Net Zero Strategy: Exploring Opportunities, Confronting Challenges for Developing Countries

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Abstract

The Paris Agreement aims to keep global warming well below 2°C, and hence, countries worldwide are re-examining their strategies for attaining net zero goals. The decarbonization vision calls for steps to shift to a low-carbon economy, with a focus on infrastructure compatible with sustainable practices and government agency cooperation. All of these factors have increased the pressure on developing nations to reduce their carbon emissions. Since there isn't a single, globally accepted methodology, nations at both the national and sub-national levels combine a range of methodologies to determine the most favorable pathways. Several projects globally showcase innovative and pioneering low-carbon solutions. This paper aims to analyze prevalent patterns in four sectors, including electricity and heating, transport, manufacturing, and construction, regarding greenhouse gas emissions at the global level. The opportunities identified to reduce greenhouse gas emissions among developing nations, such as promoting the use of renewable sources and nuclear power for energy generation, are crucial. In the transportation sector, electro-fuels, bio-fuels, hydro-fuels, and electric vehicles can substitute for traditional transport methods. We must transform the manufacturing and construction industries by incorporating sustainable measures like carbon capture and enhancing the effective life of equipment. This chapter also considers the challenges associated with successful implementation of these initiatives. Implications, limitations, and scope for future research on the study are furnished towards the end.

Keywords: Net Zero Strategy, Environmental Sustainability, Net Zero Policies, Developing countries, Challenges

11.1 Introduction

Climate change is the foremost environmental issue of the century and one of the most intricate dilemmas facing humanity (Wei et al., 2022). Several climate discussions have been conducted by the global community in order to tackle the issue of climate change. The Paris Agreement set a goal to keep the increase in average global temperature within the range of 1.5°C–2°C (Allen et al., 2018). Even if all the countries that have officially agreed to this deal fulfill their commitments to reduce greenhouse gas emissions (GHG), the global temperature is still projected to increase by more than 3°C compared to preindustrial levels (Olhoff & Christensen, 2020). Just 4.5% of nations have successfully attained carbon neutrality, while the majority of countries are still in the process of planning to accomplish this goal by the years 2050–2070

(Chen et al., 2022). Therefore, achieving a stable atmospheric concentration of greenhouse gases that can support the earth is a challenging and unfinished endeavor requiring contributions from different stakeholders (Singh, Khan et al., 2024). Furthermore, it is likely that emissions will need to be reduced to a point where there is a net reduction in the level of carbon dioxide (CO^2) in the atmosphere after this period. Deep targets encompass all greenhouse gases, including methane (CH^4) and black carbon, which must be reduced by at least 50% by 2050, and nitrous oxide (N_2O), which must be reduced by at least one-third (Bataille et al., 2020).

The Paris Agreement specifies that the implementation of emission reductions should take place within the framework of sustainable development and poverty eradication efforts, while also considering the unique circumstances of each nation (Fay et al., 2015). This involves designing climate policies that encompass the entire economy and specific sectors, with the aim of maximizing the benefits that align with the motives of energy saving, sustainable economic growth, job creation, poverty reduction, maintaining the air and water quality, access to energy, and similar ones (Waisman et al., 2019). Net-zero deep decarbonization can only be achieved by employing policies that are country-specific, including through analysis of the strengths and weaknesses of a nation. It is important to note that achieving net-zero deep decarbonization requires more than just reducing emissions in the short term. It also involves making significant changes to energy, transportation, manufacturing and construction industries, and land use, which are the top greenhouse gas emitting sectors globally as referred to in Figure 1 (Ritchie et al., 2024a), in order to achieve deep reductions in all sectors by mid-century, specifically among developing nations (Bataille et al., 2016; Das & Gosh, 2023; Iyer et al., 2017).

