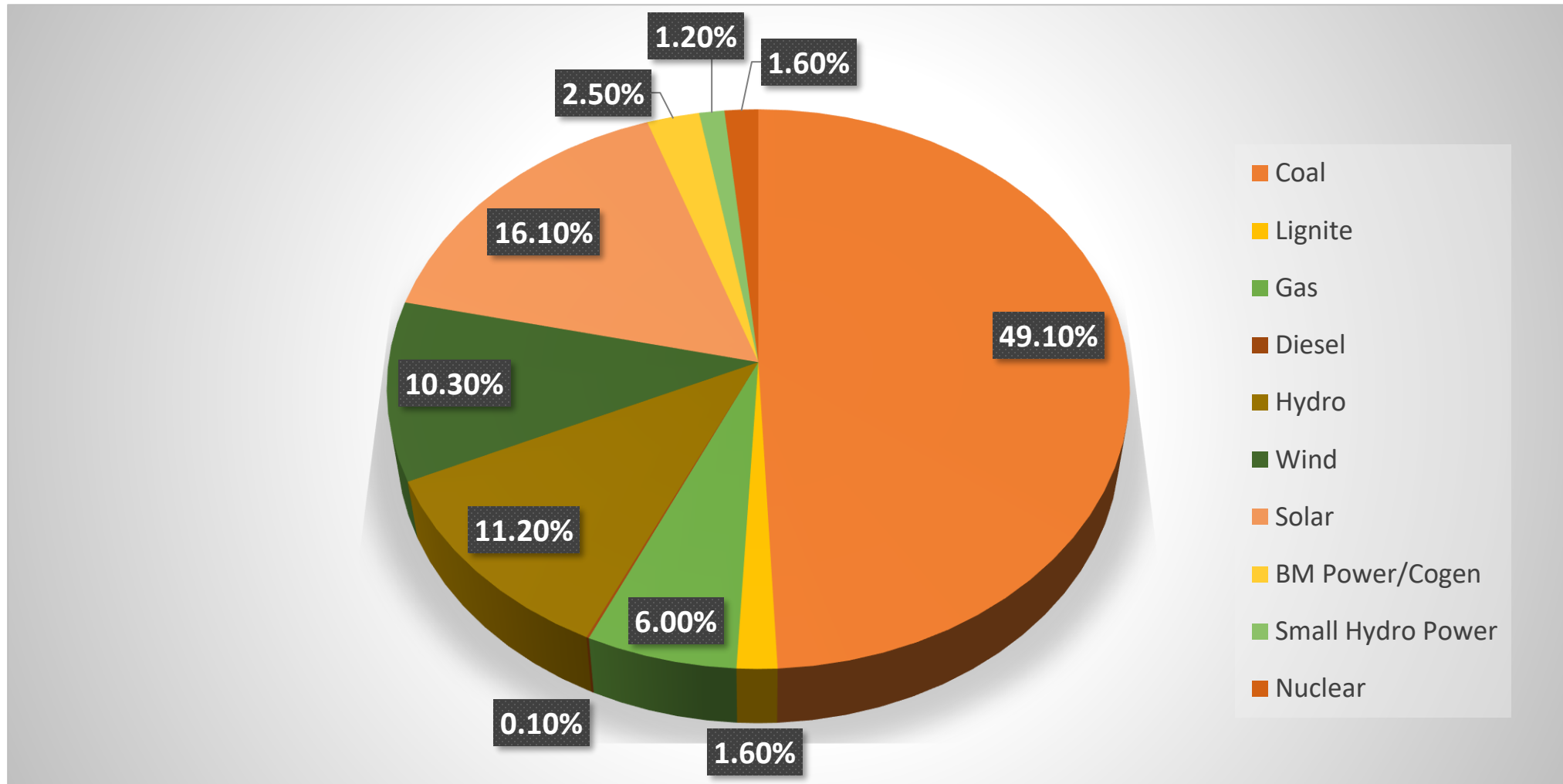


Total Capacity – 4,17,668MW

Technology wise Installed Generation Capacity(MW) India



