

Introduction to Energy Efficiency

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Key concepts, benefits, and practical approaches for improving energy use in homes, businesses, and industry.

1. What Is Energy Efficiency?

Definition	Explanation
Energy efficiency	Using less energy to perform the same task or achieve the same outcome.
Energy intensity	Amount of energy consumed per unit of output (e.g., kWh per square meter, BTU per product).
Efficiency vs. Conservation	<i>Efficiency</i> improves the ratio of useful output to energy input. <i>Conservation</i> reduces overall demand (e.g., turning off lights). Both are complementary.

2. Why Energy Efficiency Matters

Reason	Impact
Cost Savings	Lower utility bills for households and businesses.
Environmental Protection	Reduces greenhouse?gas emissions, air pollutants, and resource extraction.
Energy Security	Less reliance on imported fuels; stabilizes supply.
Economic Growth	Creates jobs in retrofitting, manufacturing of efficient products, and services.
Regulatory Compliance	Meets building codes, corporate sustainability targets, and government mandates.

3. Core Principles

- 1. Eliminate Waste** – Identify and remove unnecessary energy losses (e.g., leaks, standby power).
- 2. Optimize Systems** – Match equipment size and performance to actual demand.
- 3. Upgrade Technology** – Replace old, inefficient devices with high?efficiency alternatives.

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4. **Control & Automate** – Use sensors, timers, and building management systems to adjust operation in real time.
 5. **Maintain Performance** – Regular maintenance keeps equipment operating at design efficiency.
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4. Major Sectors & Typical Measures

Sector	Typical Efficiency Measures
Residential	• LED lighting • High-efficiency HVAC (heat pumps, variable-speed compressors) • Proper insulation, window glazing • Smart thermostats and occupancy sensors • Energy-Star or LEED-certified appliances
Commercial Buildings	• Building automation systems (BAS) • High-performance glazing and daylighting • Demand-controlled ventilation
Industrial	• Variable-frequency drives (VFDs) on motors • Heat recovery and waste-heat utilization • Process optimization (e.g., pinch analysis) • Insulation of pipes, tanks, and furnaces
Transportation	• Aerodynamic design, low-rolling-resistance tires • Hybrid/electric powertrains • Regenerative braking • Route optimization and telematics
Utilities	• Smart grid technologies • Time-of-use pricing to shift load • Distributed generation (e.g., rooftop solar) paired with storage

5. Measurement & Verification (M&V)

1. **Baseline Establishment** – Record historical energy use (kWh, therms, etc.) for a defined period.
2. **Performance Metrics**

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- **Energy Use Intensity (EUI)** – kWh/m²·yr (buildings)
- **Specific Energy Consumption (SEC)** – kWh/ton of product (industry)
- **Coefficient of Performance (COP)** – Output/energy input (heat pumps, chillers)

3. Monitoring Tools

- Submetering, smart meters, IoT sensors
- Data analytics platforms (dashboards, trend analysis)