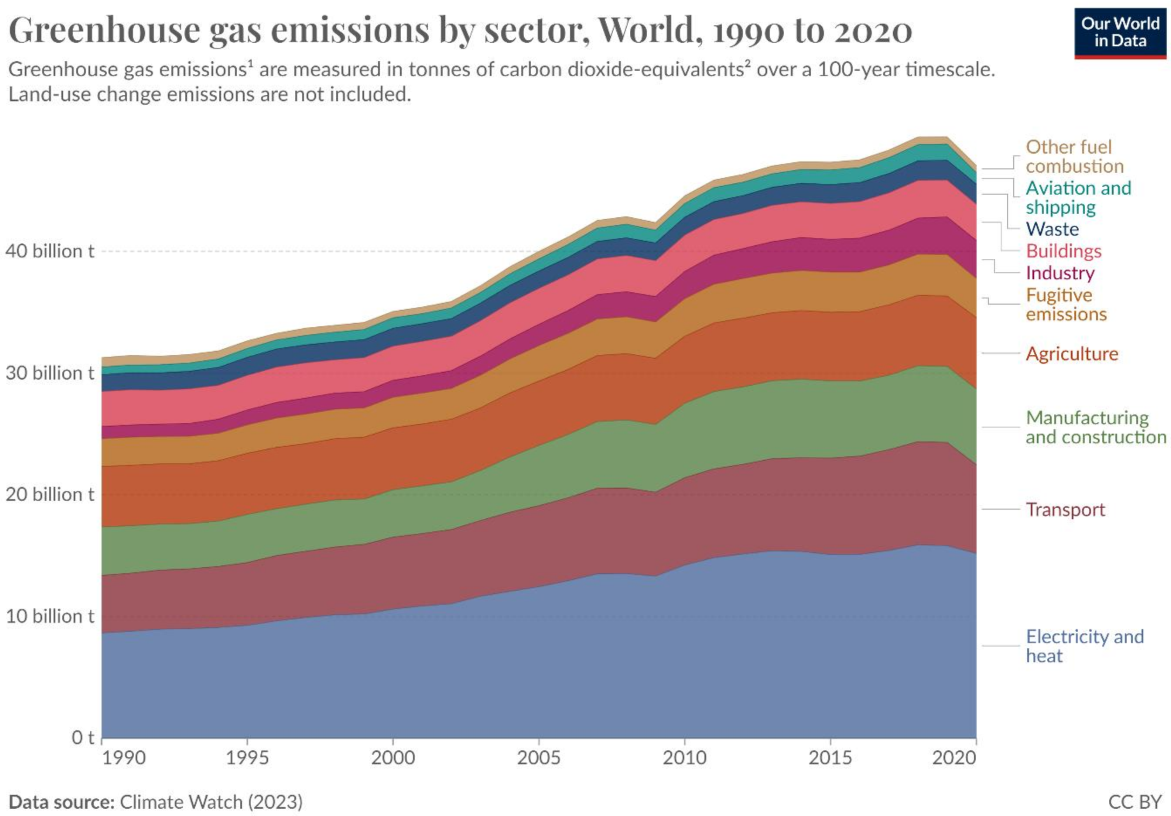

Figure 1. Sector wise greenhouse gas emissions

The United States has allocated approximately $80 billion per year for climate-related expenditures from 2022 to 2027 through several acts, including the Inflation Reduction Act (Carey & Shepard, 2022). These investments cover a wide range of areas, from basic scientific research to the implementation of clean technologies in the commercial sector. The Inflation Reduction Act is projected to allocate over $114 billion towards investments in renewable energy by 2031. This will be accomplished through a range of programs, including government loans, tax credits, and loan guarantees provided to corporations and industrialists. Additionally, tax credits will be offered to end users, including consumers, and grants will be given to governments at the local and state levels. These investments and activities are expected to reduce carbon emissions in the United States by up to 40% by 2030, compared to the levels in 2005. This is not driven by a sense of kindness but rather by an imperative need to achieve global net zero. Finland and Sweden, for instance, have set goals to achieve net-zero GHG emissions by 2035 and 2045, respectively, and then transition to a state of net negativity (Rogelj et al., 2021). The objective of the European Union is not only to realize net-zero emissions but also to follow a framework to strive for net-negative emissions by 2050. Such efforts can offset comparatively lower reductions made by other countries facing more significant technical or political challenges. In addition, the targets must be receptive to being made more stringent.

National governments have framed policies in this direction, but the focus has remained on energy generation rather than diversifying the framework for heating and transportation, where legislation has been less robust. As of 2020, 145 countries have incorporated renewable energy into the power sector through the imposition of regulatory policies. In contrast, 65 nations have implemented similar regulations for the transport sector, while only 22 nations have done so for the heating and cooling sector (Gibb et al., 2022). However, it should be noted that many of these countries have not yet reached their targets because, despite the progress made in the energy sector, several South Asian economies continue to encounter difficulties in obtaining contemporary energy sources in order to strike a harmonious equilibrium between their economies and environment (Guo et al., 2020). Developing countries encounter significant obstacles that impede the implementation of decarbonization measures, including organizational, social, political, and economic issues (Singh, Ravesangar et al., 2024; Virmani et al., 2022). Therefore, difficulties such as financial obstacles, inadequate infrastructure, an incompetent workforce, lock-in effects, and other considerations necessitate context-specific solutions (Das & Ghosh, 2023). In response to these issues, we present a strategic plan for four major sectors aimed at achieving a state of net-zero emissions in the industrial sector by the year 2050. Developing markets and emerging economies that have the ability to produce renewable energy and power are significant contributors to carbon dioxide removal (Godin et al., 2021). That is why the advancements for lowering CO^2 are notably targeted at developing economies by utilizing renewable energy sources, some of which may be exported (Obobisa, 2022).

This chapter aims to identify the status of the top four sectors in terms of greenhouse gas emissions at the global level and discuss the most appropriate measures to lower such emissions, with special reference to developing nations, through an in-depth review of the literature on the subject at hand. Solutions to confront sector-specific challenges are also deliberated in the literature review section. The findings and implications are also provided along with the conclusion. Towards the end, limitations and future research scope are presented.

