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GREEN TECHNOLOGY: A PATH TOWARDS ENVIRONMENTAL SUSTAINABILITY

A LEGAL, CONSTITUTIONAL AND COMPARATIVE ANALYSIS

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Abstract

There has never been a more pressing need to integrate technology, law, and environmental responsibility. This article explores green technology as a multifaceted tool of environmental sustainability, examining its constitutional foundations in the Indian legal system, significant court rulings that have influenced the development of environmental jurisprudence, and international policy responses from major economies like Germany, China, and the European Union. This article makes the case that green technology is a constitutional need rather than just a policy choice by referencing key Supreme Court and High Court rulings, current legislative frameworks, and constitutional requirements. It also examines comparative national models, highlights major obstacles to its acceptance, and analyses new trends that point to a new age in the relationship between law, technology, and the environment. Specifically, we look at the landmark Supreme Court decision in M.K. Ranjitsinh v. Union of India, which came down in 2024 and established, as a basic right under Articles 14 and 21, the right to be free from the adverse effects of climate change.

Keywords: Renewable Energy, Climate Change, Constitutional Law, Article 21, Green Technology, Environmental Sustainability, and Environmental Jurisprudence.

I. INTRODUCTION

Over the course of human civilisation, the connection between technical advancement and the natural environment has fluctuated between guardianship and exploitation. This has occurred throughout the entire lifespan of human civilisation. Despite the fact that the Industrial Revolution ushered in a time of unprecedented material affluence, it also unleashed forces that are progressively deteriorating the ecological underpinnings of the globe. The repercussions of that agreement, which include rising sea levels, catastrophic weather events, disappearing biodiversity, and polluted air and water, are now confronting us with alarming clarity. As a result, a broad consensus has emerged: technology must now be conscripted in the service of the environment that it once helped to ruin.

The greatest potential vehicle for this change is green technology which may be generally characterised as the application of science, engineering and innovation to reducing environmental harm, conserving natural resources and promoting sustainable

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development[214]. The idea includes renewable energy systems, energy-efficient buildings, electric transportation, waste processing technologies, clean water solutions, and a host of digital tools to help monitor and manage ecosystems at large scales. As per Indian law, environment is defined as "water, air and land and the interrelationship which exists among and between them and human beings and other living creatures, plants, micro-organisms and property". Part 2(a) of the Environmental Protection Act of 1986 provides this explanation.[215]

The constitutional and legal argument for eco-friendly technology in India is strong and comprehensive. After being an implied aim for forty years of progressive law, the right to a clean environment is now a basic right that the Supreme Court may hear cases on. Both the state and its citizens are positively obligated to preserve and improve the environment according to the Constitution's Directive Principles and Fundamental Duties[216]. These prerequisites are responsible in a favorable way. The right to be immune from the negative consequences of climate change is a protected right, according to a 2024 judgement by India's Supreme Court in M.K. Ranjitsinh v. Union of India. This ruling has lately heightened the feeling of urgency around these fundamental obligations.[217]

The article is broken up into eight different sections. In the second part of this introduction, which follows, we will discuss the notion of green technology as well as its breadth. In Part III, we investigate the constitutional foundations of environmental protection and the consequences these foundations have for environmentally friendly technologies. Indian environmental jurisprudence has been significantly influenced by landmark case legislation, which are discussed in Part IV. In the fifth section, we discuss the significance of environmentally friendly technology as well as its benefits. In Part VI, we address the challenges that its implementation faces. The model of the European Union, Germany, China, and other countries is examined in Part VII. Part VIII takes a look at the most current trends. Part IX is where the conclusion is presented.

II. The Concept, Scope and Types of Green Technology

A. The Concept and the Meaning

Green technology is any technology, product, service or process that consumes less non-renewable resources, produces less waste and pollution and has a measurably lower negative impact on the environment than the conventional alternative. Green technology is also called clean technology or environmental technology. This initiative's primary objective is to reconcile economic activity with ecological constraints. Its goal is to make sure that development does not eat up the conditions needed for future development to take place.

Green technology is a departure from previous concepts of technical progress that considered success only in terms of output and efficiency but also introduces environmental performance as an equally important measure. It spans the entire spectrum from incremental improvements to revolutionary developments, and it covers a variety of different industries including agriculture, construction, information technology, and transportation, as well as energy and transportation.

