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Climate Change and Renewable Energy

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Module 1: Overview of Climate Change and Renewable Energy

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the role of renewable energy (RE) within the global portfolio of GHG mitigation strategies.
- **Identify** the primary drivers and barriers affecting the deployment of diverse RE technologies.
- **Analyze** energy-related CO₂ emissions using the Kaya identity to determine the impact of carbon intensity and energy efficiency.

Executive Summary: Sustainable development requires energy services that are secure, affordable, and environmentally benign. While fossil fuels currently dominate the global energy supply (85%), renewable energy is essential for climate change mitigation. Achieving temperature stabilization goals (2°C to 2.4°C) requires global CO₂ emissions to decrease by 50% to 85% by 2050, necessitating a structural shift toward energy efficiency and a diversified RE portfolio.

Design Fundamentals

All societies require energy services (lighting, cooking, mobility, etc.) to meet basic human needs and serve productive processes. To be sustainable, delivery must be secure and low-impact. As of 2008, fossil fuels provided 85% of total primary energy, accounting for 56.6% of anthropogenic GHG emissions.

The Role of This Special Report

This report assesses the potential of RE sources to provide energy services for a sustainable development path. Key areas of focus include:

- **Resource Identification:** Chapters 2–7 assess available technologies and climate impacts.
- **Integration:** Chapter 8 addresses transmission, storage, and grid constraints.
- **Sustainable Development:** Chapter 9 explores linkages between RE growth and social/economic development.
- **Mitigation and Policy:** Chapters 10 and 11 detail economic costs, mitigation potential, and policy implementation strategies.

Climate Change Context

Global average temperatures are rising due to anthropogenic GHG concentrations, which exceeded 390 ppm CO₂ by the end of 2010. To limit temperature rises to 2°C, atmospheric GHG concentrations must stabilize between 445 and 490 ppm CO₂eq.

The Kaya Identity for Emission Decomposition

To develop effective reduction strategies, engineers use the **Kaya identity** to decompose energy-related CO₂ emissions into four factors:

Equation 1-1: CO₂ emissions = P * G * E * C

Where:

- **P** = Population
- **G** = GDP per capita (GDP / Population)
- **E** = Energy intensity (Total Primary Energy Supply / GDP)
- **C** = Carbon intensity (CO₂ emissions / Total Primary Energy Supply)

