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AN AUTONOMOUS INSTITUTION



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Chennai

23MCT003 – ENVIRONMENTAL SCIENCE & SUSTAINABILITY

3-RENEWABLE ENERGY SOURCES

## 3.6– CASE STUDY ON ENERGY RESOURCES IN INDIA AND ITS SUSTAINABILITY

### Case Study: Energy Resources and Sustainability in India

India, one of the fastest-growing economies in the world, faces increasing energy demands due to rapid industrialization, urbanization, and population growth. With the dual challenges of meeting these energy needs and reducing greenhouse gas emissions, India has developed various policies and projects aimed at increasing the share of renewable and sustainable energy resources in its energy mix. Here's a detailed case study on the state of energy resources in India, focusing on key examples and analyzing their sustainability.

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#### 1. Overview of Energy Mix in India

India's energy mix includes a variety of sources, ranging from fossil fuels to renewables. As of recent years:

- Coal: Dominates India's energy mix, accounting for about 70% of total electricity generation due to abundant domestic reserves and relatively low costs.
- Natural Gas and Oil: Together contribute to around 20% of India's energy needs, with natural gas increasingly being used for cleaner power generation.
- Hydropower: Contributes around 10% of total energy, leveraging India's extensive river network.
- Renewable Energy (Solar, Wind, Biomass): Accounts for around 20% of installed capacity, with solar and wind energy seeing the highest growth rates.

India has committed to reducing its dependence on coal and increasing the share of renewable energy, targeting 50% of total installed capacity from non-fossil fuel sources by 2030.

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#### 2. Key Renewable Energy Initiatives and Sustainability Analysis

India has taken significant steps to promote renewable energy, with major initiatives in solar, wind, biomass, and hydropower. Let's examine a few prominent case studies to understand the sustainability of these efforts.

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### **Case Study 1: Solar Energy - The Gujarat Solar Park**

Overview: The Charanka Solar Park in Gujarat is one of the largest solar power plants in Asia, with an installed capacity of over 1,000 MW. It covers thousands of acres in the Patan district and was developed as part of Gujarat's Solar Power Policy.

Sustainability Aspects:

1. **Economic Sustainability:** By reducing dependence on imported fossil fuels, the solar park contributes to India's energy security and economic stability. Solar power also offers low operational costs once installed.
2. **Environmental Sustainability:** Solar power generation emits no greenhouse gases during operation, helping reduce the carbon footprint. It also preserves water resources, as solar energy has a low water requirement compared to thermal power plants.
3. **Social Sustainability:** The Gujarat Solar Park has created jobs in installation, operation, and maintenance, benefitting the local community. It has also provided stable power supply to surrounding rural areas, contributing to social development.

### **Challenges and Future Development:**

- **Land Use and Environmental Concerns:** Large-scale solar parks require significant land, which can impact local ecosystems and agriculture.
- **Energy Storage:** Solar energy is intermittent, and reliable storage solutions are needed to ensure a continuous supply, especially for nighttime and cloudy days.

Conclusion: The Gujarat Solar Park demonstrates how large-scale solar can effectively meet energy demands sustainably. Future focus on battery storage technology and land-use optimization can further enhance sustainability.

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### **Case Study 2: Wind Energy - Tamil Nadu Wind Farms**

Overview: Tamil Nadu is a leader in wind energy in India, with the Muppandal Wind Farm being one of the largest in the country. The state benefits from strong wind currents due to its geographic location, making it ideal for wind energy production.

Sustainability Aspects:

1. **Economic Sustainability:** Wind power provides a low-cost source of electricity once the initial installation is complete, contributing to energy cost stability and affordability.
2. **Environmental Sustainability:** Wind energy generates no direct emissions, significantly reducing greenhouse gas emissions compared to coal. It also requires minimal water, helping to conserve water resources.
3. **Social Sustainability:** Wind farms in Tamil Nadu have created employment opportunities and have helped power remote areas that previously had limited access to electricity.

