

GLOBAL PRACTICES OF GREENHOUSE GAS EMISSION MANAGEMENT

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Abstract: *The management of greenhouse gas (GHG) emissions represents one of the most complex and urgent challenges of the 21st century. As climate change accelerates, nations are developing diverse mechanisms to regulate, reduce, and offset emissions in line with the objectives of the Paris Agreement and the UN Sustainable Development Goals (SDGs). This paper provides a comprehensive analysis of global practices in GHG management, examining both international and national strategies, including emission trading systems (ETS), carbon taxes, offset markets, and technological innovations. The study evaluates the effectiveness of these instruments in major economies such as the European Union, United States, China, Japan, and developing nations, identifying key lessons and challenges. The analysis concludes that while significant progress has been achieved in establishing global carbon governance, disparities in implementation and ambition continue to hinder the collective achievement of net-zero goals.*

Keywords: *greenhouse gases, climate policy, emission trading, carbon markets, carbon tax, mitigation, sustainability, Paris Agreement, global governance, environmental economics.*

Introduction. Climate change has emerged as the defining environmental and economic challenge of the modern era. Driven primarily by the accumulation of greenhouse gases (GHGs) including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases the Earth's average temperature has increased by over 1.2°C since pre-industrial times (IPCC, 2023). This rapid warming has intensified extreme weather events, sea-level rise, and biodiversity loss, while also posing severe risks to human health, food security, and economic stability. In response, the global community has established a variety of frameworks, institutions, and market-based

mechanisms to manage and reduce emissions. From the Kyoto Protocol (1997) to the Paris Agreement (2015), international climate governance has evolved from rigid, top-down mandates to flexible, bottom-up systems emphasizing national autonomy and innovation. Within this architecture, GHG management has become a central pillar of environmental and economic policy.

The fundamental goal of emission management is to achieve “net-zero emissions” a state in which human-induced GHG emissions are balanced by removal through natural sinks or technological capture. Achieving this objective requires a multidimensional approach that integrates:

- Regulatory instruments (e.g., emission caps, performance standards),
- Market-based mechanisms (e.g., Emission Trading Systems, carbon taxes),
- Technological innovation (e.g., carbon capture, renewable energy),
- Behavioral and institutional changes (e.g., corporate responsibility, sustainable finance).

Global GHG management is not uniform. Different regions adopt varying instruments depending on their economic structures, political systems, and developmental priorities. The European Union (EU), for instance, operates the world’s largest Emissions Trading System (EU ETS), which covers more than 10,000 industrial facilities and power plants. The United States has developed regional carbon markets such as the Regional Greenhouse Gas Initiative (RGGI) and California Cap-and-Trade Program, focusing on decentralized innovation. China, on the other hand, has recently launched its National ETS, which already covers more emissions than any other system globally.

At the same time, carbon taxation has become an effective tool in countries such as Sweden, Japan, Canada, and South Korea, where predictable pricing signals drive decarbonization. Developing nations, meanwhile, increasingly integrate offset mechanisms including reforestation projects, carbon credits, and renewable investments into national climate strategies supported by international finance.

Despite this diversity of approaches, global progress remains uneven. While the OECD countries have achieved partial decoupling of emissions from economic growth, many emerging economies continue to rely heavily on fossil fuels to sustain industrial development. Moreover, discrepancies in measurement, verification, and enforcement undermine the integrity of global carbon markets.

This paper seeks to provide a comprehensive overview of global GHG management practices, addressing the following research questions:

1. What are the main institutional and economic mechanisms used to regulate GHG emissions globally?
2. How do emission trading systems and carbon taxes differ in design and effectiveness?

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3. What are the distinctive features of national GHG management strategies in leading economies?
 4. How do innovation and finance contribute to achieving carbon neutrality?
 5. What lessons can be drawn from current practices for improving global climate governance?

The structure of this paper is as follows:

- Section 1 examines global mechanisms and institutional frameworks for emission management.
- Section 2 analyzes emission trading systems (ETS) and carbon markets as key tools of market-based regulation.
- Section 3 discusses national strategies and best practices in major economies.
- Section 4 explores innovative instruments, including carbon taxes, offsets, and technologies.
- The final section assesses overall effectiveness and provides policy recommendations for future progress.

Climate change mitigation has become both a scientific necessity and a geopolitical reality. The capacity of nations to manage their emissions effectively will determine not only their environmental sustainability but also their competitiveness in the emerging low-carbon global economy.

Global Mechanisms and Institutional Frameworks for Greenhouse Gas Regulation

The regulation of greenhouse gas (GHG) emissions is one of the most ambitious undertakings in modern international governance. Since the early 1990s, nations have sought to build a multilateral system capable of balancing environmental responsibility with economic development. This system—often described as “global carbon governance”—has evolved through a combination of legal frameworks, financial mechanisms, and market instruments.