11.2 Literature Review

11.2.1 Electricity and Heating

Global electricity production has been steadily increasing, with a rise from 76 thousand kWh (kilowatt hour) in 1975 to 179 thousand kWh in 2022 (Statista, 2023). In 2022, coal combustion accounted for almost 35% of electricity production, while natural gas contributed 22%, hydropower contributed 15%, and nuclear power contributed 9%. The remaining electricity generation was derived from sources such as wind, solar, and oil. The proportion of electricity generated by coal has declined from 38% in 2000 to 35% in 2022, which is still very high as compared to other sources (Ritchie et al., 2024b). Hence, there is a need for significant transformations in this sector for increased use of other sources for energy generation, especially renewable sources of energy.

11.2.1a Harnessing the Renewable Energy Sources

The idea of transitioning the worldwide energy system to rely solely on renewable sources has been present for a considerable period. This concept has mainly emerged as a response to concerns about global warming, to eliminate carbon emissions from the energy sector entirely, to meet the worldwide energy demand through the utilization of carbon approaches, and to maintain low prices to ensure that clean and inexpensive energy is available to everyone (Aktar et al. 2020). Additionally, it aims to tackle broader issues such as the depletion of fossil fuel reserves, deterioration of the quality of regional air, and lower availability and fairness in energy distribution. The commercialization of renewable technology has been significantly influenced by decades of successful research and development initiatives. Solar photovoltaic (PV) and wind technologies are becoming the primary sources of new power generation (Gibb et al., 2022) in light of the fact that these technologies will be even more economically viable in the future. Bloomberg New Energy Finance (BNEF) conducted a study that reveals a significant decrease in the actual cost of solar PV modules over the past ten years. The role of research and development in enhancing the usefulness, cost-effectiveness, and dependability of these innovations remains crucial.

In the field of solar PV, research programs should prioritize the reduction of the leveled cost of electricity through advancements in solar cell efficiency and durability, enhanced manufacturing profitability, and decreased reliance on expensive rare earth materials (Renné, 2022). It would have expanded market applications like the integration of PV with agricultural production and the implementation of efficient reuse programs or recycling at the end-of-life in accordance with international standards and protocols. Furthermore, it is crucial to maintain research and development efforts aimed at enhancing grid flexibility, reliability, digitization, and resiliency. So, it can be concluded that it is technically possible to establish a system with 100% renewable energy sources, especially with ongoing advancements in storage systems, energy-saving appliances, innovative grid systems, advanced biofuels, and hydro-fuel cells for transportation sectors that are difficult to electrify. Ongoing advancements, propelled by government and commercial research and development funding, will continue to reduce the expenses associated with solar photovoltaic (PV), concentrated solar power (CSP), and wind technologies (Obobisa, 2022). Nevertheless, there is still a requirement for more robust policy support across national, regional, and municipal levels of government.

11.2.1b Increasing Nuclear Energy generation

As a part of any power system, nuclear power plants (NPPs) offer minimal energy emissions and ensure a reliable energy supply. Electricity generation through nuclear power rose from 2 thousand kWh in 1990 to 2.6 thousand kWh in 2022. But the overall share of energy generated using nuclear power in global power generation declined from 17% in 1990 to 10% in 2022 (Ritchie et al., 2024b; Statista, 2023). Hydropower and geothermal energy, as renewable sources, have limited potential due to the climatic characteristics of a place and rely heavily on weather conditions (Alhusni et al., 2014). Wind and solar energy, like other renewable sources, are subject to discontinuity due to weather conditions, resulting in changes in the supply-demand gap (Mertens, 2022). Advancement of the nuclear program involves evaluating security infrastructure factors that need to be addressed prior to deciding to initiate a nuclear power program.

Nuclear reactors generate excess heat that is not utilized for power generation and must be extracted from the system. Typically, this excess heat is dissipated into the environment through the use of water, which is either discharged into lakes, rivers, or the sea or released into the atmosphere through cooling towers. For many years, several areas have been using excess heat from nuclear power stations to provide heat for buildings and local communities using specialized hot water networks, a practice known as district heating (Chen et al., 2021). Leurent et al. (2018) examined 18 sites where nuclear heat recovery was used for district heating systems, including four locations in EU countries. Currently, the predominant method of hydrogen synthesis is steam methane reforming. This process is highly efficient and necessitates a heat source, which can be generated by the combustion of natural gas, the utilization of renewable electricity, or the utilization of heat from a nuclear reactor. This possibility is a possibility now being investigated by many countries (Värri & Syri, 2019). Similar initiatives may be used in developing nations to harness the full potential of nuclear energy.

11.2.2 Transportation Sector

On a global scale, the transport sector has a share of 16.2% of all GHG emissions, ranking second only to the electricity and heat generation sector (Ritchie et al., 2024a). Hence, there is a need to expedite the shift towards carbon-neutral transportation to decrease the level of emissions in the industry. Incorporations of electric vehicles and alternate fuels are widely established methods across countries to limit the carbon footprints of this sector.

