TRANSFORMING THE INDUSTRIAL REVOLUTION: A VISION FOR TECH-BASED SOLUTIONS FOR CLIMATE CRISIS

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Abstract

The society has undergone a significant transformation, transitioning from reliance on farms, villages, and feudalism to embracing the advancements of modern technologies in the last few years. Over the past half a century, there has been a substantial increase in the consumption of fossil fuels, accounting for eight times the amount used in the pre-industrial era. Consequently, these additional greenhouse gases produced by anthropogenic activities that emerged during the post-industrialisation period are adversely affecting the environment. This research takes an exploratory approach to understanding how the climate crisis, largely generated by the Industrial Revolution, can be mitigated through technological innovation under the principles of ecological modernisation. While doing so, it explores how, under the aegis of ecological modernisation, technologies like carbon capture and storage, low-carbon energy production, and nuclear energy present feasible solutions to the increased reliance on fossil fuels. The study also analyses the social impact of environmental damage control by incorporating the idea of transitioning to a circular economy which has not been explored in other studies under the ambit of ecological modernisation.

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Introduction

Climate change has emerged as a twin crisis from the combination of both natural factors and anthropogenic activities. Since the Industrial Revolution, dating back to the 18th century, human activities have contributed immensely to the rising atmospheric carbon dioxide (CO_2) by around 50 per cent. Before the Industrial Revolution, the total atmospheric carbon dioxide was recorded at 280 parts per million (ppm) or less.[1] However, as of May 2023, the CO_2 levels have reached 420 ppm.[2] Societies have transformed from rural agrarian and pastoral economies to the advanced use of modern technologies. The latter was facilitated by the utilisation of coal, oil, and natural gas which tore the environment into fragments. Thus, the consumption of fossil fuels over the past half a century has increased eight-fold since 1950 (i.e., the pre-industrial era).[3] However, the demand and reliance have shifted towards a combination of oil and gas rather than just being contingent on coal. Most of the economies that are flourishing in the world today are developed based on coal, oil, gas, and minerals. The utilisation of these fossil fuels (coal, oil, and gas) has worsened the current climatic conditions because the CO_2 produced by the burning of fossil fuels warms the climate. The Intergovernmental Panel on Climate Change (IPCC) noted that the burning of fossil fuels—human activity—releases greenhouse gases (GHGs) and traps heat in the atmosphere, leading to warming of the atmosphere.[4] This leads to the deduction that the additional GHGs that are produced by the anthropogenic activities—that have emerged in the post-industrialisation scenario are adversely affecting the environment. This research employs an exploratory approach to understanding how climate crises, generated largely by the Industrial Revolution, can be mitigated using technological innovation under the aegis of ecological modernisation.

Theoretical Framework

The research uses the theoretical framework of ecological modernisation. The inception of the ecological modernisation theory can be traced back to the early 1980s, primarily within a selected cluster of countries in western Europe, specifically Germany, the Netherlands, and the United Kingdom (UK). Joseph Huber, a German sociologist was the founding father of this theory.[5] Numerous present-day environmental social scientists and commentators propose that a significant shift took place during the 1980s, which further eroded the foundations of sustenance in Western industrial societies. The famous Brundtland Report is widely viewed as formalising that revolutionary process, which was accompanied by several other historical events, most notably, the 1992 United Nations Conference on Environment and Development (UNCED).[6] While there is considerable agreement about this change, the following interpretations have evolved:

(i) The nature of the alteration;
(ii) The individuals and initiatives responsible for fostering innovations in societies' interactions with the natural environment;
(iii) The extent to which environmental improvements reflect evolving environmental ideologies and discourses; and
(iv) the social and geographic distribution of these changes.

Martin Janicke in his paper published in 2002, *The Political System's Capacity for Environmental Policy: The Framework for Comparison*, deduced that a multitude of social scientists have conducted analyses concerning various aspects of this shift, exploring topics such as the evolving role of the nation-state in environmental protection[7] and the involvement of social movements in advocating for environmental concerns, especially with regards to economic actors.[8] However, more comprehensive explanations for the ongoing transformations in environmental practices, discourses, and institutions remain rather scarce. Among these efforts, a growing collection of publications has emerged under the umbrella term of 'ecological modernisation'. Scholars from diverse disciplines worldwide have dedicated nearly two decades to developing and scrutinising this body of work.