B. Principal Types and Critical Domains

Eco-friendly technology may be found in a variety of significant domains. Technologies in the energy sector that allow for the production of power without the combustion of fossil fuels include small hydro plants, tidal energy converters, wind turbines, solar photovoltaic

[214] Rocket makers, 'The Definitive Guide To Green Technology in 2024', available at: https://www.rocketmakers.com/blog/guide-to-green-technology (last visited May 2025).
[215] Section 2(a), Environment (Protection) Act, 1986.
[216] The Constitution of India, 1950, Preamble.
[217] M.K. Ranjitsinh v. Union of India (Great Indian Bustard Case), 2024 SCC OnLine SC 382.

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cells, and similar devices. Greenhouse gas emissions are drastically reduced as a consequence of this. The International Renewable Energy Agency reports that between 2010 and 2024, the price of solar photovoltaic electricity fell by over 85% and that of onshore wind power fell by 70%. For much of the world, this means that renewable energy is now the best bet for producing new power at a reasonable cost.[218]

Examples of green architecture in the built environment include the design of passive cooling and heating systems, insulated building envelopes, rainwater harvesting, and intelligent energy management systems. These are all examples of green architecture that help minimise the energy and water footprint that a building has during its lifetime. The internal combustion engine is being quickly replaced in the transportation sector by electric cars, hydrogen fuel-cell technology, and intelligent public transit systems. Agricultural practices such as precision farming, drip irrigation, organic composting, and monitoring soil health all contribute to the conservation of water and soil while also preserving crop production. Anaerobic digestion, waste-to-energy facilities, and circular economy models are all examples of waste management practices that aim to enhance resource recovery and minimise the amount of garbage that is sent tolandfills.

Increasingly, digital technologies are becoming a component of environmentally friendly technology. Emissions, energy consumption, and water quality can all be monitored in real time thanks to artificial intelligence and the Internet of Things, which also makes it possible to immediately address any issues that were discovered. Sustainable software design helps to lessen the impact that digital infrastructure has on the environment. There were significant developments in the sector in 2024, including as the creation of perovskite solar cells with conversion efficiencies that were greater than 25% and the introduction of new organic redox flow batteries that had a higher energy density.[219]

III. CONSTITUTIONAL FOUNDATIONS: THE LEGAL ARCHITECTURE FOR GREEN TECHNOLOGY IN INDIA

A. The Preamble and Environmental Justice

India is committed to ensuring social, economic, and political justice for all of its residents, as stated in the Preamble to the Constitution of India. Despite the fact that the word "environment" is not included in the Preamble, constitutional experts and the Supreme Court have repeatedly concluded that concerns pertaining to environmental justice are included under the more comprehensive idea of social and economic justice. People who are living in close proximity to hazardous industrial waste, inhaling polluted air, or drinking contaminated water are deprived of the basic foundation upon which they might build a life that is worthy of respect. This reading sees the Preamble's promise of justice as dependent on environmental sustainability.

B. Article 21: The Right to Life as Environmental Right

The Indian Constitution states in its Preamble that the country would ensure all of its residents enjoy social, economic, and political justice. Although the word “environment” does not appear in the Preamble, constitutional scholars and the Supreme Court have repeatedly held that environmental justice is subsumed within the larger conception of social and economic justice. A people who breathe polluted air, drink contaminated water or live next to toxic industrial waste are deprived of the very basis for a dignified life. In this sense the Preamble’s promise of justice is inextricable from environmental well-being.

In 1988's Rural Litigation and Entitlement Kendra v. State of U.P., also known as the Dehradun Quarrying Case, the Supreme Court made history by ruling that Article 21's guarantee

[218] IRENA, 'Renewable Power Generation Costs in 2023', International Renewable Energy Agency, 2024.

[219] Article 14, Constitution of India, 1950.

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of a safe and healthy environment is fundamental.[220] The right to live in an environment free of pollution was subsequently upheld by the Court in M.C. Mehta v. Union of India (1987), which also announced the groundbreaking notion of unlimited responsibility for businesses involved in dangerous activities, under Article 21.[221]

In 2024, the link between Article 21 and environmentally friendly technologies was made more apparent. The Great Indian Bustard Case, also known as M.K. Ranjitsinh v. Union of India, was the first occasion the Supreme Court of India clearly acknowledged the right to be free from the negative consequences of climate change as a basic right protected by Articles 14 and 21. The shift to renewable energy sources is a fundamental need with its origins in the right to life, and the Court has recognized that climate change is a constitutional issue, not just a legislative one.[222]