11.2.2a Promoting the Use of Electric Vehicles

Road transportation is a significant contributor to GHG emissions and outdoor air pollution. This type of pollution caused deaths from various health issues such as heart and lung disease, lung cancer, and other respiratory infections (Health Effects Institute, 2019). As a result, the low-emission means of transport have led to a shift from the conventional internal combustion engine to the ones that are powered by battery technology, basically lithium-ion. The use of such batteries is highly prevalent in electric vehicles (EVs). This technology is widely used in EVs due to its reliability, higher energy density, and safety features (Husain, 2021). The policies implemented by national governments are essential in facilitating the development of low-carbon circular economy practices and promoting the use of electric vehicles (Bonsu, 2020). Due to the negative effects on the environment and public health caused by emissions from road traffic, the national governments are strongly advocating for the adoption of electricity as an ultra-low-emission technology (Chen et al., 2022). Electricity has numerous advantages in the transportation sector, including increased efficiency, decreased CO^2 emissions, and enhanced air quality.

Developing nations can learn from the United Kingdom's transition to ultra-low-emission vehicles (ULEVs), which is considered a viable approach for improving air quality by eliminating GHG emissions and enhancing energy savings (Chen et al., 2021). The shift towards electric vehicles will lead to innovation and extensive research and development, as currently, trucks powered by either batteries or hydrogen are being utilized for short-distance trucking. The UK's effort to solidify its position as a global leader in battery technologies and cutting-edge innovation to support the development of automotive batteries for energy savings This initiative is in line with the projects funded by the Faraday Battery Challenge and the UK Battery Industrialization Centre (Chen et al., 2021). Ultimately, it is determined that electrifying the transportation sector is the most effective method for reducing the industry's carbon emissions.

11.2.2b Efficient Use of Alternatives fuels

There is an anticipated rise in the worldwide need for energy in transportation; hence, light-duty vehicles can be easily converted to hydrogen fuel, which is an energy-dense liquid fuel (IEA, 2017). It can be done without significant alterations in performance; however, there can be potential reductions in range and time taken for refuelling the vehicles. It is expected that liquid fuels, due to their high energy density, will continue to be the preferred choice for transportation services even for long- distances, assuming they are accessible (Muratori et al., 2017). Possible choices for such fuels encompass ammonia, alcohols, ethers, and hydrocarbons. For different categories, there are choices available for generating low-carbon or carbon-neutral fuels that may be incorporated into an energy system with zero GHG emissions. Additionally, each of these options can be converted into another using existing thermochemical processes. This improves the cost-effectiveness and safety of transitioning to alternative energy sources in various regions worldwide.

Bio-energy, including biogas and bio-methane projects, remains the predominant choice for investment in low-carbon gas, constituting 40% of the overall investment. They are highly utilized for the reduction of carbon emissions as a substitute for fossil fuels. Prussi et al. (2019) explored the utilization and prospects of biogas as a fuel for transportation throughout the European Union. The study stressed the process of enhancing biogas to bio-methane. By 2030, the consumption of bio-methane in automobiles as a substitute for natural gas is projected to reach 30 billion cubic meters per year. In addition, bio-methane will be utilized for maritime and inland waterway transportation. The use of bio-methane will result in a reduction of roughly 1000 million metric tons (Mt) of greenhouse gas (GHG) emissions by the year 2040. This pertains to the CO^2 emissions due to the use of natural gas as well as the methane emissions that would have resulted from the combustion of fossil fuels (Ghafoori et al., 2022). Due to its identical nature with natural gas, bio-methane is fully compatible with natural gas vehicles, and it can be used without making any changes to the equipment used by end-users or distribution systems.

11.2.3 Manufacturing Industry

The manufacturing industry, together with construction, stands in third place when it comes to GHG emissions (Ritchie et al., 2024a). There are two primary mechanisms of GHG in the manufacturing sector: first, the combustion of fuel to generate heat results in the release of combustion emissions, and second, the conversion of materials into new products leads to the release of industrial process emissions. Manufacturing activities also result in indirect greenhouse gas emissions by utilizing electricity generated from fossil fuels. Nevertheless, policies that target emissions originating from manufacturing have the potential to impact both indirect emissions and direct emissions. In this section, two sectors with high GHG emissions are discussed.

11.2.3a Transforming the Iron and Steel industry

The iron and steel industry (ISI) contributes a significant amount to CO^2 emissions, accounting for around 25% of direct emissions to greenhouse gases worldwide. In 2018, it accounted for around 7% of the total direct emissions (The World Steel Association, 2019). Managerial science can be utilized to efficiently allocate resources and optimize the production of iron and steel, managing issues such as low concentration, high costs, excessive production capacity, and inadequate specialization. To decrease GHG emissions in the industry, it is crucial to improve the efficiency of iron and steel products, curtail the increasing demand, and reduce the overall energy consumption in the production process. These objectives can be accomplished through the replacement of materials, enhancements in design, and the recycling and reutilization of steel. Partial substitution of iron and steel goods with carbon fiber or aluminum alloy can be done to cope with the existing demand (Soares et al., 2017). In industrialized nations, the amount of steel used in commercial buildings is double the necessary amount according to safety requirements in the building industry. However, this excessive use of steel does not enhance the overall service life of the structures. This surplus steel can be conserved for alternative applications (Plocher & Panesar, 2019).