As an evolving school of thought, ecological modernisation can be classified into three stages from inception to development to maturation (up to some extent). The initial phase of this environmental discourse exhibited a notable emphasis on the significance of technological innovation, a critical perspective concerning the role of the state and a bias favouring market-driven solutions.[9] In contrast, the subsequent phase, spanning from the late 1980s to the mid-1990s, adopted a more balanced approach, acknowledging the roles of technological innovation, the state, and the market while highlighting the influence of institutional and cultural dynamics.[10] This shift in thinking was exemplified by the *Brundtland Report* on the common future, which incorporated these emerging perspectives into the overarching principles that recognised the necessity of concerted socioeconomic and cultural changes on an international scale for long-term environmental preservation.[11] Additionally, Agenda 21 of the United Nations Conference on Environment & Development (UNCED) 1992 served as a codified framework, outlining the processes through which such changes could be achieved.[12]

In the current, i.e., the third stage of the environmental discourse, the focus has expanded to encompass the role of consumption patterns and global processes within the international arena. Environmental challenges are now conceptualised as necessitating (preventative) social, technical, and economic reforms, with increasing recognition of the importance of market dynamics and economic agents. Consequently, the nation-state has transformed into more decentralised and consensual modes of governance, reflecting the characteristics of political modernisation.[13] Furthermore, social movements have adjusted their roles to prioritise the advocacy of reform ideologies over confrontation with the state, while intergenerational solidarity towards environmental protection is assumed as a guiding principle.

Besides the features of the ecological modernisation theory, one facet that it gathers criticism for is that it builds on green capitalism. Green capitalism is defined as an approach that a free market or a neoliberal economy—that is environmentally conscious—is the best means to mitigate anthropogenic climate change.[14] Two notions of market economy follow in this regard. The first argument contends that climate change is a market failure, with greenhouse gas producers, mainly the countries from the global north, avoiding global consequences while impacting regions that are not directly responsible for emissions.[15] In this view, it provides three solutions: carbon pricing/trading, technological innovation towards low-carbon, and incentive/disincentive to regulate market behaviour. The second argument is that a form of environmentalism within the neoliberal framework, where economic growth in the future, is propelled by technological innovation. They acknowledge human-caused environmental impacts, including climate change, but believe that a market economy driven by innovation and entrepreneurship is the key to reversing these effects while sustaining the economic growth that has benefited nations and individuals since the Industrial Revolution.[16]

Nonetheless, in its true sense, the concept of green capitalism is characterised by its capacity to integrate and assimilate ecological considerations into the mechanisms of capital accumulation.[17] This concept further advances the idea of 'green spirals', wherein the development and adoption of environmentally sustainable infrastructure and energy technologies give rise to novel markets. These emerging markets, in turn, stimulate ongoing technological advancements. These interconnected cycles of innovation and market creation serve as the foundation for policy frameworks, both in advanced industrialised nations and developing countries.[18] Importantly, they can serve as catalysts for enhanced productivity and increased production capacity.

This research is largely based on the third stage of ecological modernisation that deals with innovation and technology to mitigate the climate effects with regard to including social and economic reforms and considers green capitalism as a subject which is out of the scope of this research. The paper also integrates the core hypothesis of ecological modernisation, i.e., the production processes are designed and manufactured keeping in mind the ecological consciousness.

Background

Throughout the vast majority of human civilisation, the primary sources of energy were limited to simple, rudimentary forms, including the utilisation of human and animal muscle power, as well as burning biomass, such as wood or crops. The Industrial Revolution, however, served as a transformative turning point in history, as it introduced an entirely new source of energy: fossil fuels. The emergence of fossil fuel energy can be credited with catalysing significant advancements across multiple sectors, including technological, social, economic, and developmental domains, leading to unprecedented progress and growth in various spheres of human life. The estimates of global and national fossil CO_2 emissions cover the release of CO_2 resulting from various activities involving fossil fuels. These activities include combustion (such as transportation and heating) as well as chemical oxidation (such as carbon anode decomposition in aluminium refining).