C. Articles 48A and 51A(g): The Constitutional Green Mandate

"In 1976, the Constitution (Forty-second Amendment) Act included two sections that, when taken together, comprise what is sometimes referred to as the constitutional green imperative of India to protect the environment. Article 48A, which was placed into Part IV of the Constitution (Directive Principles of State Policy), mandates that the state must make every effort to maintain and promote the environment, as well as to protect the woods and animals of the nation. Specifically, it is a Directive Principle. It is not immediately enforceable in a court of law as per the statute. Conversely, it is an essential principle of government, and courts have often relied on it to identify the constitutionality of governmental actions.

Every Indian citizen has a moral obligation to protect and improve the country's natural resources, including its forests, lakes, rivers, and wildlife, according to Article 51A(g) of the revised chapter on Fundamental Duties.[223] In the 1988 case of L.K. Koolwal v. State of Rajasthan, the Rajasthan High Court granted this clause a great deal of interpretative authority. People have the right to petition the Court to have the state fulfill its environmental duties, according to the court's interpretation of Article 51A (g) of the constitution[224].

In terms of environmentally friendly technologies, this constitutional framework has obvious ramifications. When a state makes the decision to purchase power derived from coal despite the availability and affordability of renewable alternatives, or when companies are allowed to discharge hazardous effluents without sufficient treatment, these decisions can be evaluated in light of the constitutional norm outlined in Articles 48A and 51A(g). A normative baseline against which the actions of governmental and corporate actors may be judicially scrutinised is provided by the constitutional commitment to environmental preservation. This commitment is not a legal mandate, but rather a normative baseline.

D. Articles 14 and 19(1)(g): Equality, Business, and Environmental Limits

There have been instances when the State's environmental judgments have been overturned by invoking the concept of equality before the law, as contained in Article 14. The decision of the Supreme Court of India in the case of Bangalore Medical Trust v. B.S. Muddappa (1991) upheld the principle that the Chief Minister's decision to turn over public park land to a private hospital without taking environmental impacts into account was arbitrary, exceeding his authority, and violated Article 14.[225]

[220]Rural Litigation and Entitlement Kendra v. State of U.P., AIR 1988 SC 2187 (Dehradun Quarrying Case).
[221]M.C. Mehta v. Union of India, AIR 1987 SC 1086 (Oleum Gas Leak Case).
[222]Columbia Law School Climate Change Blog, 'Ranjitsinh v. Union of India (2024): Recognizing Freedom from Adverse Effects of Climate Change as Fundamental Right', August 28, 2024.
[223] Article 48A, Constitution of India, inserted by the Constitution (Forty-Second Amendment) Act, 1976.
[224] Article 51A(g), Constitution of India, inserted by the Constitution (Forty-Second Amendment) Act, 1976.
[225] Bangalore Medical Trust v. B.S. Muddappa, (1991) 4 SCC 54.

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The freedom to engage in any lawful occupation or commercial activity is guaranteed in Article 19(1)(g), although it is subject to reasonable limitations to protect the public interest. Judgment from many courts has shown that no business may use Article 19(1)(g) to justify actions that endanger public health. A business cannot rely on Article 19(1)(g) protections if it releases untreated effluents, according to the Gujarat High Court's decision in Abhilash Textiles v. Rajkot Municipal Corporation (1988). This implies that the industry's bottom line must not be allowed to dictate how public health is prioritized.[226]

E. Article 47 and Public Health

Article 47 states... It is the primary duty of the state to ensure that its inhabitants are healthy and to improve their nutrition and overall quality of life. It has been interpreted that this clause, which is in agreement with Article 21, is meant to support the view that the state cannot be indifferent to degradation of the environment that harms public health. In light of this, it is not only desirable for the state to invest in clean energy, clean water infrastructure, and pollution management, but it is also legally mandatory for green technology.

IV. JUDICIAL LANDMARKS: CASE LAWS SHAPING INDIA'S ENVIRONMENTAL AND GREEN TECHNOLOGY JURISPRUDENCE

A. The Polluter Pays and Precautionary Principles: Vellore Citizens' Welfare Forum (1996)

Vellore Citizens' Welfare Forum v. Union of India [227]is widely recognised as one of the most significant environmental judgements in the annals of Indian law, although popularly referred to as the Tanneries Case. The tanneries of Tamil Nadu were dumping untreated effluents into the River Palar and the agricultural land around it for several decades. As a result, about 35,000 hectares of land had become partially or totally unsuitable for agriculture and 350 of the 467 wells had been polluted. The Precautionary Principle, Sustainable Development, and Polluter Pays have all been formally adopted into Indian law by the country's highest court, the Supreme Court of India.

