

Introduction to Energy and Resources

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Key concepts, classifications, and the role of energy in society

1. What Is Energy?

Definition	Core Idea
Energy is the ability to do work or produce heat.	It can be transferred or transformed but never created or destroyed (Law of Conservation of Energy).
Units	Joule (J) – SI unit; other common units: kilowatt-hour (kWh), British Thermal Unit (BTU), calorie.
Forms	Mechanical, thermal, chemical, electrical, nuclear, radiant (light).

1.1 Energy Transformations

- **Potential → Kinetic** (e.g., water behind a dam → flowing water).
 - **Chemical → Thermal/Electrical** (e.g., combustion of gasoline).
 - **Solar → Electrical** (photovoltaic cells).
 - **Nuclear → Thermal → Mechanical → Electrical** (nuclear power plant).
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2. Energy Resources: Classification

Category	Typical Sources	Characteristics	Environmental Impact
Fossil Fuels	Coal, oil, natural gas	High energy density, finite, carbon-based	CO ₂ emissions, air pollutants, land disturbance
Renewables	Solar, wind, hydro, geothermal, biomass	Replenishable, often low-carbon	Variable output, land/water use, habitat effects
Nuclear	Uranium, thorium	Very high energy density, low CO ₂ during operation	Radioactive waste, accident risk, mining impacts

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Category	Typical Sources	Characteristics	Environmental Impact
Emerging/Alternative	Hydrogen, advanced biofuels, tidal, wave	Still scaling, often require new infrastructure	Dependent on production pathway; can be low? impact

2.1 Primary vs. Secondary Energy

- **Primary Energy** – Energy found in nature in raw form (e.g., coal, sunlight).
- **Secondary Energy** – Energy that has been converted (e.g., electricity, gasoline).

3. Energy Conversion & Supply Chains

1. **Extraction/Harvesting** – Mining coal, drilling oil, installing solar panels.
2. **Processing/Refining** – Cracking crude oil, purifying uranium, converting biomass to biofuel.
3. **Transportation** – Pipelines, tankers, power lines.
4. **Conversion** – Power plants (thermal, hydro, nuclear), wind turbines, PV modules.
5. **Distribution** – Grid transmission, local distribution networks, fueling stations.
6. **End Use** – Residential heating, industrial processes, transportation, electronics.

Diagram (textual)

Primary Resource ? Processing ? Conversion ? Distribution ? End?Use

4. Energy Balance & Efficiency

- **Energy Balance** = Energy Input – Energy Output (useful work).
- **Efficiency (?)** = (Useful Energy Output / Energy Input) × 100?%.
- Typical efficiencies:
 - Coal power plant: 33?40?%
 - Natural?gas combined cycle: 55?60?%
 - Modern wind turbine: 40?50?% (capacity factor)
 - Solar PV: 15?22?% (module)

Improving efficiency reduces fuel consumption, emissions, and cost.

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5. Global Energy Consumption Patterns

Sector	Approx. Share of Global Energy Use (2023)
Industry	35%
Transportation	30%
Buildings (residential & commercial)	25%
Agriculture & Others	10%