Fuel wise Installed Generation Capacity India



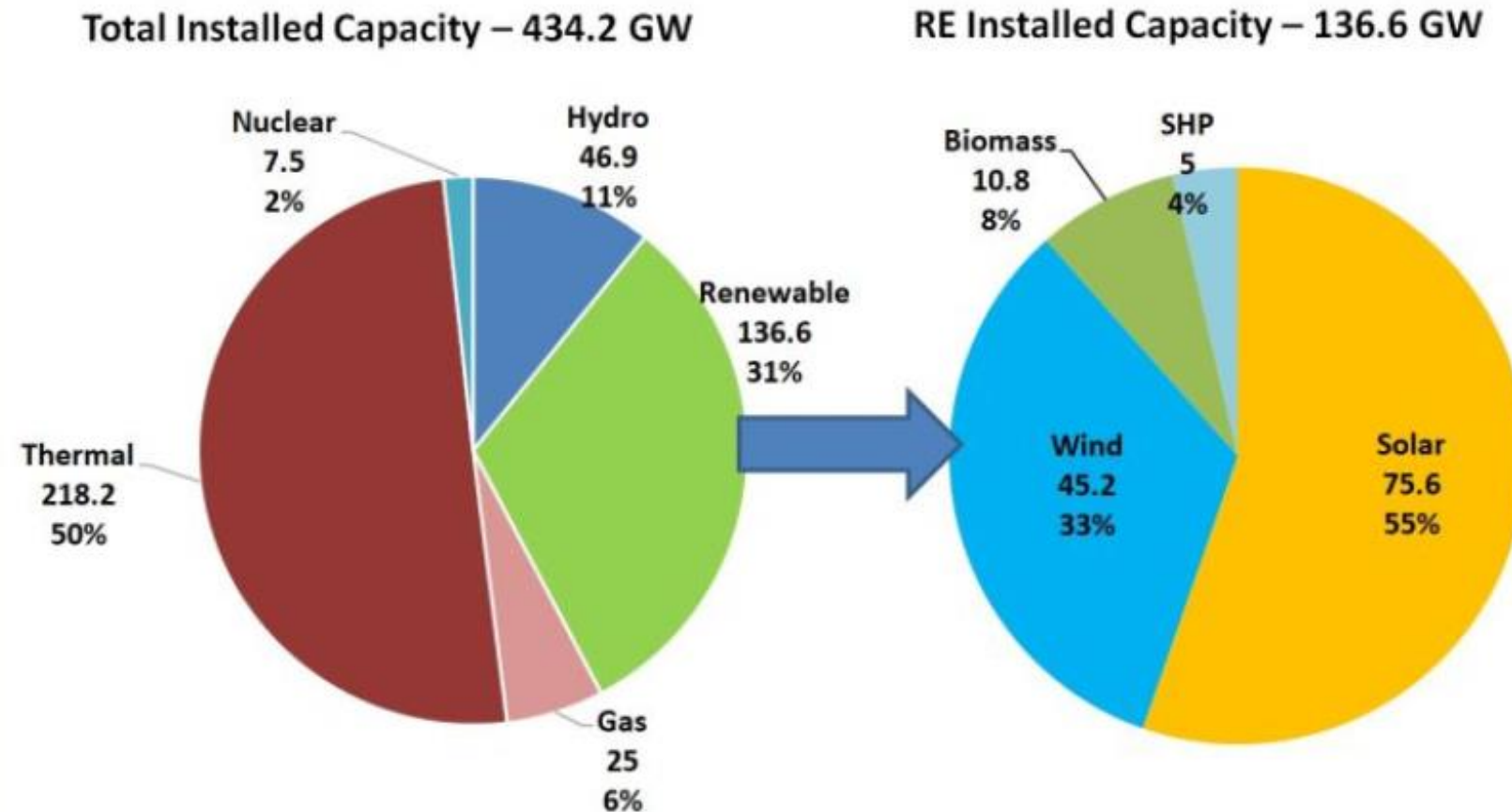
Fossil Fuel 56.8% Non Fossil fuels –RES -41.4% Nuclear -1.6% others – 0.2%