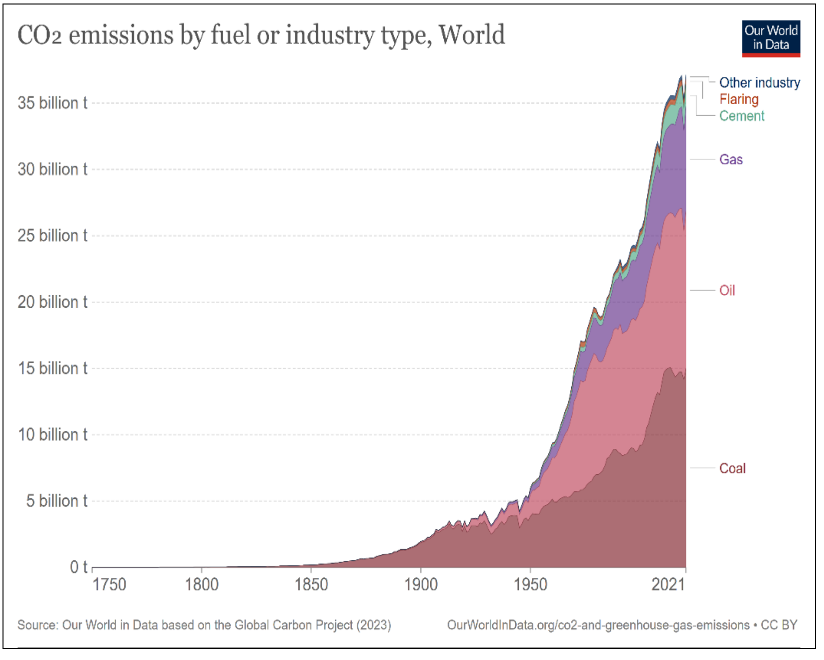
Data suggests that the seeds sown by the Industrial Revolution are reaping into what we call an existential threat today, i.e., climate change. At the time of the British Industrial Revolution, coal was considered of the highest value because of its ability to provide resourceful fuel that would in return transform iron ore into iron, followed by steam engine followed by electricity. To expand further, known as the Dark Satanic Mills, the cotton manufacturing industry was revolutionised by the coal that powered the machinery. It then gave birth to the Boulton and Watt Rotative Steam Engine in 1785, the first of its kind that was independent of wind, water, and muscle, reducing the need to hire labour.[19] Resultantly, these steamships and railways trans-bounded British products across the globe and unleashed the potential of the British export market, as the steamships and railways saved the time in which coal was bought into factories. During this era of coal supremacy as a primary fuel source, it not only powered engines that extracted water from coal mines located in hard-to-reach places but also remained a crucial component even after steel replaced iron as the main building material. The transportation sector experienced significant improvements with the advent of advanced steamships and locomotives that eventually led to the decline of older modes of transport like canal boats, sailing ships, and stagecoaches. In due course, the British locomotives, steamships, rails, and coal themselves became highly sought-after exports as other countries tried to emulate Britain's prosperity. In this manner, coal paved its way through the historic first Industrial Revolution, boosting the British economy and making it a workshop of the world.

Linkage: Industrial Revolution and Climate Crisis

In 1896, Svante Arrhenius, a Swedish chemist, predicted the changing climate and attributed it to human beings. He described the warming of the atmosphere as a phenomenon caused by the excessive extraction of fossil fuels by the industry.[20] However, his scientific claims were negated by the mainstream scientific community which regarded the phenomenon as a slow-onset process and something unlikely to be caused by human beings. By the 1950s and the 1960s, with the advent of enhanced measuring instruments for long-wave radiation, scientists were able to provide empirical evidence supporting Arrhenius's theory.[21] Concurrently, studies conducted during that period also validated the consistent increase in carbon dioxide levels year after year. Thus, it was then deduced that there exists an unequivocal link between coal and climate change and most of the environmental degradation is caused by the use of coal. However, the linkage of the inception of the climate crisis with the onset of the Industrial Revolution can be understood through the following graph.[22]

Figure 1

CO_2 Emissions by Fuel or Industry Type



Source: Global Carbon Project (2023)

Figure 1 above shows a linear growth in carbon dioxide emissions with the beginning of the Industrial Revolution. The use of coal began in 1750, but from 1850 onwards— with the advent of the steam engine— coal energy was utilised in a more effective manner which made the emission have a more gruesome effect.