Increasing the production and utilization of lightweight cars while maintaining performance standards would result in a substantial reduction in the demand for steel (Kawajiri et al., 2020). In order to achieve this, one can utilize finite element analysis to optimize the design of the body, resulting in a reduction in steel usage while at the same time preserving the physical characteristics of the main structure (Plocher & Panesar, 2019). The efficiency of production lines and the lifespan of industrial goods can be improved to reduce iron and steel loss in the industrial sector (Li & Hanaoka, 2020). This implies that an organized system for recovering, recycling, and reusing scrap must be established for the ISI. Furthermore, additional assistance should be provided to the recycling industry, and efforts should be made to promote technological advancements in electric arc furnaces (EAF). Concurrently, the percentage of EAF steelmaking could potentially rise to 40–70%, leading to a substantial increase in the electrification rate of this industry and promoting the utilization of renewable energy. It is stated that if all the scrap is successfully recovered during the production of ferrous materials, then the GHG emissions can potentially be decreased up to the level of 60–110 million metric tons by 2030 and 130–170 million metric tons by 2060 (Vercammen et al., 2017). A study highlighted that the Industry 4.0 strategy suggests a substantial integration of information technology into industrial manufacturing processes (Lu et al., 2016). Management approaches that utilize information technology should be implemented in many production procedures to enhance effectiveness, such as EAF, casting, and workshop operations. Consequently, production management systems can be useful to achieve the goals regarding energy conservation and emission reduction.

11.2.3b Adopting Reforms in the Cement Industry

The cement industry has recently attracted the great attention of climate activists and researchers, as it alone accounts for 7-8 percent of direct CO^2 emissions at the global level (Barbhuiya et al., 2024). Cement is widely used in the construction industry due to its versatile, binding, and durable properties. Approximately 40% of the CO^2 emissions produced during the manufacturing of cement come from the use of fossil fuels, while the remaining share results from the process of calcining calcium carbonate (CaCO3), which is commonly found in limestone (Dean et al., 2011). To eliminate process emissions, it is necessary to make significant modifications to the cement production through the installation of carbon-capture technology or changing the materials used during the process (Barker et al., 2009). It is stated that the concentration of CO^2 in cement plants is usually over 30% by volume, which is higher than the concentration of CO^2 in power plants, which ranges from 10 to 15%. This higher concentration makes post-combustion carbon capture more feasible in cement plants. An alternative approach is to utilize oxygen and recycled CO^2 for firing the kiln (Zeman & Lackner, 2006). A significant portion of carbon dioxide emissions generated during cement manufacture is naturally reabsorbed within a timeframe of 50 years as the natural process of carbonation of cement (Xi et al., 2016). Therefore, capturing emissions from cement production might potentially lead to a net reduction in emissions due to the carbonation process of the cement produced.

The carbon pricing process can also be useful, which has two primary approaches: carbon tax and cap-and-trade systems (Carl & Fedor, 2016). In the case of carbon tax, a direct charge is placed on the specific emissions of CO^2 or the amount of carbon present in fossil fuels that are used during the process. It encourages the decrease of emissions by imposing a payment obligation on firms proportional to their emissions. Conversely, the cap-and-trade system establishes a maximum threshold or limit on the overall permissible amount of emissions. The emission permits corresponding to precise quantities of emissions are exchanged in a controlled marketplace (Chen et al., 2020). Gradually, the limit on emissions decreases, leading to a decrease in total emissions. Mission Innovation and Cement Challenge is a global effort that includes the European Commission along with 24 countries with a purpose to collectively drive progress in renewable energy technology (Oberthür et al., 2021). Its main objective is to attain significant decreases in CO^2 emissions resulting from cement manufacturing. The challenge seeks to reduce the industry's substantial impact on GHG emissions by implementing low-carbon and carbon-neutral technology. Developing nations must be made a part of such initiatives to support them in achieving low carbon emissions.

11.2.4 Construction Industry

It is essential in the construction business to implement sustainable measures to address significant material and energy flows and their associated environmental implications. Urban areas have long been recognized as the primary sources of GHG emissions, and this trend is expected to continue growing, thus resulting in more construction. According to a projection, the urban population will exceed 70% of the total global population by the year 2050 (Kadakia & Galea, 2020). Therefore, it is viewed as the need of the hour to strategically design, construct, and manage a building structure or urban area, considering its entire lifespan, in order for it to be a valuable resource for future generations rather than a burdensome legacy.