The Principal of Polluter Pays This theory proposes that polluters, and not society at large, should foot the bill for environmental damage prevention and repair. The recommendations have integrated the Precautionary Principle, which states that where there is a possibility of catastrophic or permanent harm, a lack of complete scientific knowledge should not be used to delay cost-effective efforts to avert environmental deterioration. The Court's decision to establish an authority to repair and recoup the cost of ecological restoration from the polluting tanneries was an effort to develop a restorative paradigm of environmental enforcement.

B. The Public Trust Doctrine: M.C. Mehta v. Kamal Nath (1997)

It was in the Span Motel case that India's highest court first evaluated and upheld the country's Public Trust Doctrine. An environmentally fragile riverine tract has been leased out by the government of Himachal Pradesh to a private hotel, owned by the family of a Union Minister. The family diverted the course of the River Beas using bulldozers to protect his resort. This is the first time such damages were awarded in India. The government cannot be deemed to be the rightful owner of natural resources for private economic benefit, according to the court's ruling. Hence, the court revoked the lease, directed restoration of the environment and imposed exemplary penalties.

C. Absolute Liability for Hazardous Industry: M.C. Mehta v. Union of India (1987)

While considering the oleum gas leak case at the Delhi facility of Shriram Industries in 1985—just months after the Bhopal tragedy—the Supreme Court advanced the notion of absolute culpability.Absolute Liability is a more recent legal principle as compared to the English

[226] Article 19(1)(g), Constitution of India, 1950.

[227] Vellore Citizens' Welfare Forum v. Union of India, (1996) 5 SCC 647.

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principle of Strict Liability and no exemptions are provided under Absolute Liability. In Absolute Liability, any business involved in inherently hazardous activities is liable to compensate all the persons who are harmed as a result of any accident occurring as a result of such activities. The implementation of this principle resulted in the creation of substantial financial incentives for the use of safer and cleaner technology, which in turn transformed the legal environment for enterprises.

D. Right to Clean Water: Subhash Kumar v. State of Bihar (1991)

A right to safe drinking water was at issue in the 1991 case of Subhash Kumar v. State of Bihar.According to the Supreme Court's decision in Subhash Kumar v. State of Bihar, access to safe drinking water and air is an element of the right to life guaranteed by Article 21[228]. An individual's right to a remedy, as established by a Supreme Court ruling, may include the elimination of air or water pollution that threatens that person's quality of life. So that decision gave a constitutional basis for lawsuits against industry water pollution and for the call for investment in technology to clean water.

E. Sanitation as a Fundamental Right: Municipal Council, Ratlam v. Vardhichand (1980)

In this landmark judgment, Justice V.R. Krishna Iyer held that a municipality cannot escape its public health obligations by pleading financial inability.[229] Decency and dignity are non-negotiable aspects of human rights and constitute a primary responsibility on local self-governing authorities, the Court said, compelling the Ratlam municipality to provide proper sanitation and drainage.' This decision demonstrated that judicial compulsion can drive investment in environmental infrastructure — a principle applicable to green technology mandates today.

F. Protection of Urban Green Spaces: Bangalore Medical Trust v. B.S. Muddappa (1991)

One example of the constitutional protections afforded to urban green infrastructure is the Supreme Court's decision to intervene to prevent the privatization of a public park. Because it would be in direct conflict with the Constitutional mandate, the Court ruled that private interests cannot outweigh the public interest in reserving and preserving open areas for playgrounds and parks. This principle has since been extended to protect urban trees, wetlands, and green belts from encroachment.

G. The 2024 Breakthrough: M.K. Ranjitsinh v. Union of India

The Great Indian Bustard case, which reached the Supreme Court in March 2024, is a watershed moment in the evolution of environmental constitutional law in India. At last, the highest court in India has ruled that protection against climate change's negative impacts is a constitutionally guaranteed right, as stated in Articles 14 and 21. While the bench ultimately permitted certain renewable energy projects in the bird's habitat on the ground that renewable energy is essential to combat climate inequality, the constitutional recognition itself is of epoch-making importance.