****CEA Report updated on 12-06-2023**

Electrical Energy & Renewable Energy Potential

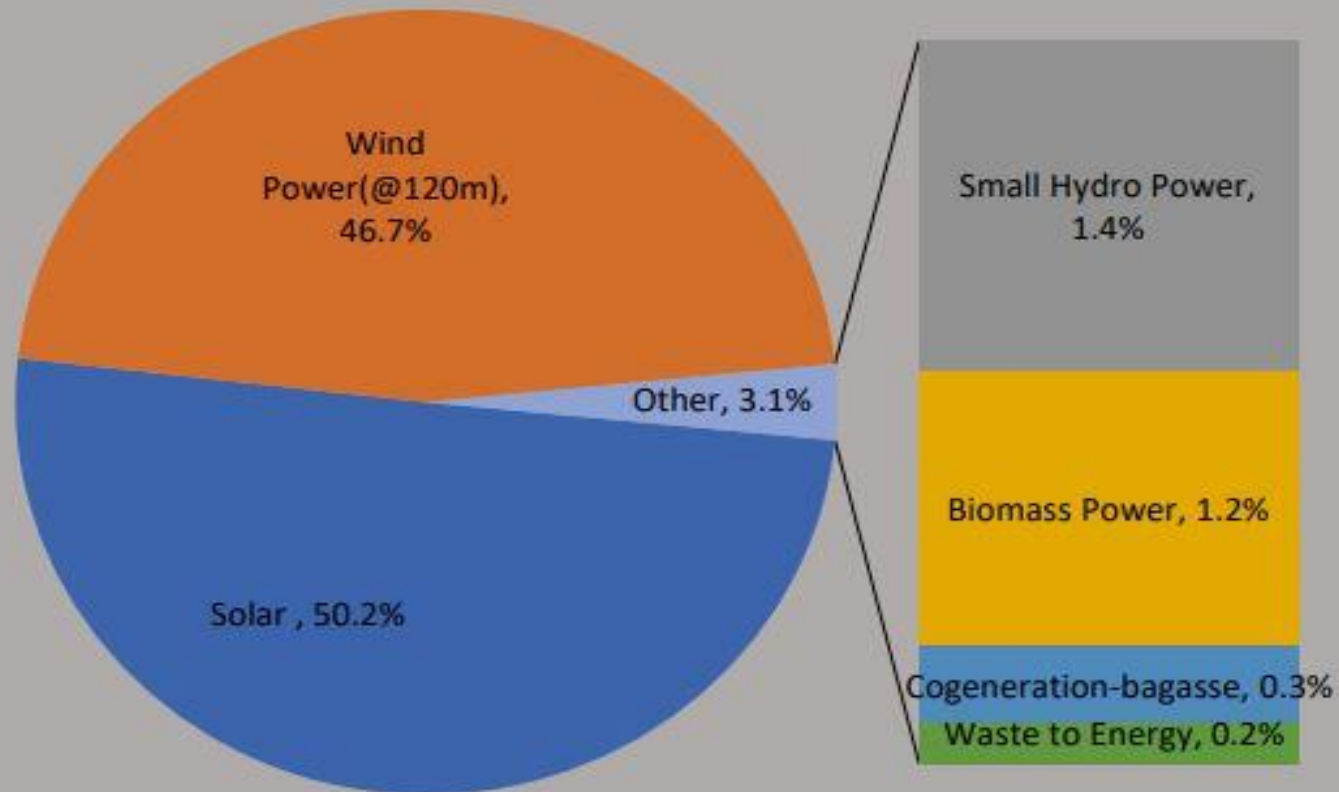
Bharat – Electric Installed Capacity

(as on 29.2.2024)