#### **Challenges and Future Development:**

- **Grid Integration and Stability:** Wind energy is variable and seasonal, requiring advanced grid infrastructure and balancing solutions.
- **Land Use and Noise:** The installation of large turbines can affect local landscapes and may produce noise, affecting nearby communities.

**Conclusion:** Tamil Nadu's wind farms have successfully harnessed renewable wind energy, contributing to India's green energy goals. With better grid technology and storage solutions, wind energy can further support sustainable development.

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#### **Case Study 3: Hydropower - The Tehri Dam, Uttarakhand**

**Overview:** The Tehri Dam, built on the Bhagirathi River in Uttarakhand, is one of India's largest hydropower projects with an installed capacity of over 1,000 MW. It supplies electricity to North Indian states, including Delhi, Uttar Pradesh, and Uttarakhand.

##### **Sustainability Aspects:**

1. **Economic Sustainability:** Hydropower provides a reliable source of power with low operational costs. The Tehri Dam's electricity production helps stabilize energy prices in the region.
2. **Environmental Sustainability:** While hydropower produces no direct emissions, large dams impact local ecosystems and can alter river flows, affecting biodiversity and fish populations.
3. **Social Sustainability:** The Tehri Dam project has provided employment opportunities during its construction and operation phases. It has also contributed to local infrastructure improvements, including roads and facilities.

### **Challenges and Future Development:**

- **Resettlement Issues:** The construction of large dams often requires relocating communities, as seen with the Tehri Dam, where thousands were displaced.
- **Ecological Impact:** Dams can disrupt river ecosystems, affect sediment flow, and impact aquatic species, requiring careful management and environmental monitoring.

**Conclusion:** The Tehri Dam shows the benefits and challenges of hydropower in India. Smaller, run-of-the-river hydropower projects could be a more sustainable alternative with fewer ecological and social impacts.

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### **3. Government Policies Supporting Renewable Energy in India**

India has introduced several policies and initiatives to promote sustainable energy resources, including:

- **National Solar Mission:** Launched in 2010, this mission aims to establish India as a global leader in solar energy by achieving 100 GW of solar capacity by 2022 (recently expanded to 300 GW by 2030).
  - **National Wind-Solar Hybrid Policy:** This policy encourages the development of hybrid power plants that combine solar and wind energy, optimizing land use and enhancing energy stability.
  - **Hydro Power Policy:** The government promotes small hydropower projects (up to 25 MW) to minimize ecological impact while supporting rural electrification.
  - **Biomass Power and Cogeneration Program:** This program incentivizes the use of agricultural residues and other biomass resources for power generation.
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### **4. Future Path for Energy Sustainability in India**

To ensure a sustainable energy future, India must focus on the following:

1. **Diversifying Renewable Sources:** India needs to balance its renewable portfolio, using solar, wind, hydro, and biomass based on regional potential to create a resilient and efficient energy system.
2. **Energy Storage and Smart Grids:** Investing in energy storage solutions like batteries and developing smart grids will enable better integration of variable renewables and ensure a reliable power supply.
3. **Energy Efficiency Initiatives:** Reducing energy demand through energy-efficient appliances, industrial practices, and buildings can complement renewable energy by minimizing overall consumption.

4. R&D in Emerging Technologies: Exploring geothermal, ocean energy, and advanced storage technologies will diversify India's renewable energy options.
  5. Public Awareness and Community Involvement: Educating the public on energy conservation and involving local communities in renewable projects ensures social acceptance and enhances sustainability.
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### **Conclusion**

India's transition to a sustainable energy system presents significant challenges and opportunities. By focusing on renewable resources like solar, wind, and hydropower, India can reduce its dependence on fossil fuels, curb emissions, and promote economic stability. Through projects like the Gujarat Solar Park, Tamil Nadu's wind farms, and the Tehri Dam, India demonstrates the potential of renewable energy in meeting its vast energy needs sustainably. However, ongoing innovation, careful environmental management, and community involvement are essential to fully realize the benefits of a sustainable energy future.