The excess use of coal produces emissions into the atmosphere, including but not limited to carbon dioxide (CO_2), a major greenhouse gas; sulfur dioxide (SO_2), a contributor of acid rain causing respiratory illness; and nitrogen oxides (NOx), a major contributor of smog, haze causing lung diseases, mercury, fly ash and bottom ash known as the residues left during the combustion of coal.[23]

In essence, fossil fuels have been identified as primary contributors to climate change and their impact is predominantly long-term and of a global magnitude. Excess carbon dioxide in the atmosphere contributes to a warming impact that surpasses natural temperature limitations, resulting in a slew of negative repercussions such as droughts, sea-level rise, flooding, severe weather patterns, and species extinction. The intensity of these effects is directly proportional to the quantity of CO_2 emitted, especially from coal-fired power plants, emphasising the critical significance of shifting to more sustainable energy sources.

Exploitation by Global Capitalist Chains

The first step towards reversing the utilisation of coal is to understand its entrenchment in the first place. According to data recorded in 2020, the largest coal reserves in the world are concentrated in the United States, Russia, Australia, and China accounting for a billion tons.[24] At the UN Climate Change Conference in Glasgow, (Cop26), the debate followed by that of limiting the global temperature to pre-industrial level, i.e., below 2°C, was dovetailed with the provision of phasing out coal. This debate was met with resentment from India and China who ultimately contested for altering the language from ‘phase-out to phase-down’.[25] On that note, China’s coal production stands at 50.7 per cent, which is more than half the global production combined.[26] Thus, despite the pledges at various UN and climate forums, world-leading companies are investing in new plans to expand their use of oil and gas. Since Russia invaded Ukraine in February 2022, Western nations have implemented sanctions targeting the Russian energy sector. As a consequence, the International Energy Agency's (IEA) Stated Policies Scenario (STEPS), which represents the status quo, now anticipates a decrease of approximately 20 per cent in Russian hydrocarbon production by 2030 compared to 2021 levels. This is in contrast to the IEA's previous projection, made last year, which foresaw a four per cent increase in Russian oil production and a 13 per cent increase in gas production during the same timeframe.[27]

In a noteworthy development, the IEA's annual World Energy Outlook predicts that global fossil fuel usage will peak before 2030 across all scenarios, even without additional climate policies.[28] This shift can partly be attributed to the ongoing energy crisis, which has exposed the economic risks associated with heavy reliance on fossil fuels. According to a recent research conducted by Global Witness and Oil Change International, it is projected that the world's largest oil and gas companies, including Shell, Exxon, and Gazprom, will allocate a substantial amount of €857 billion towards the development of new oil and gas fields by the year 2030. This expenditure is expected to escalate further, reaching a staggering sum of €1.4 trillion by 2040.[29] The release of this new analysis coincided closely with UN Secretary-General Antonio Guterres' statement made just a week prior, wherein he referred to investing in new oil and gas as both “morally and economically misguided.”[30]

It is noteworthy that the situation has only exacerbated over the years. This year, COP28 will be hosted in the UAE, and Sultan al-Jaber will preside over the succeeding rounds of climate talks. The president-designate is the Chief Executive Officer of Abu Dhabi National Oil Co., responsible for pumping 4 million barrels of crude every day, with hopes to expand it to 5 million daily.[31] Additionally, advancements in land restoration techniques can help rejuvenate ecosystems that have been harmed or degraded due to historical exploitation. Reforestation initiatives, for example, can help restore biodiversity and combat deforestation, which has been a common consequence of colonial practices. By utilising technology, such as remote sensing and Artificial Intelligence (AI), we can better monitor and manage these restoration efforts to maximise their effectiveness. The United Arab Emirates (UAE) holds a position among the top ten oil-producing nations globally. As per the Organisation of Petroleum Exporting Countries (OPEC), the UAE's state oil company, Adnoc, extracted approximately 2.7 million barrels of oil per day in 2021. According to a United Nations assessment conducted last year, the current policies of various countries are projected to result in an 11 per cent increase in emissions by 2030 compared to 2010 levels. However, scientists insist that a significant reduction of nearly 43 per cent from 2019 levels is necessary to achieve the goal of limiting the temperature increase to 1.5 degrees Celsius above pre-industrial levels.[32] Climate activists and advocates are concerned that such kind of initiatives could lead to green washing by oil and gas companies that would keep using fossil fuels and the actionable plan on climate change would get lost somewhere.