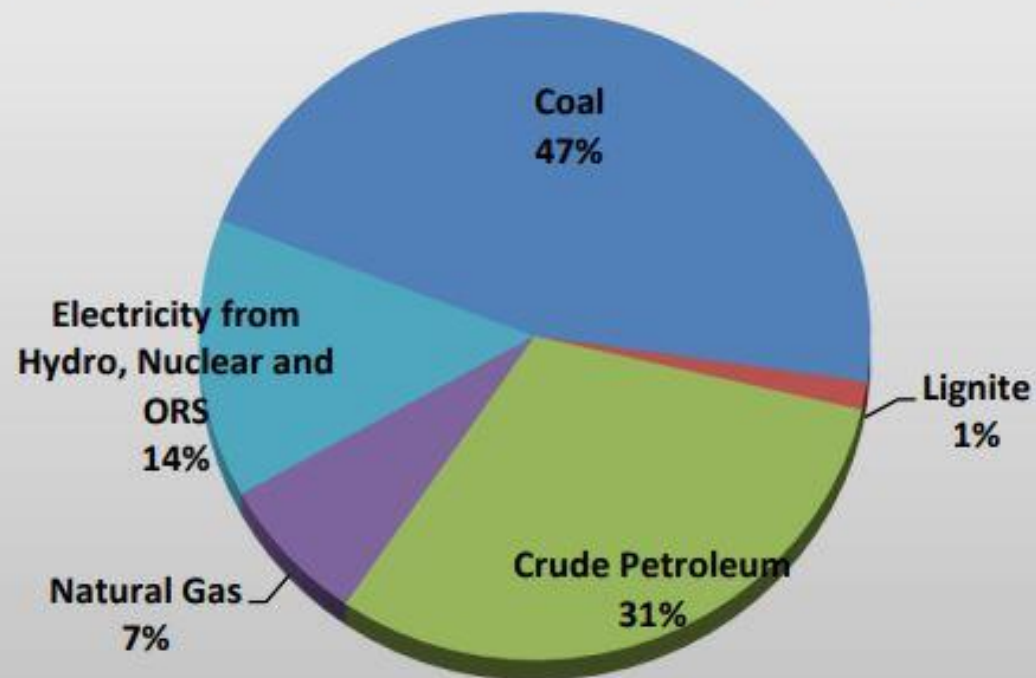
Renewable Energy Potential

Fig 1.5: Source wise Estimated Potential of Renewable Power in India as on 31.03.2022



Source wise Energy Consumption in India

Fig 6.4: Sourcewise Consumption of Energy during 2021-22 (P)



Total Energy Consumption = 33,508 PJ

Energy Intensity

- Energy Intensity is the ratio between the Gross Inland Consumption of Energy and the Gross Domestic Product for a given calendar Year. It measures the energy consumption of an economy and its overall energy efficiency.

$$EI = FC / GDP$$

Where: EI = Energy intensity, national level, toe per million US \$

FC = Total final consumption, national level, toe

GDP= Gross domestic product, million US \$

Purchase Power Parity

- The use of PPPs ensure that the GDP of all countries is valued at a uniform price level and thus reflects only actual volume of the economy.
- Adjustments are required to give a better picture than comparing gross domestic product (GDP) using market exchange rates.
- A Purchasing Power Parity exchange rate equalizes the purchasing power of different currencies in their home countries for a given basket of goods.
- PPP gives a more picture of the country's purchasing power. Energy intensity is expressed as Energy Intensity kgoe/US\$PPP GDP

Electricity Pricing in India

- State Electricity Regulatory Commissions(SERC) are authority for setting tariff.
- Power tariffs in India for industries and commercial establishments are among the highest in the world as it cross subsidizes agricultural and domestic power consumption.
- High Tension consumers are charged based on Maximum Demand (KVA) and Energy Consumed (KWh) while domestic consumers pay based on KWh only.

Availability Based Tariff (ABT)

- System of scheduling and dispatch, which requires both generators and beneficiaries to commit to day-ahead schedules.
- A performance-based tariff system for the supply of electricity by generators owned and controlled by the central government.
- Rewards and penalties to enforce day ahead precommitted schedules.
- Variations are permitted if notified one and half hours in advance
- Prompt payment of dues and nonpayment of prescribed charges will be liable for appropriate action.