The judgment places India among the very small group of jurisdictions — alongside the Netherlands, Germany, and Colombia — where courts have constitutionally anchored climate rights. This ruling indicates that courts will consider both traditional environmental criteria and the constitutional right to be free from climate change when evaluating energy and industrial policies in the future.

H. Other Key Judgments

The Supreme Court's decision in Virender Gaur v. State of Haryana (1995) established a constitutional obligation for the State and municipalities to provide a clean environment since it is a part of the right to a healthy

[228] Subhash Kumar v. State of Bihar, (1991) 1 SCC 598.

[229]Municipal Council, Ratlam v. Vardhichand, AIR 1980 SC 1622.

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existence.[230] As an early acknowledgement that air quality is a right, not a luxury, the Supreme Court ruled in Murli S. Deora v. Union of India (2002) that non-smokers could not be compelled to breathe in secondhand smoke in public places, prohibiting smoking in public.[231] Judgment in T.N. Godavarman Thirumulpad v. Union of India (1996) reflected judicial acknowledgement that the Indian government cannot be relied upon to manage the country's natural resources on its own. The court issued extensive directives for forest governance.[232]

V. SIGNIFICANCE AND BENEFITS OF GREEN TECHNOLOGY

A. Decarbonisation of the Economy

The most immediate significance of green technology lies in its capacity to decarbonise economic activity. A decade ago, the idea of installing wind and solar electricity on a worldwide scale would have seemed unimaginable. Now, projections show that installations will surpass one terawatt in the next two years, bringing the total to 3.5 terawatts.[233] Renewable energy now supplies over one-third of global electricity, and the trajectory is sharply upward. For a country like India, which is both highly vulnerable to climate change and has significant per-capita energy poverty, the expansion of green technology is simultaneously a climate imperative and a development opportunity.

B. Public Health Benefits

A number of Indian cities, including Delhi and Kolkata, rank high on international pollution indexes, making air pollution a major cause of early mortality in the country. The replacement of coal-fired power and combustion-engine vehicles with renewable energy and electric transport would dramatically reduce ambient concentrations of particulate matter, nitrogen oxides, and sulphur dioxide - yielding enormous public health dividends. This is more than just a policy goal; it is a legally enforceable entitlement due to the connection between Article 21 and the right to breathe clean air.

C. Energy Security

India spends hundreds of billions of dollars annually on fossil fuel imports, creating chronic current account deficits and strategic vulnerabilities. Green technology, particularly solar and wind, draws on domestic resources that cannot be embargoed or price-manipulated by foreign suppliers. A nation that generates its energy from sunlight and wind is a nation less susceptible to geopolitical coercion. The Supreme Court in Ranjitsinh implicitly acknowledged this dimension when it reasoned that renewable energy investment was necessary to combat 'climate inequality.'

D. Employment and Economic Growth

More and more people are finding work in the renewable energy industry. Solar installation, wind turbine maintenance, energy storage manufacturing, and green construction generate jobs across urban and rural geographies. According to the International Renewable Energy Agency, more than 13.7 million people are employed by the renewable energy industry worldwide, with India being one of the areas that is seeing the most rapid growth. Green technology investments also stimulate supply chain development, research and development activity, and export opportunities.

E. Constitutional Compliance

Spending money on environmentally friendly technologies is not only the right thing to do, but it's also mandated by the constitution. To preserve and enhance the environment, the State is obligated to do so by Article 48A, while people are obligated to do so by Article 51A(g). The Sustainable Development Goals adopted in 2015, with their focus on affordable clean energy (SDG 7), sustainable cities (SDG 11), climate action (SDG 13), and responsible consumption

[230]Virender Gaur v. State of Haryana, (1995) 2 SCC 577.
[231]Murli S. Deora v. Union of India, AIR 2002 SC 40.
[232]T.N. Godavarman Thirumulpad v. Union of India, (1996) 9 SCR 982.
[233]S&P Global Commodity Insights, 'Top 10 Trends in Clean Energy Technology in 2024', January 22, 2024.