11.2.4a Replicating Sustainable Design for Cities and Buildings

In order to meet the CO2 emission reduction targets outlined in Paris agreement, just increasing the share of renewable energy sources in for energy generation it is not sufficient. It is also necessary to decrease the usage of energy by setting and attaining aggressive goals for energy efficiency. Nevertheless, the attainment of existing energy and climate goals is contingent upon the decarbonization of cities, given that cities are responsible for almost two thirds of energy consumption as well as GHG emissions (Farga-De-Cal et al., 2021). The objective of decarbonizing cities can be achieved by fostering the development of buildings and areas that produce either no or more energy than they consume, and by reproducing these models to encourage cities to meet their sustainability targets. Several projects in smart cities demonstrate innovative and pioneering approaches, often characterized by their creativity. For instance, smart city initiatives supported by the European Union may be viewed as pioneer projects. There is a REMINING-LOWEX system utilized the heat energy generated from the mine shafts to regulate the temperature of buildings (New et al., 2023). Similarly, the STORM project focuses on enhancing energy efficiency at the district level through the development of a district heating and cooling network controller that utilizes self-learning algorithms. Diverse methodologies are showcased in urban living laboratories, experimental sites, trial runs, and flagship initiatives which can be replicated in developing nations. The objective of this replication method must be to streamline the implementation of sustainable solutions for the cities.

The current trend place greater emphasis on the design phase of new buildings, specifically in relation to energy and GHG emissions which are referred as energy efficient buildings (Uspenskaia et al., 2021). In this initial phase of architectural development of building, it is essential to make important decisions on several aspects such as the selection of materials, arrangement of rooms, utilization of rainwater, incorporation of green areas, choice of energy sources, and the overall compactness of the building. These decisions greatly impact the future performance and the quality of the building. To achieve a comprehensive and unified approach at the building, it is necessary to combine the different needs and functions of each building component within the broader context by utilizing particular tools or tactics (Scherz M et al. 2023) that are designed to address these intricate difficulties. The utilization of a systemic approach in the designing of building model will facilitate the management of complexity and minimize the need for extra effort during the initial design phase. Contractors of construction along with project managers, and building owners should be provided with the tools to organize sustainability criteria, process them in a clear manner, and ensure a comprehensive supervision.

11.2.4b Strategic public procurement (SPP) in Housing Sector

The process of acquiring goods, services, or works by public entities in a deliberate and planned manner to achieve certain objectives is known as strategic public procurement (SPP). SPP can be employed as a sustainable initiative that goes beyond the conventional mode of acquiring normal goods and services for achieving policy-related and societal objectives (de Coninck et al., 2023). By implementing SPP in the former way, governments can effectively tackle this significant issue and achieve sustainable results (George et al., 2024; Patrucco et al., 2017). The housing industry is responsible for around 40% of worldwide CO2 emissions (ICE 2022). In the case of social housing, the owners, either individuals or local governments, should utilize SPP to actively involve local suppliers in the implementation of retrofit programs, the reduction of carbon emissions from the already constructed social houses, and the construction of environmentally friendly homes (Hawkins et al., 2023). This is achieved through various initiatives, including novel ways of competing and collaborative efforts between public and private sector organizations to develop sustainable solutions. Citizens' involvement and support are crucial for decarbonization efforts, extending beyond the participation of construction and material providers (Trischler et al., 2023).

To reduce carbon emissions in the housing sector, it would be beneficial to bring together various stakeholders, such as technicians and builders, to promote the use of innovative renewable heating technology. This approach might be particularly effective in the social housing sector, which is quite large (Hawkins et al., 2023). In addition to contractors, governments can carefully consider engaging business units, employees, functional departments, and all the involved stakeholders (George et al., 2024). Employees can greatly contribute towards achieving net zero goals in general (Bhushan & Singh, 2024). In the case of SPP, they participate in various aspects of the implementation process, including project design, auctioning and bidding, partnering with suppliers as well as end users, project execution, supervision, and control (Patrucco et al., 2023). Social housing is a substantial sector of the housing market, as social housing in the UK accounts for 15% of the country's GHG emissions, according to DBEIS 2021. Within the UK, strategic public procurement plays a crucial role in local governments due to the requirements set forth by the Public Service (Social Value) Act. This act mandates that the public sector must take sustainability factors into account when acquiring goods and services (Selviaridis et al., 2023). Similar acts may be proposed in developing nations to uplift the value of sustainable housing.

11.3 Confronting Challenges in the way of Developing Countries

It is not easy for developing countries to achieve the net zero goals due to several reasons which are discussed as below:

11.3.1 Challenges in Energy and Heating Sector

Lack of policy support and inadequate infrastructure are the most common challenges in the way of switching to complete renewable energy sources. Financing is an additional obstacle that needs to be addressed to achieve the net zero targets. A robust policy framework that encompasses not only the legislature but also infrastructure and funding can resolve this issue. Similarly, the process of setting up a nuclear power plant is in itself very challenging, from the proposal to the approval process (Rahmanta et al., 2023). The legislative process is very cumbersome due to the high risk involved in selecting a location and the possible environmental implications. The foundation of the nuclear program can be made safe and sustainable when established through a legal framework, a special agency for managing the implementation of the entire process, and regulations governing the utilization of nuclear power. These measures would guarantee the secure establishment and functioning of a power plant. To ensure the safety of the of the infrastructure of such plants, there should be ongoing enhancements in multiple areas, including the decommissioning and handling of waste, to guarantee the safety of these stages and prevent any harm to the environment. Locations with a low probability of volcanic, seismic, and tsunami disasters should be preferred to avoid contingencies.