Reversing Historical Emissions

The ecological problem can be traced back to the colonial problem, which emerged from the historical process of colonisation. Colonialism has long been intertwined with nature, as it involved the invasion and domination of indigenous lands, often accompanied by the commodification of natural resources. To reverse the historical emissions and address the ecological challenges, technology can play a crucial role as mentioned in the theory of ecological modernisation. Advancements in various fields have provided us with tools and opportunities to mitigate the negative impacts of colonisation and work towards a more sustainable future. The sixth Intergovernmental Panel on Climate Change (IPCC) report emphasises the urgent need for climate action. To begin addressing the issue, we should prioritise reducing the levels of greenhouse gases, particularly carbon dioxide (CO_2), in the atmosphere.[33]According to the report, there are two main approaches to lowering CO_2 atmospheric concentrations. Firstly, we must actively work on reducing our CO_2 emissions, which arise from activities like burning fossil fuels for energy, agriculture, transportation, and land-use changes such as deforestation. Secondly, we should explore technological innovations like carbon capture methods that involve removing CO_2 from the atmosphere. To make a substantial difference, it is crucial to focus on both solutions simultaneously.

One crucial aspect involves the development of renewable energy technologies. We can drastically cut carbon emissions and alleviate environmental deterioration caused by previous emissions by switching from fossil fuels to clean and renewable energy sources such as solar, wind, and hydroelectric power. Adopting energy-efficient technologies and practices can help us accelerate our attempts to reverse the environmental costs of colonialism. Furthermore, technology can facilitate practices for sustainable agricultural. Precision farming techniques, for instance, can optimise resource usage, reduce chemical inputs, and minimise the ecological footprint of agriculture. Applying innovative solutions like vertical farming and hydroponics can also help meet food demands without compromising natural ecosystems.

In essence, leveraging technology allows us to address the historical emissions caused by colonial practices. By embracing renewable energy, land restoration techniques, and sustainable agricultural practices, we can address the ecological consequences of colonisation and pave the way for a more harmonious relationship with nature. Some of these examples are listed in the following lines:

Carbon Capture and Storage

Throughout COP27, the imperative for advancing climate action, particularly carbon removal, was of utmost importance. It became evident that, alongside ambitious efforts to reduce emissions, it is essential to actively extract CO_2 from the atmosphere to uphold the mission of sustaining the environment and limiting global warming to 1.5 degrees Celsius. Carbon Removals at COP diligently monitored and reported on initiatives for carbon removal announced during the conference. Additionally, the pavilion facilitated various events and daily briefings, featuring prominent figures and specialists in the field of carbon removal, thereby promoting knowledge exchange and fostering collaboration within this domain.[34] In that context, the Working Group-III of the Intergovernmental Panel on Climate Change (IPCC) published a special report on carbon dioxide capture and storage (CCS).[35] As defined by the report, the CCS technique is a developmental process that involves separating carbon dioxide from all the resources that encompass industry and energy, and its efficiency to achieve an isolation from the atmosphere.

It is significant to note that the primary objective of CO_2 capture is to obtain a concentrated stream of CO_2 at high pressure that can be easily transported to a storage site. However, due to the related energy and other costs, transporting and injecting the gas stream with low quantities of CO_2 is not feasible. As a result, producing a virtually pure CO_2 stream is required for successful transport and storage. Several industrial applications, such as natural gas treatment plants and ammonia manufacturing plants, now operate and entail large-scale CO_2 extraction. Currently, CO_2 removal is mainly employed for purifying other industrial gas streams, and only a few cases utilise it for storage purposes, with most cases resulting in CO_2 emissions to the atmosphere. Capture processes have also been employed to obtain commercially useful amounts of CO_2 from flue gas streams generated by the combustion of coal or natural gas. However, there have been no significant applications of CO_2 capture in large-scale power plants, even those with a capacity of 500 MW, signifying untapped potential.