Renewable Purchase Obligation

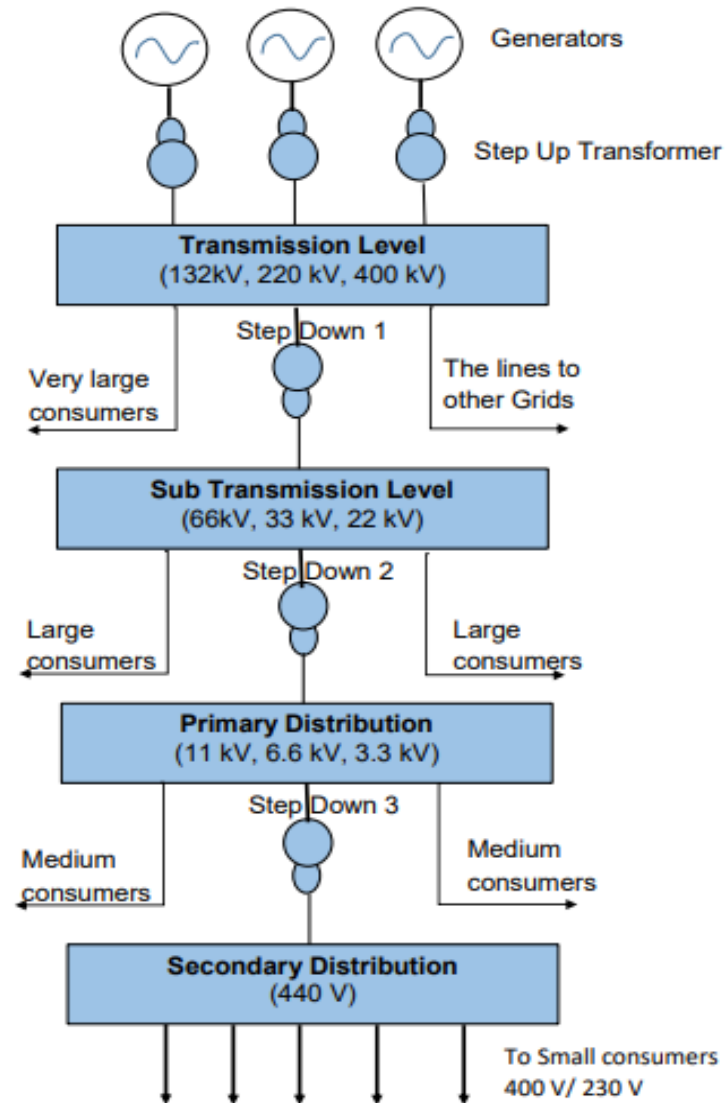
- The Ministry of Power (MoP) issued corrigendum on Renewable Purchase Obligation (RPO) and Energy Storage Obligation Trajectory till 2029-30 order dated 22nd July 2022.
- This facilitate use of Renewable Energy (RE) by the consumers and to further accelerate India's RE programs.
- RPO is Renewable Purchase Obligation requires each retail seller of electricity to include in its resource portfolio a certain proportion of power is from renewable sources such as wind, solar, small hydro or various forms of biomass energy.
- The rule provides that the tariff for the supply of green energy shall be determined separately by the Appropriate Commission based on the Average Pooled Power Purchase Cost of the renewable energy, cross-subsidy charges (if any), and service charges covering the prudent cost of the distribution licensee for providing the green energy

Strategies for Energy Security

- Reducing energy requirements
- Substituting imported oil/gas with domestic alternatives
- Diversifying energy supply sources
- Expanding energy resource
- Developing alternative energy source

Single Line Diagram

Single Line Diagram of Electrical Power system from Generation to Distribution



Energy Efficiency & Energy Conservation

- Energy Conservation and Energy Efficiency are separate, but related concepts
- Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels.
- EE provides additional economic value by preserving the resource base and reducing pollution. Example Replacement of 60 W lamp by 8 W LED
- Energy conservation is achieved when growth of energy consumption is reduced in physical terms.
- It is the result of several processes or developments, such as awareness creation productivity increase or technological progress.
- Energy efficiency is a subset of energy conservation

Energy Efficiency Benefits

Industry	Nation	Globe
Reduced energy bills	Reduced energy imports	Reduced GHG and other emissions
Increased Competitiveness	Conservation of limited resources	Maintains a sustainable environment
Increased productivity	Saving of foreign exchange	
Improved quality	Avoided costs can be used for other works	
Increased profits	Improved energy security	

Long Term Energy Scenario for India

- **Coal** - Coal will continue to remain the dominant fuel in the Indian economy. Coal is used in industry as well as for about sixty percent of electricity generation capacity . coal imports are expected to increase drastically in future to satisfy the industrial and power generation requirements.
- **Oil** - India imports 82% of its oil needs and it is top third importer of crude oil . India aims to bring import down to 67% by 2022 by replacing it with local exploration renewable energy and indigenous ethanol fuel

Long Term Energy Scenario for India

- **Natural Gas-** Demand for natural gas in India has been on the increase. 45.3% of Indian natural gas/LNG requirement is met by import.
- **Electricity-** Utilization of existing installed capacity and addition of capacity in view of economic growth .
- Reduction of Aggregate Technical & Commercial (AT&C) losses to 12-15% by FY 2024-25. Making available reliable and quality power.