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(SDG 12), align perfectly with India's constitutional commitments.[234]

VI. CHALLENGES IN THE PATH OF GREEN TECHNOLOGY

Despite dramatic cost reductions in solar and wind generation, the upfront capital costs of deploying green technology at scale remain formidable, particularly for developing economies and small enterprises. Green hydrogen, carbon capture, and offshore wind remain significantly more expensive than their fossil alternatives, limiting their near-term scalability without sustained public subsidy or innovative financing mechanisms. Solar panels don't produce electricity during the night, and wind turbines can't provide power regardless of the wind speed, hence renewable energy sources are inherently unstable. Without adequate energy storage infrastructure and smart grid capabilities, large shares of renewable energy in the power mix can create reliability problems. India's grid infrastructure, particularly in rural areas, requires substantial modernisation to accommodate decentralised renewable generation. On the institutional side, India's environmental regulatory architecture is characterised by overlapping jurisdictions, understaffed agencies, and inconsistent enforcement. When it comes to enforcing environmental regulations, the Central Pollution Control Board and the State Pollution Control Board, which were set up under the Water Act of 1974 and the Air Act of 1981, respectively, often fall short due to a lack of funding, expertise, and political autonomy.[235][236] The proliferation of notifications, exemptions, and amendments to the Environmental Impact Assessment regime has diluted rather than strengthened regulatory rigour. The 2023 amendment to the Forest Conservation Act, widely criticised by experts, excluded large patches of forest from its protective ambit — directly in tension with the constitutional mandate of Article 48A. Apart from that, Fossil fuel industries, and the political and economic interests associated with them, represent powerful constituencies resistant to the green transition. Litigation challenging renewable energy projects, delays in environmental clearances, and lobbying against clean energy policy are all manifestations of this resistance. A dynamic that persists in hindering the transition to green technology is the repeated sacrificial offering of public interest in environmental preservation to private interests, as pointed out by the Supreme Court in the Bangalore Medical Trust case. In addition to that, Large-scale green energy projects — solar parks, wind farms, transmission corridors — require land, and land acquisition has historically been a site of social conflict in India. Communities displaced by projects, often tribal or rural poor, may find themselves bearing the costs of a green transition from which they receive little benefit. The constitutional imperatives of Article 21 and the sustainable development framework demand that the transition be just, inclusive, and attentive to the rights of the most vulnerable. Paradoxically, the expansion of environmental constitutional rights can itself create uncertainty for green technology investors. As the Ranjitsinh judgment illustrated, even renewable energy projects can face constitutional challenges where they threaten endangered species or ecologically sensitive areas. The absence of a comprehensive national climate law, combining emissions targets, sectoral roadmaps, and transition finance mechanisms, creates legal uncertainty that complicates long-term investment decisions.

VII. COMPARATIVE GLOBAL MODELS: HOW OTHER NATIONS APPROACH GREEN TECHNOLOGY

A. The European Union: The Green Deal and Legislative Framework

Launched in 2019, the European Green Deal lays out the world's most extensive legal framework for green technologies. Its declared goal is to make Europe the first continent to

[234]United Nations, 'Transforming Our World: The 2030 Agenda for Sustainable Development', September 25, 2015.

[235]The Water (Prevention and Control of Pollution) Act, 1974.

[236]The Air (Prevention and Control of Pollution) Act, 1981.

achieve carbon neutrality by 2050.[237] Accompanying the Green Deal is a robust legislative package that includes the following: the European Climate Law, which solidifies the goal of reaching net-zero emissions by 2050; the Fit for 55 package, which aims to reduce emissions by 55% from 1990 levels by 2030; the Renewable Energy Directive, which sets a binding target of 42.5% renewable energy by 2030; and the Carbon Border Adjustment Mechanism, which imposes a carbon price on imports from countries without comparable climate ambition.

One unique aspect of the European Union's strategy is the way it combines industrial policy with climate regulation. Reducing reliance on Chinese supply chains and speeding up decarbonization are the goals of the Net Zero Industry Act and the Critical Raw Materials Act, which aim to increase European manufacturing capacity in solar panels, batteries, wind turbines, and clean hydrogen. The EU AI Act, which came into force in August 2024, explicitly integrates sustainability considerations into the governance of artificial intelligence — recognising that digital technologies can either support or undermine the green transition.

B. Germany: Energiewende and the Constitutional Dimension

Germany's Energiewende — literally 'energy transition' — represents the world's most ambitious national programme for the phased elimination of both nuclear energy and fossil fuels in favour of renewables and energy efficiency.[238] In comparison to 1990 levels, Germany plans to cut emissions by 65% by 2030 and 88% by 2040. In a historic ruling from 2021, the German Federal Constitutional Court found that the federal government's climate protection policies were inadequate to safeguard the basic rights of future generations. The court ordered the government to establish more rigorous near-term goals. This judgment — establishing intergenerational equity as a constitutional constraint on climate policy — has direct resonance with India's own developing environmental jurisprudence.

