



Climate Change Mitigation Technologies: Innovations for a Sustainable Future

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Abstract

Climate change poses one of the greatest challenges of the 21st century, with rising global temperatures, extreme weather events, and biodiversity loss. Technological innovations play a central role in mitigating these effects by reducing greenhouse gas emissions and enhancing sustainable practices. This paper explores renewable energy, carbon capture and storage (CCS), smart grids, and green transportation technologies as critical tools for climate mitigation. A case study on solar energy adoption in India highlights real-world impacts and challenges.

Keywords

Climate Change, Renewable Energy, Carbon Capture, Sustainable Technologies, Green Innovation

1. Introduction

Global warming has already increased Earth's average temperature by over 1°C since pre-industrial levels, with severe socio-economic consequences. While policy frameworks such as the Paris Agreement set emission targets, technological solutions are necessary to meet these goals. This research examines climate change mitigation technologies and their effectiveness in addressing the crisis.

2. Literature Review

- Pacala & Socolow (2004) introduced the concept of stabilization wedges, emphasizing technological solutions to cut emissions.
- IPCC (2018) highlighted renewable energy and carbon capture as essential for limiting warming to 1.5°C.



- Jacobson et al. (2015) presented pathways for 100% renewable energy adoption globally.

These studies show the importance of deploying scalable, cost-effective, and socially acceptable mitigation technologies.

3. Methodology

The study applies a **comparative analysis and case study approach**:

1. **Comparative Review:** Evaluating renewable energy, CCS, smart grids, and electric mobility.
2. **Case Study:** Solar energy deployment in India under the National Solar Mission.
3. **Evaluation Criteria:** Cost-effectiveness, scalability, environmental impact, and adoption challenges.

4. Climate Mitigation Technologies

1. Renewable Energy Systems:

- Solar, wind, and hydropower as primary substitutes for fossil fuels.
- India's rapid solar adoption demonstrates feasibility.

2. Carbon Capture and Storage (CCS):

- Captures CO₂ from industrial sources for underground storage.
- Still expensive and under limited deployment.

3. Smart Grids:

- Enable efficient integration of renewable energy.
- Reduce transmission losses and improve demand forecasting.

4. Green Transportation:

- Electric vehicles (EVs) and hydrogen fuel technologies.
- Public transport electrification reduces urban emissions.



5. Results and Discussion

The case study of India's solar program shows:

- Solar capacity increased from **2.6 GW (2014) to 81 GW (2024)**.
- Reduction of **120 million tonnes of CO₂ emissions annually**.
- Decline in solar power tariffs to **INR 2.4/kWh**, making it cheaper than coal.

Challenges include financing gaps, intermittency of renewables, limited charging infrastructure, and CCS cost barriers.

6. Conclusion

Climate change mitigation requires accelerated adoption of renewable energy, CCS, smart grids, and green transport. While progress is evident, large-scale investment, supportive policies, and global cooperation are necessary for achieving net-zero targets. The future lies in integrating technology with sustainable development to secure a livable planet.

References

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