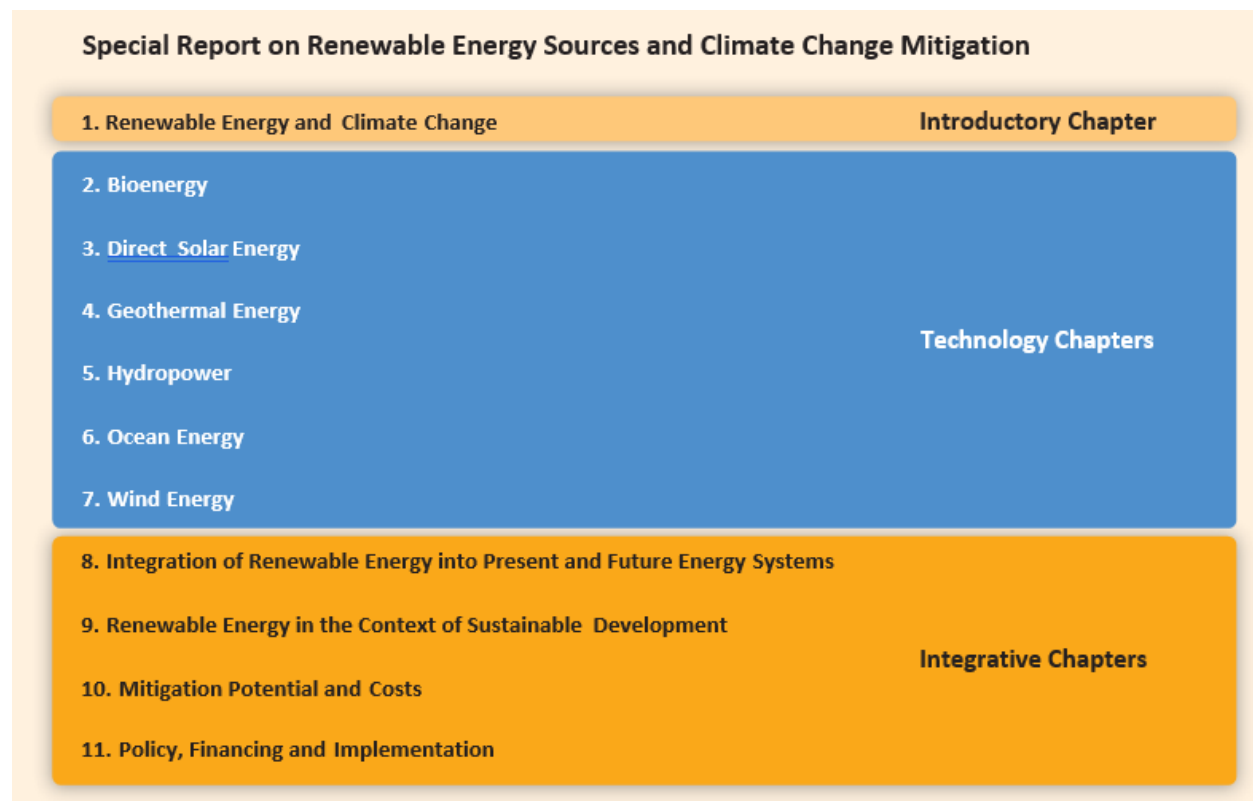


Figure TS.1.1. Structure of the report.

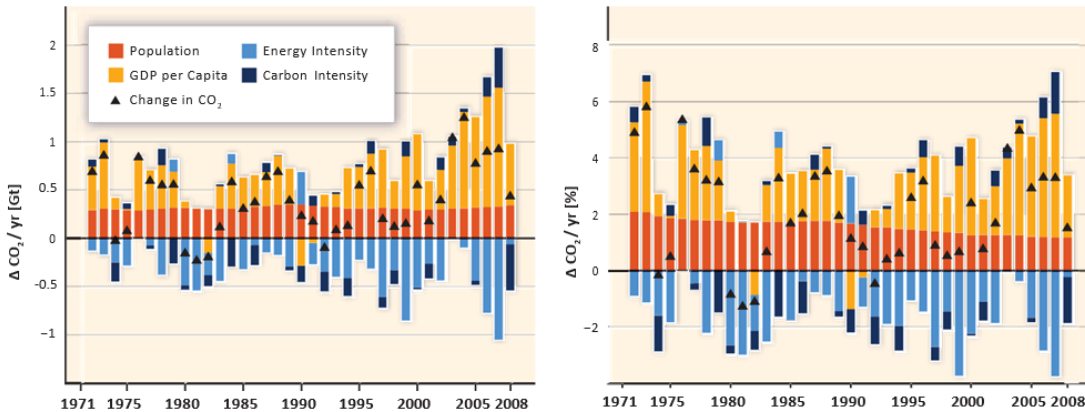


Figure TS.1.2. Decomposition of (left) annual absolute change and (right) annual growth rate in global energy-related CO₂ emissions by the factors in the Kaya identity; population (red), GDP per capita (orange), energy intensity (light blue) and carbon intensity (dark blue) from 1971 to 2008. The colours show the changes that would occur due to each factor alone, holding the respective other factors constant. Total annual changes are indicated by a black triangle.

Current Renewable Energy Shares

In 2008, RE accounted for **12.9%** of the 492 EJ total primary energy supply.

- **Biomass:** 10.2% (approx. 60% is traditional use).
- **Hydropower:** 2.3%.
- **Other RE (Wind, Solar, Geothermal, Ocean):** 0.4%.
- **Electricity Contribution:** RE provided approximately 19% of global electricity (16% hydro, 3% other).