C. China: Industrial Policy and Clean Technology Leadership

China has, in the space of two decades, transformed itself from the world's largest emitter and fossil fuel consumer to the global leader in the manufacture and deployment of clean energy technologies. Through its Made in China 2025 strategy, which included green energy technology among its priority sectors, China achieved global dominance in solar panel manufacturing, battery production, and electric vehicle technology.[239] Chinese companies and government entities have invested over $220 billion in overseas clean technology manufacturing since 2022 — comparable in scale to the Marshall Plan — and these investments and exports are estimated to have reduced global emissions by more than 1 percent in 2024 alone. Before 2030, China plans to attain peak carbon emissions, and by 2060, the country will have achieved carbon neutrality.

D. United States of America: The Inflation Reduction Act

The Inflation Reduction Act of 2022 is the biggest climate investment ever made by the US, with $370 billion earmarked over ten years for green energy tax credits, industrial incentives, and environmental justice initiatives. The IRA's design — using tax incentives rather than mandates — reflects a market-driven approach characteristic of American regulatory philosophy. Its impact has been dramatic: clean energy investment in the US surged to a record $303 billion in 2023, with solar and battery manufacturing experiencing a particular boom.

E. Japan and South Korea: Technology Initiatives and Innovation Strategies

Japan's Green Innovation Fund, capitalised at 2 trillion yen (approximately $15

[237]European Commission, 'The European Green Deal', COM(2019) 640 final, Brussels, 2019.

[238]Springer Nature, 'Strategies toward Carbon Neutrality: Comparative Analysis of China, USA, and Germany', Carbon Neutral Systems, April 2025.

[239]M.C. Mehta v. Union of India (Taj Trapezium Matter), [1997] 2 SCC 353.

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billion), supports research and demonstration projects in offshore wind, ammonia fuel, and green hydrogen. When it comes to fuel cell automobiles and stationary power production, Japan was an early adopter of the technology. As a plan for environmental improvement and economic recovery after the epidemic, South Korea's Green New Deal allots substantial public funding to green energy, green buildings, and green transportation infrastructure.

F. Nordic Countries: Policy Leadership and Performance

The Nordic countries — Norway, Denmark, Sweden, and Finland — consistently lead global rankings for environmental performance. Norway generates over 90% of its electricity from hydropower and is the world's largest per-capita market for electric vehicles. Denmark generates over 50% of its electricity from wind power. Sweden has legislated a target of zero net emissions by 2045. These countries demonstrate that ambitious targets, consistent long-term policy, and the absence of regulatory uncertainty can drive remarkable transitions.

VIII. RECENT TRENDS AND THE ROAD AHEAD

A. Constitutionalisation of Climate Rights – A Global Wave

The most significant trend in Indian and global environmental law is the constitutionalisation of climate rights — the recognition that the right to a stable climate and protection from its adverse effects is a fundamental right, not merely a policy preference. India's 2024 Ranjitsinh decision is part of a global wave: courts in the Netherlands, Germany, Pakistan, Colombia, and elsewhere have now recognised constitutional climate rights. This trend will have significant implications for the pace and ambition of India's green technology transition, as it subjects government inaction to judicial review on constitutional rather than merely administrative law grounds.

B. A Significant Development Green Hydrogen and Next-Generation

The production of green hydrogen, which is achieved by the electrolysis of water using renewable power, is quickly becoming an essential strategy for reducing carbon emissions in industries such as cement, steel, shipping, and aviation. India's National Green Hydrogen Mission, with a target of producing five million metric tonnes per year by 2030, positions the country to be a significant producer and exporter. Advances in battery technology, including solid-state batteries and the organic redox flow batteries developed at MIT, are extending storage duration and reducing costs, solving renewable energy's intermittency challenge.

C. Artificial Intelligence, Internet of Things and the Digital Green Transition

The digital green transition, the internet of things (IoT), and artificial intelligence (AI) are revolutionizing modern civilization by boosting efficiency, taking sustainability into positive consideration, and introducing new technologies. They are transforming environmental monitoring and management. AI-powered satellite imagery can detect illegal deforestation, industrial emissions, and ocean plastic in near real-time. Smart grids with AI-optimised demand response can dramatically improve grid stability and efficiency. AI helps industries make smarter decisions through data analysis, automation, and predictive technologies[240]

In 2024, advanced AI systems began to be deployed for predictive maintenance of renewable energy infrastructure, reducing downtime and extending asset lifespans. The National Green Tribunal and environmental regulators are beginning to leverage technology for compliance monitoring."

