

Renewable Energy Systems: A Technical Overview

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Solar photovoltaic (PV) systems convert sunlight directly into electricity using semiconductor materials. The global installed capacity reached 1,500 GW in 2025, with an average module efficiency of 22.5%. Key factors affecting output include solar irradiance, panel orientation, temperature coefficients, and shading losses.

Wind energy systems harness kinetic energy from atmospheric motion. Modern onshore turbines have a rated capacity of 3-6 MW, while offshore installations can exceed 15 MW per unit. The capacity factor for well-sited wind farms ranges from 30-50%.

Battery energy storage systems (BESS) are critical for grid integration of variable renewable sources. Lithium-ion technology dominates with round-trip efficiency of 85-95%. The levelized cost of storage has decreased by 90% since 2010.

Performance Metrics and Analysis

Table 1: Renewable Energy Cost Comparison (2025)

| Technology | LCOE (\$/MWh) | Capacity Factor |
|-----------------|---------------|-----------------|
| Solar PV | 25-35 | 15-25% |
| Onshore Wind | 30-45 | 30-45% |
| Offshore Wind | 55-80 | 40-55% |
| Battery Storage | 120-180 | N/A |

Figure 1 below shows the capacity distribution across regions. The Asia-Pacific region leads with 45% of global installed capacity, followed by Europe at 28% and North America at 18%.



Figure 1: Regional Capacity Distribution (illustrative)

Conclusion: The transition to renewable energy is accelerating globally. Cost reductions, policy support, and technological improvements continue to drive adoption. However, grid integration challenges require significant investment in storage and transmission infrastructure.