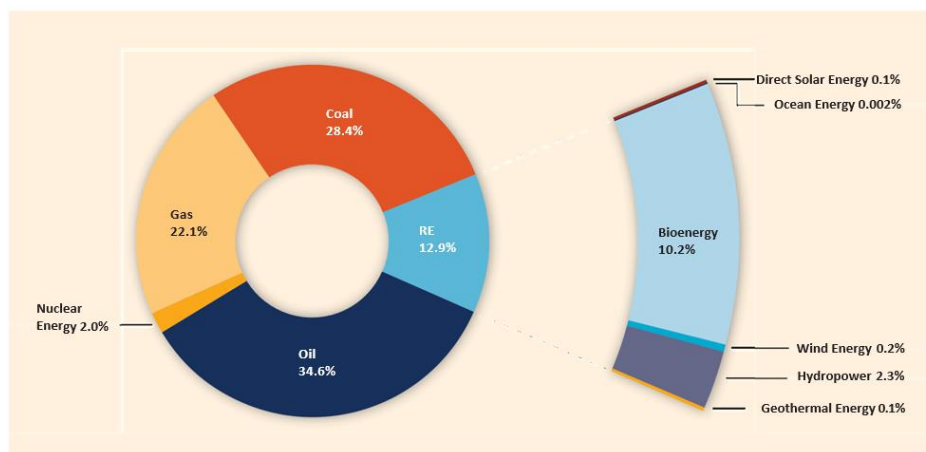


Figure TS.1.3. Shares of energy sources in total global total primary energy supply in 2008 (492 EJ). Modern biomass contributes 38% of the total biomass share.

Growth Trends and Deployment

Despite financial challenges, RE capacity grew rapidly in 2009:

- **Wind Power:** 32% increase (38 GW added).
- **Grid-connected PV:** 53% increase (7.5 GW added).
- **Renewable Additions:** 140 GW of the 300 GW total new global capacity was RE.