There are three main approaches to capturing CO_2, depending on the process or power plant application and the type of primary fuel used (coal, natural gas, oil, biomass, or their mixtures):

1. *Post-Combustion Systems:* These systems separate CO_2 from the flue gases produced by combusting the primary fuel in the presence of air. Typically, liquid solvents are used to capture the small fraction of CO_2 (usually 3-15 per cent by volume) in the flue gas stream dominated by nitrogen. Organic solvents like monoethanolamine (MEA) are commonly used in current post-combustion capture systems, especially for modern pulverised coal (PC) or natural gas combined cycle (NGCC) power plants.
2. *Pre-Combustion Systems:* The primary fuel is processed in a reactor with steam, air, or oxygen to generate a mixture mostly composed of carbon monoxide and hydrogen (known as "synthesis gas"). Additional hydrogen is created in a second reactor (a "shift reactor") by reacting carbon monoxide with steam. The resultant hydrogen-CO_2 combination can be separated into separate CO_2 gas hydrogen streams. If CO_2 is stored, hydrogen can be used as a carbon-free energy carrier for power generation and/or heat generation. Although the initial fuel conversion stages in pre-combustion systems are more difficult and expensive than those in post-combustion systems, the large concentrations of CO_2 generated and the high pressures involved in these applications make CO_2 extraction easier. In power plants that use integrated gasification combined cycle (IGCC) technology, pre-combustion systems are commonly used.

3. *Oxy-fuel Combustion Systems:* This method substitutes oxygen for air in the burning of the main fuel, resulting in a flue gas largely consisting of water vapour and CO_2. CO_2 concentrations in the flue gas are high (more than 80 per cent by volume). Cooling and compressing the gas stream removes the water vapour. Oxy-fuel combustion requires the separation of oxygen from air, with most contemporary designs aiming for a purity of 95-99 per cent oxygen. Before CO_2 is transferred for storage, additional treatment to eliminate air contaminants and non-condensed gases may be required. Oxy-fuel combustion systems are now being tested for CO_2 collection in boilers, and they are also being investigated for use in gas turbine systems, however, conceptual designs for both applications are still being developed.

Overall, these different approaches to CO_2 capture cater to various industrial processes and power plant technologies, providing options for effectively capturing and storing CO_2 emissions that could help cater to the rising climate crises.

Nuclear Technology for Net-Zero Transition

Around 75 per cent of global CO_2 emissions stem from energy production and consumption. Among these emissions, approximately 40 per cent are generated by electricity and heat plants. As the global electricity demand is projected to increase in the coming decades, transitioning from fossil fuels to low-carbon electricity generation becomes crucial in significantly reducing emissions and addressing climate change. Nevertheless, decarbonising electricity production by incorporating nuclear power, hydroelectricity, wind, and solar energy represents only the initial phase. Additional measures must be taken to reduce energy-related emissions originating from direct heat production in industrial and residential buildings, as well as transportation. This can be achieved through either electrification, assuming the utilisation of low-carbon technologies for electricity generation, or by substituting fossil fuels with alternative energy sources and clean heat solutions. These alternatives may include clean heat sources and the utilisation of alternative energy carriers such as hydrogen and other synthetic fuels.

Addressing climate change and ensuring energy security are two major global issues that necessitate a total overhaul of the planet's energy infrastructure. Per the 2015 Paris Agreement, countries pledged to reduce their greenhouse gas emissions and maintain the average global temperature well below 2°C to avert catastrophic climate events. If the global average temperature rise is to be kept at or below 1.5°C above pre-industrial levels, a swift transition to a carbon-neutral economy is essential to combat anthropogenic climate change. However, to achieve a carbon-neutral economy, it is imperative to first reduce its dependency on fossil fuels and move towards decarbonisation.

As a wise alternative to the aforementioned, experts propose the use of nuclear power to support the successful transition to a carbon-neutral future. Nuclear energy plants emit no greenhouse gases while in operation, and over their lifetime, they emit roughly the same amount of carbon dioxide-equivalent emissions per unit of electricity as wind energy and one-third of the emissions per unit of electricity as solar energy. Therefore, reducing the dependence on imported fossil fuels for energy consumption. However, despite the growing acknowledgement of nuclear energy's part in meeting national climate objectives, the present market may be unable to generate the amount of nuclear investment required to accomplish net zero ambitions.[36] To reach both energy and climate security goals, public sector funding and the construction of infrastructure will be essential to completely unleash the capability of financial markets. Recently, the use of 'green bonds' has become more common as a financial tool for projects that have a quantifiable environmental or climate impact. This has opened up the chance for governments to secure private sector financing during and after the building process of nuclear projects.