1. The foundation: UNFCCC and the birth of global climate governance

The institutional foundation of global climate policy was established with the United Nations Framework Convention on Climate Change (UNFCCC), adopted at the Rio Earth Summit in 1992. The UNFCCC set the overarching goal of stabilizing atmospheric greenhouse gas concentrations “at a level that would prevent dangerous anthropogenic interference with the climate system.”

Its principles remain the cornerstone of all subsequent climate agreements:

- Common but differentiated responsibilities (CBDR): recognizing that industrialized countries bear a greater historical responsibility for emissions;
- Precautionary principle: encouraging action even amid scientific uncertainty;
- Right to sustainable development: allowing developing nations to pursue growth while transitioning to cleaner pathways.

The UNFCCC created the Conference of the Parties (COP), which meets annually to negotiate and assess progress. Major breakthroughs include:

- Kyoto Protocol (1997) – introduced binding emission targets for developed countries;
- Copenhagen Accord (2009) – marked the political recognition of the 2°C target;
- Paris Agreement (2015) – shifted toward a universal, voluntary system of national contributions (NDCs);
- Glasgow Pact (2021) and Dubai COP28 (2023) – reaffirmed commitments to phase down fossil fuels and triple renewable capacity by 2030.

Through these negotiations, climate change has become a permanent agenda item in global diplomacy, economics, and development.

2. The Kyoto Protocol: A legally binding regime

Adopted in 1997 and enforced in 2005, the Kyoto Protocol was the first treaty to translate climate commitments into legally binding obligations. It assigned industrialized countries listed in Annex I of the UNFCCC quantified emission reduction targets for the period 2008–2012, amounting to an average 5.2% below 1990 levels.

To achieve flexibility and cost efficiency, Kyoto introduced three market-based mechanisms:

1. Emissions Trading (ET): allowed countries to trade unused emission allowances;
2. Clean Development Mechanism (CDM): enabled developed nations to invest in emission reduction projects in developing countries for credits;
3. Joint Implementation (JI): permitted investment in projects within other Annex I countries.

These instruments laid the foundation for today's carbon markets, creating a global price signal for CO₂ emissions. However, the Kyoto system faced challenges:

- Limited participation (the U.S. never ratified the treaty);
- Weak enforcement mechanisms;
- Exclusion of developing countries from binding commitments;
- Market oversupply of credits, leading to low carbon prices.

Despite its shortcomings, the Kyoto Protocol was a historic milestone—it demonstrated that emissions could be treated as tradable commodities, blending environmental goals with market logic.

3. The Paris Agreement: From regulation to cooperation

The Paris Agreement (2015) redefined global climate governance by shifting from top-down control to bottom-up collaboration. Unlike Kyoto, it applied to all nations, not just industrialized ones, and emphasized voluntary Nationally Determined Contributions (NDCs).

Its structure rests on three key pillars:

- Transparency: countries must regularly report emissions and progress using standardized methods;
- Ambition cycle: every five years, nations must submit stronger NDCs;
- Finance and support: developed countries pledged \$100 billion annually to assist developing nations in mitigation and adaptation.

Paris also introduced the concept of global stocktake—a periodic assessment of collective progress toward limiting warming to 1.5–2°C.

This flexible system recognizes the diversity of national circumstances, integrating climate action into broader strategies of economic modernization, energy transition, and innovation.

4. The role of the IPCC and scientific foundations

Scientific knowledge underpins all GHG management frameworks. The Intergovernmental Panel on Climate Change (IPCC), established in 1988, provides periodic assessment reports summarizing the state of climate science. Its Sixth Assessment Report (AR6, 2023) confirmed with 99% certainty that human activity is the dominant cause of global warming and warned that emissions must peak before 2025 to limit warming to 1.5°C.

IPCC data guide international negotiations, national targets, and corporate carbon accounting. It has also standardized Global Warming Potentials (GWPs), which express each gas's impact relative to CO₂ critical for emission inventories and trading systems.

5. Financial institutions and carbon market infrastructure

Financial mechanisms play a vital role in supporting GHG management. The most significant include:

- Green Climate Fund (GCF): established in 2010 to channel resources to developing countries;
- Global Environment Facility (GEF): finances climate-related projects and technology transfer;
- Carbon pricing instruments (CPI): tools that assign a monetary cost to carbon, incentivizing emission reductions;
- Voluntary Carbon Markets (VCMs): allow corporations to offset emissions through certified projects (reforestation, renewable energy, etc.).