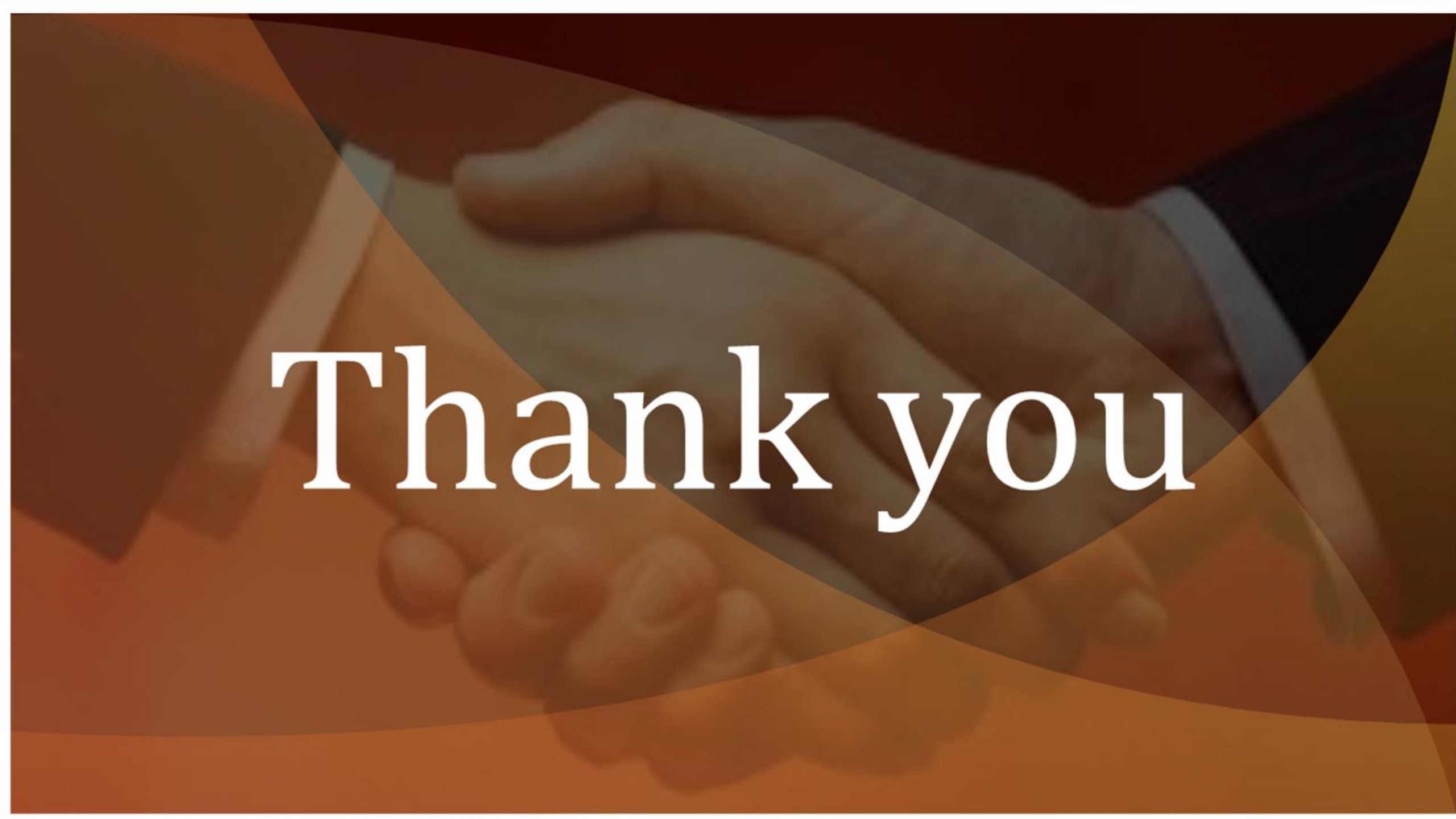
Short & Long Questions

- Write a short description about Availability Based Tariff (ABT)
- Briefly explain “Renewable Purchase Obligation (RPO) and means by which this requirement can be met?
- Give a short description about primary and secondary energy with examples
- Convert the following in to tones of oil equivalent- 10,000 kg of coal with a calorific value of 4000 Kcal/kg , 10 Lakh kWh

Ans: $\text{Toe} = (10,000 \times 4000) / 10^7 = 4 \text{ Toe}$

$$(10,00,000 \times 860) / 10^7 = 86 \text{ Toe}$$

- What is meant by PPP?
- Explain the difference between Energy Conservation & Energy Efficiency with Example
- List five strategic measures for meeting Energy security of a country.



Thank you



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Website: www.greentechlearning.com

Mailid: greentechlearningsolutions@gmail.com

Mobile: +919037502805