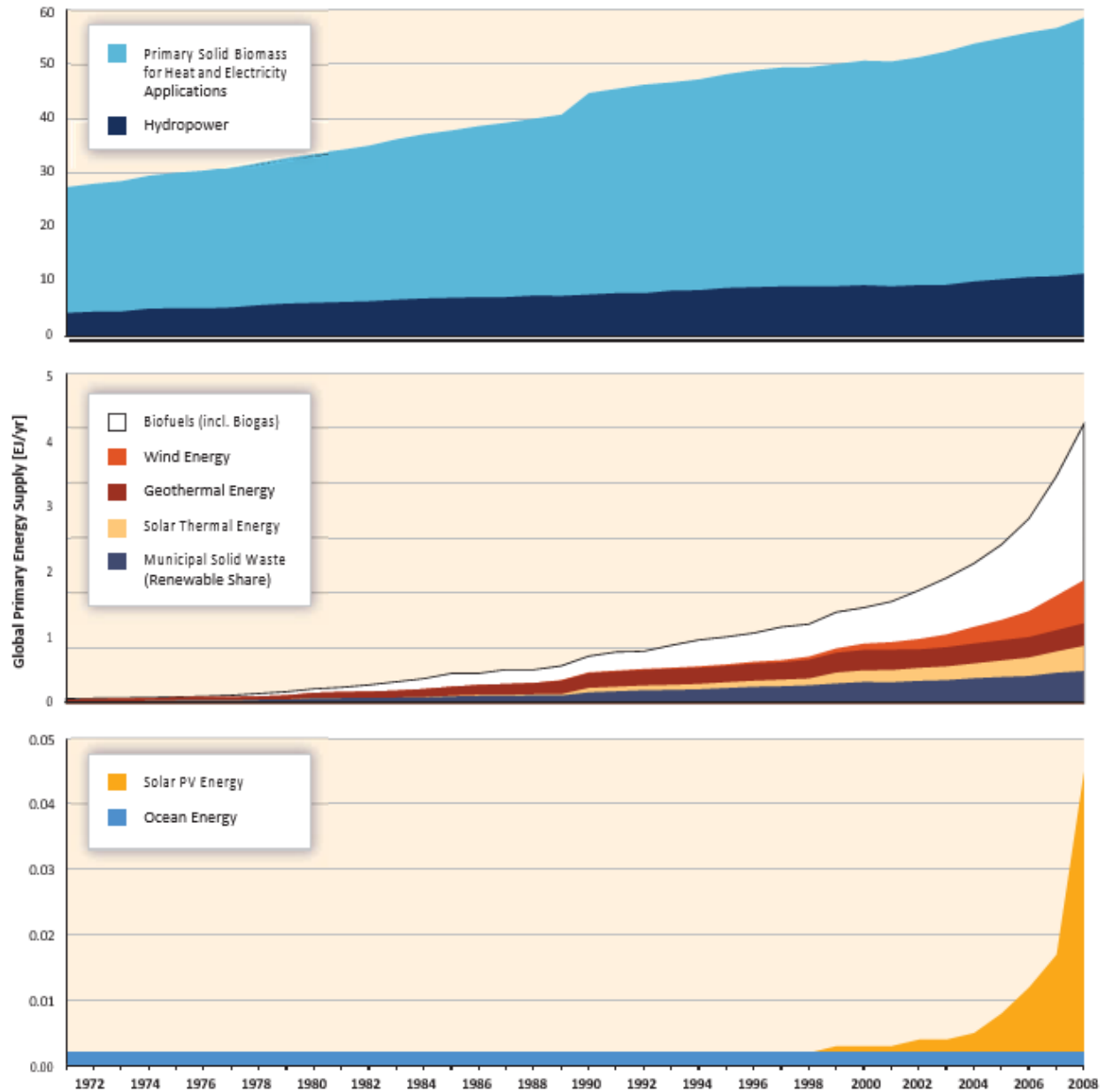


Figure TS.1.4. Historical development of global primary energy supply from renewable energy from 1971 to 2008.

Strategic Mitigation Options

To lower GHG emissions, engineers must consider the following portfolio:

- **Supply-side efficiency:** Improving conversion and distribution.
- **Demand-side efficiency:** Enhancing processes in buildings, industry, and transport.
- **Carrier Shifting:** Moving from coal/oil to gas, nuclear, or RE.
- **Carbon Capture and Storage (CCS):** Preventing CO₂ from entering the atmosphere.

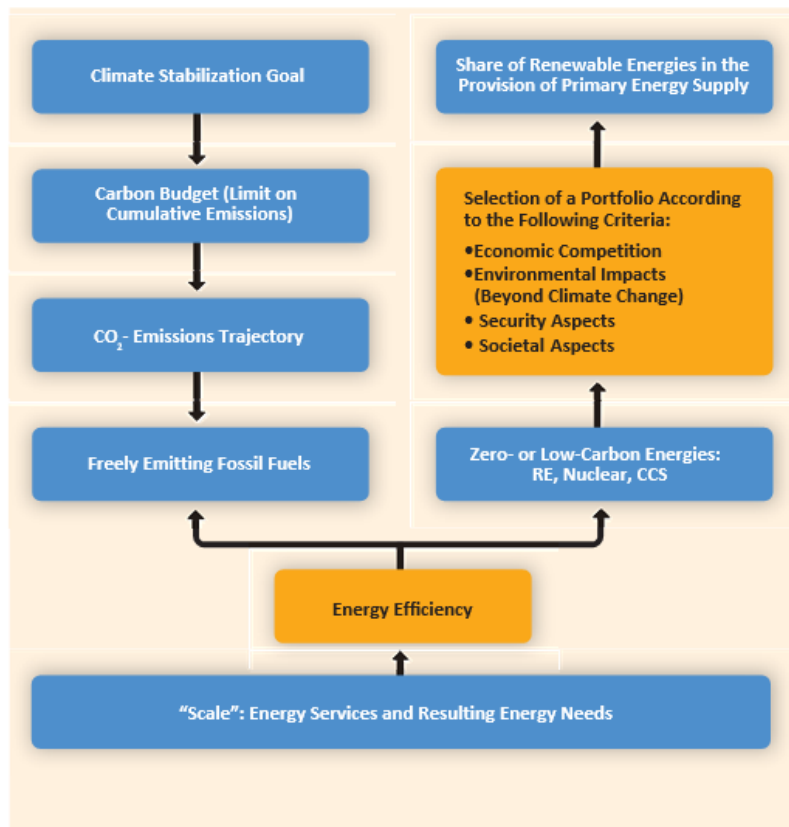


Figure TS.1.5. The role of renewable energies within the portfolio of zero- or low-carbon mitigation options (qualitative description).

Resource Potential and Technical Fundamentals

Renewable Energy is energy from solar, geophysical, or biological sources replenished at a rate equal to or exceeding its use.

The Conversion Chain

Energy is converted from a primary source to an energy carrier, and finally to an energy service.



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