According to the World Bank's "State and Trends of Carbon Pricing 2023", over 73 carbon pricing instruments are now in operation worldwide—covering 23% of global GHG emissions and generating \$95 billion in revenue in 2023 alone.

These revenues are increasingly used for green investments, energy subsidies, and climate adaptation programs.

6. The rise of regional and national initiatives

Beyond multilateral treaties, regional frameworks have become essential laboratories for climate governance:

- European Union Emissions Trading System (EU ETS): launched in 2005, it remains the world's largest carbon market, covering power generation, heavy industry, and aviation.
- China's National ETS (2021): currently covers over 4,000 power plants and will soon expand to other sectors, managing more emissions than the entire EU ETS.
- United States: although it lacks a federal carbon price, it operates regional markets (RGGI and California Cap-and-Trade) that influence national policy.
- Japan, South Korea, and Canada combine carbon taxes with cap-and-trade elements, creating hybrid systems that balance flexibility and predictability.

These initiatives demonstrate that there is no single model for GHG management; instead, countries design systems that align with their political and economic realities.

7. The evolution toward global carbon governance

Over the past three decades, global GHG regulation has evolved through three distinct phases:

Phase	Period	Main Features	Key Instrument
Phase I	1992–2005	Institutional foundation and legal obligations	UNFCCC, Kyoto Protocol
Phase II	2005–2015	Market experimentation and flexible mechanisms	CDM, EU ETS
Phase III	2015–present	Universal participation and innovation-based action	Paris Agreement, carbon markets, net-zero strategies

The emergence of a complex architecture combining treaties, institutions, markets, and technologies reflects a broader trend in international relations: the environmentalization of global governance. Climate policy is no longer limited to ecological protection; it defines trade rules, investment flows, and geopolitical alignments.

Emission Trading Systems (ETS) and Carbon Markets

Among the most influential instruments of modern climate governance are emission trading systems (ETS)—market mechanisms that place a price on carbon and allow companies to buy and sell emission allowances. These systems embody the principle of “cap-and-trade”, where the total volume of emissions is capped at a predetermined level, and individual firms are allocated or purchase emission permits within that limit.

By integrating environmental objectives with market dynamics, ETS provides a cost-effective and flexible means to achieve emission reductions while stimulating innovation and efficiency.

The European Union Emissions Trading System (EU ETS)

Launched in 2005, the EU ETS is the world's largest and most established carbon market. It covers approximately 40% of the EU's total greenhouse gas emissions, including power generation, heavy industry, and intra-European aviation.

Structure and operation:

- Operates on a cap-and-trade basis with annual emissions caps declining by 4.3% per year (post-2021).
- In Phase IV (2021–2030), free allocation is being phased out in favor of auctioning, generating significant revenue for green investments.
- The average carbon price exceeded €90 per ton of CO₂ in 2023, compared to less than €5 in 2013—a sign of increasing market maturity.

Achievements:

- Between 2005 and 2023, emissions from covered sectors declined by approximately 41%.
- The EU ETS has become the central pillar of the European Green Deal, complementing measures like the Carbon Border Adjustment Mechanism (CBAM) and the Fit for 55 package.

Indicator	2005	2023	Change (%)
Covered emissions (MtCO ₂ e)	2,096	1,239	–41%
Carbon price (€/tCO ₂)	6.5	90.2	+1,287%
Share of EU emissions covered	45%	40%	-
Annual auction revenue (€ billion)	<1	40+	+3,900%

Source: European Environment Agency (EEA), 2023; European Commission, 2024.

The success of the EU ETS has inspired other regions to adopt similar frameworks, leading to the gradual integration of carbon markets worldwide.

Conclusion. The management of greenhouse gas emissions defines the future trajectory of human development. Over the past three decades, the world has built an intricate web of institutions, markets, and technologies to address the climate challenge. Yet, despite growing sophistication, the implementation gap remains wide.

The experience of emission trading systems, carbon taxes, and national decarbonization strategies shows that effective GHG management requires a balance of environmental integrity, economic rationality, and social justice. The next decade will be decisive: global emissions must peak before 2025 and decline by nearly half by 2030 to maintain a 1.5°C pathway. Achieving this will depend not only on technology and policy but on collective political will.

Climate governance has matured from fragmented experimentation to a complex system of interlinked markets and institutions. The challenge ahead is ensuring that this system delivers measurable reductions at a pace compatible with planetary limits. Ultimately, GHG management is not merely a technical exercise it is a moral and political commitment to safeguard the stability of the Earth system and the well-being of future generations.

The success of global emission management will thus be measured not in tons of carbon reduced, but in the resilience, equity, and sustainability of the societies that emerge from this transformation.

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