[240] World Economic Forum, *AI, IoT and the Future of Digital Transformation*, 2022.

D. Carbon Markets and Environmental Financing

India launched its Carbon Credit Trading Scheme in 2023, establishing a framework for domestic carbon pricing that will create financial incentives for emissions reduction and green technology adoption across industries. Carbon markets, when properly designed and regulated, can channel capital from high-emission to low-emission activities more efficiently than command-and-control regulation alone. For India's market-based environmental instruments, the Perform, Achieve, and Trade initiative for industrial energy efficiency serves as an example.

E. NGT Galvanisation and Environmental Governance

An essential institution for environmental justice, the National Green Tribunal combines judicial power with technical knowledge. It was founded under the National Green Tribunal Act of 2010.[241] The NGT's 2024 orders, including the repeated stays on construction in Shimla's green belts and its oversight of industrial pollution cases, demonstrate its continuing relevance. The institutionalisation of the Central Empowered Committee by Supreme Court order in 2023 strengthened another pillar of environmental governance.[242]

F. India's National Action Plan on Climate Change and Mission-Based Approach

In 2008, India unveiled its National Action Plan on Climate Change, which outlined eight national missions to combat the warming planet. These missions included solar power, energy efficiency, water conservation, sustainable agriculture, the Himalayan ecosystem, Green India, or climate change strategy.[243] The subsequent scaling up of the International Solar Alliance — India's diplomatic initiative to mobilise solar energy investment globally — reflects a recognition that India's green technology ambitions require international partnership as well as domestic action.

IX. CONCLUSION

The great paradox of our time is that technology, which drove the environmental crisis, must now lead the environmental recovery. Green technology is not a luxury for wealthy nations; it is a survival strategy for a planet approaching its ecological limits. For India — a nation of 1.4 billion people with a constitutional commitment to environmental protection, a growing renewable energy sector, and an ambitious but uneven regulatory framework — the green technology transition is both an opportunity and an obligation.

The constitutional case for green technology is unambiguous. Articles 21, 48A, 51A(g), 47, and 14 together create a legal architecture that demands environmental protection as a matter of fundamental right and constitutional duty. The Supreme Court has, across four decades of activist jurisprudence, transformed these provisions from parchment promises into enforceable rights. Recognizing freedom from the repercussions of climate change as a basic right, the most recent and ambitious manifestation of this constitutional promise is the 2024 Ranjitsinh judgment.

The global experience is instructive. The European Union's Green Deal demonstrates that comprehensive legislative frameworks can drive transformative change. Germany's constitutional jurisprudence on intergenerational equity provides a model for India's courts. China's industrial policy leadership shows what sustained state commitment to green technology can achieve. The Nordic countries demonstrate that ambitious targets, consistently pursued, deliver results.

Climate action, waste management, biodiversity protection, and pollution control are some of the

[241]National Green Tribunal Act, 2010.
[242]Bar and Bench, 'Important Environmental Law Orders and Judgments Passed in 2024', January 17, 2025.
[243]National Action Plan on Climate Change, Government of India, 2008.

environmental programs and policies that India is now examining and implementing. Some of the most important recent developments as an example are, New Solid Waste Management Rules, 2026 with Stronger penalties and better regulation for urban and rural waste handling. The governance is also positively thinking and acting on Updated Climate Commitments (NDCs for 2035). Marine Pollution Rules are currently in the pipeline. There is also a proposal on Biodiversity Bill that would be beyond territorial/State jurisdictions; Green Budgeting Initiatives are already been taken. River Conservation Policies have been chalked out.

The challenges, however, are real - capital costs, grid infrastructure, regulatory capacity, and the political economy of incumbency - but they are not beyond control. What they require is precisely the Constitution safeguard: a state committed to improving the environment, citizens who at the same time, also have to perform their duty to protect it, and institutions strong enough to hold both to account. Green technology, at its best, is not merely an economic proposition, It is the technological embodiment of the constitutional guarantee of a dignified life for all Indian citizens, which ensures both environmental sustainability and sustainable development for generations to come. Those generations will be able to appreciate how our own were sensitive and compassionate in carrying out their generational duties.

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