11.3.2 Challenges in Transportation Sector

The shift of the transportation sector towards renewable energy poses significant difficulties, especially when it comes to large-scale, long-distance vehicles and aircraft (Dominković et al., 2018). When comparing trucks with the same range, battery- or electric-powered heavy-duty trucks can transport around 40% less cargo compared to diesel-fueled trucks with internal combustion engines. A study uncovered various challenges related to electric car batteries, such as ethical dilemmas, the over-extraction of raw materials for battery production, the absence of legislation addressing emissions during manufacture, and a limited market for recycled batteries (Bansu, 2020). Wu et al. (2021) examined the challenges and remedies for implementing vehicles running on hydrogen fuel cells across China, highlighting hurdles like inadequate infrastructure, few manufacturers, and safety issues regarding hydrogen fuel. The analysis has shown that a circular economy has the potential to reach net-zero carbon emissions targets by the year 2050. Nevertheless, the concept of a circular economy should not be restricted solely to the repurposing of batteries and recycling of raw materials. Concerns such as reduction of emissions along the value chain, developing sustainable infrastructure, safeguarding the environment, and responsible utilization of natural resources should also be encompassed.

11.3.3 Challenge in Manufacturing Industry

During cement manufacturing it can be difficult to control the gas composition in cement kilns that are not completely sealed, run at extremely high temperatures, and rotate (Zheng et al., 2016). In Paris agreement nations have outlined their obligations in Nationally Determined Contributions (NDCs), to adhere to the same, governments must strategically focus on the cement industry. This entails establishing emission reduction objectives that are tailored to cement manufacturing, adopting and executing innovative and sustainable methods, and allocating resources to research and technology that minimize the environmental impact of cement production. Possible strategies could involve the implementation of storage technology, the improvement of energy efficiency, the utilization of low-carbon alternatives in the cement production process.

11.3.4 Challenges in Construction Industry

Due to significant variations in historical, geographic, political, social, and economic attributes among metropolitan areas, replicating successful projects from developed countries to developing countries is not a straightforward task. The evidence-based methodology used in developed nations is valuable for assessing the effectiveness of outcomes, methods, tactics, and insights within a specific territorial setting. Simultaneously, it is important for the results of a pilot project to be applicable to different locations and situations. This will ensure that the project has a wider and more profound influence and will facilitate the promotion of urban transitions towards sustainability and resilience (Hawkins et al., 2023). To prevent pilot schemes from being sporadic, it is crucial to actively seek chances to expand and replicate successful pilots. In the housing sector, disagreements or conflicts among internal stakeholders on decarbonization goals and methods to achieve them may impede or disrupt the decarbonization process and diminish the generation of social value. Consequently, there is a requirement to enable stakeholders to take ownership of their actions and fully embrace sustainability. The implementation of SPP would strengthen vulnerable people who have less or no resources to make influential decisions and would increase their capacity to tackle social concerns (Patrucco et al., 2023).

11.4 Research Methodology

This research is completely based on secondary sources of data, such as journal articles, book chapters, conference papers, and internet sources, including websites and blogs. An intensive review of the extant literature is undertaken for this chapter. An in-depth review of existing research provides valuable insights into the current status of greenhouse gas emissions globally and measures being adopted by different countries to achieve Net Zero goals. It would help us understand the specific circumstances, target group, and scenarios in which these interventions are most effective. The challenges associated with each initiative, along with possible solutions, are also drawn from a thorough study of the literature.

11.5 Implications

Net-zero targets gain greater credibility when they incorporate specific milestones, a well-defined implementation plan, and a clear declaration regarding the long-term intention of either sustaining net zero or transitioning to net negative. Omitting these elements poses the danger of inactivity, distractions, and lack of success. They serve as important benchmarks for achieving net-negative emissions targets in the future. Although sometimes overlooked, this factor determines the most effective way to achieve net zero. Those countries with the highest capability to achieve a future with a net-negative impact must make preparations for the right future for all. In light of escalating global warming, governments and companies may deem it imperative to expedite the implementation of measures. Acceleration can be promoted by establishing a consistent timetable for reviewing objectives, similar to the ones already established for the shorter-term Nationally Determined Contributions (NDCs).

This chapter highlighted the necessity for well-defined and consistent measures regarding the Net Zero strategy. An effective formulation of plans to achieve these goals will enhance the understanding and knowledge of the different stakeholders, such as service providers, industrialists, manufacturers, and the public at large, by highlighting the advantages. In order to ensure that measures are adopted on a large scale, the government should take the initiative. Policies must be framed at several levels with the aim of promoting the use of renewable energy sources. The public sector should first be made to function with responsibility and collaborate for energy savings. Utilizing diverse communication tools, such as concise and educational videos and graphics, can facilitate the transmission of information among all stakeholders. This ensures that the advantages of renewable electricity and heating technologies are comprehensively grasped by all stakeholders and acknowledged as a means of providing value to the end-users of the service.