Therefore, the transition to low-carbon energy via the adoption of nuclear power plants is a viable option for mitigating, monitoring and adapting to the impacts of climate change. Many countries have successfully implemented this policy and are achieving substantial results. Ranked in order are Spain (7.1GW), UK (8.9GW), Ukraine (13.1GW), Canada (13.6GW), South Korea (24.5GW), Russia (29.6GW), Japan (32GW), China (50.8GW), France (63.1GW), United States of America (91.5W). [37]

Transitioning to Circular Economy

The circular economy is an innovative framework for production and consumption that emphasises the principles of sharing, leasing, reusing, repairing, refurbishing, and recycling materials and products to extend their life cycle. It aims to minimise waste generation and maximise resource utilisation. By adopting this approach, the circular economy seeks to shift away from the traditional linear economic model, characterised by the take-make-consume-throw-away pattern. One key objective of the circular economy is to reduce waste generation by keeping materials within the economy for as long as possible. Instead of discarding products at the end of their lifecycle, the circular economy promotes recycling, where materials are extracted from these products and reintroduced into production processes. By doing so, the circular economy enables the continual productive use of materials, generating additional value from them.[38] The circular economy represents a paradigm shift from the linear model, which relies on large quantities of inexpensive and readily available materials and energy. In contrast, the circular economy focuses on a more sustainable and resource-efficient approach, prioritising the conservation and reuse of materials over their depletion. It aims to create a regenerative system that not only minimises environmental impacts but also fosters economic growth and resilience.

In March 2022, the Commission unveiled an initial set of measures aimed at expediting the shift towards a circular economy, constituting a pivotal component of the circular economy action plan. The package encompasses a range of proposals, including the enhancement of sustainable products, the empowerment of consumers in facilitating the green transition, an examination of regulations about construction products, and the establishment of a comprehensive strategy on sustainable textiles.

Green Infrastructure

The idea of green infrastructure as part of ecological modernisation deals with the core hypothesis, i.e., the production processes are designed and manufactured keeping in mind the ecological consciousness. Infrastructure plays an important role in the process of attaining net-zero targets but transitioning from grey structures to green ones is a task that requires commitment.

The implementation of eco-design requirements in 2021 alone resulted in €120 billion in savings for consumers and contributed to a 10 per cent decrease in annual energy consumption by the covered products.[39] Eco-design for sustainable products regulation specifically addresses the critical aspect of product design, which accounts for up to 80 per cent of a product's environmental impact throughout its lifecycle and emphasises the importance of energy and resource efficiency in product design.[40]

Conclusion

It is important and appreciable that there has been a transition in environmental policy measures, moving away from the previous approach of ‘react and cure’ towards a new discipline of ‘anticipate and prevent’. However, progress towards prevention is slower than the release of emissions. Technological innovation is paving the path as discussed in this research but some of it still has to be dovetailed with concepts of consumer behaviour. Since climate change does not only need technological care but care on a personal level, a combined effort would collectively lower the impact of it in the future. The four main technological solutions mentioned in this research paper are well-thought-out and well-researched. They pave the way for keeping the 1.5-degree target alive, not just on paper but in reality. The concepts and applications of carbon storage, nuclear technology for energy, and transitioning to a circular economy are the need of the time and countries should start investing in these technologies to create a pathway desirable for keeping the climate crisis mitigated. Nevertheless, the existing literature underscores the urgency of investing in these transformative technologies and aligning them with comprehensive policy frameworks. Governments, businesses, and individuals must collaborate to create an enabling environment that supports the deployment and widespread adoption of these innovations. Furthermore, interdisciplinary research and knowledge exchange are essential for identifying the most effective strategies and ensuring that climate mitigation efforts are both environmentally sound and socially equitable. In conclusion, the existing literature emphasises the need for a proactive and anticipatory approach to environmental policy, supported by technological innovation and behavioural changes. By addressing the root causes of environmental challenges and accelerating the adoption of sustainable practices, we can create a pathway towards mitigating the climate crisis and building a more sustainable future.

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