Similarly, in the transportation industry, it is possible to limit GHG emissions by utilizing hydrogen, bio-methane, electricity, and electro-fuels. Among these options, electricity is the most viable and convenient alternative. There is a lack of thorough study on the appropriate methods to guarantee the long-term sustainability of energy for the whole lifecycle of the transportation sector, but there are alternative measures that are feasible to improve the efficiency of the transportation industry. Implementing travel demand management strategies for decreasing both the distance and the frequency of travel can potentially enhance efficiency within the sector (Brand et al., 2020). Moreover, the expansion of sharing economies, encompassing activities like ride-sharing, parking spot sharing, and crowdsourcing information, would enhance the efficiency of the sector, leading to a reduction in carbon emissions.

The key to further adoption of low-carbon solutions for smart cities lies in sharing the best experiences, implementing sustainable initiatives, and replicating successful projects. The success stories can build trust among stakeholders and have a positive impact on the decision-making process. Local governments, as influential purchasers, have the ability to use their buying power to stimulate the market for sustainable products and services that reduce harm to the environment and enhance social value creation by promoting social inclusion. In the manufacturing sector, specifically cement, if full carbonation is guaranteed, the process of reducing emissions through carbon capture could serve as an alternate source for carbon-neutral synthetic liquid fuels. Facilitate the transfer of technology, enhance the development of skills, and secure funding from developed countries by implementing efficient and effective measures to reduce the impact of climate change on developing nations. Utilize foreign economic assistance to support developing nations in financing sustainability-oriented systems for communities and households. Unlike the traditional method of prioritizing cost-effective reductions, achieving net-zero emissions involves choosing immediate steps that lay the foundation for long-term behavioral, technical, and institutional transformations necessary for all sectors to reach zero emissions or even achieve negative emissions (Bataille et al., 2020).

One must consider path dependencies and lock-in risks when commercializing new technologies. This includes the time it takes for these technologies to replace the existing ones, establish networks for supplying new types of energy, develop infrastructure for transport and new buildings, change energy usage behaviors and land-use patterns, However, the difficulty lies in formulating country-specific approaches that effectively carry out these extensive changes while remaining in line with the unique circumstances of each nation. Every country is not required to achieve complete greenhouse gas neutrality under net-zero decarbonization. But it is necessary that the emissions trajectory of each region and industry be directed by the objective of achieving carbon neutrality. While certain sectors or regions may not be able to achieve the net zero targets, this would necessitate other regions and sectors to experience a net-negative outcome in order to offset the difference. From the perspective of designing scenarios, this entails surpassing the goal of optimizing within a carbon constraint and instead concentrating on evaluating the highest achievable actions in each sector and identifying crucial country-led changes required to achieve these reductions in emissions or enhancements in carbon sinks. Critics may raise concerns about the significance of deliberating a strategy for achieving net-negative emissions while the world has not yet made progress towards attaining net-zero emissions. From our perspective, these discussions are vital in molding a sustainable and enduring future for our collective planet.

11.6 Conclusions, Limitations and Future Research Scope

Although short-term benefits hold significance, considering the cyclical nature of politics, it will be imperative to establish global and domestic backing for a vision that promotes a more sustainable, intelligent, and inclusive future. Effective management of change at both the national and local levels is crucial for providing the required assistance within countries. This would involve implementing measures at organizational levels to facilitate change, such as upgrading buildings. Additionally, it will involve promoting alternate modes of transportation such as cycling, walking, and public transport. Initially, if every country allocates resources to enhance investment and stimulate demand, all nations can reap the advantages in terms of increased demand and employment. Furthermore, robust projections of global economic expansion can stimulate and maintain investment. Furthermore, a dedication to sustainable technologies not only drives innovation but also enables cost reduction on a larger scale. Furthermore, there are several advantages that arise from the decrease in greenhouse gas emissions, which help all of us. Similar to the process of recovering and reconstructing after the Second World War, the current period is of utmost importance for global cooperation.

This chapter adds to existing research but the implications are limited to not only the four-sectors chosen for study but also the sub-sectors selected for elaborated discussion. Further research is necessary to get insights into other sub-sectors as well as major sectors that could be country specific. The challenges discussed in this chapter also remained focused on specific themes hence, there is a need to comprehend the political and economic aspects, as well as the behavioral aspects, that will restrict or facilitate the shift towards achieving net zero emissions. This research should focus on generating the necessary political determination to establish durable policy frameworks that will encourage widespread sustainable innovation and investments. Additionally, it should explore methods to enhance the adoption of cleaner products and services by consumers throughout the economy rather than a country as whole. It is crucial to have a deeper understanding of how the pandemic has influenced citizens' perspectives on climate change and behavior change, as well as identifying the most effective methods for establishing agreement in the future.

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