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Towards decarbonization goals: A Pathway to a sustainable future

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Abstract

Nature operates on a delicate balance of give and take. However, in the name of development, human activities have disrupted this balance by polluting ecosystems and releasing excessive greenhouse gases into the atmosphere. As a result, global temperatures are reaching unprecedented levels, leading to abrupt climatic changes that pose a significant threat to humanity. Immediate and collective action is essential to ensure the survival of future generations. The adoption of Decarbonization goals offers a promising pathway to mitigate greenhouse gas emissions and reduce the pollution burden on Earth, aiming for substantial progress by 2030.

Keywords: Conference of parties; Paris agreement; Net-Zero emissions; Rising GHG emissions

1. Climatic Change

In this 21st century, we relish the benefits of science and technology and the outputs of innovations for a happy and comfortable life. Industry 4.0 and Society 5.0 have changed and given challenges to life exponentially with limitless potential [1], [2]. Moreover, the average life expectancy of humanity in different continents like Europe, Northern America, and Asia has significantly improved compared to the past two centuries due to the innovations from various fields of medicine, engineering, industry, and artificial intelligence [3]. These technologies help us fight deadly diseases and extend our inventions beyond the earth's orbit. Even though we relish these benefits of comfort in life, somewhere in our minds, two major questions carry the day. How far are we able to adore these benefits? Are we going to share these benefits with the next generations? There is no clear-cut answer or assurance to these questions due to the environmental changes that are happening around us and the drastic climatic changes witnessed in this 21st century.

2. Current Context and Challenges

Climatic change is the popular chanting keyword, and it became so famous due to its consequences, which we all are witnessing currently. Several factors influence climatic change; the utilization of fossil fuels like coal, oil, and gas is the largest contributor to global climatic change, which is accounting for over 75% of global greenhouse gas (GHG) emissions and nearly 90% of all carbon dioxide (CO_2) emissions [4]. Apart from CO_2, methane (CH_4) is also an important contributing factor that warms the atmosphere, which is 28-36 times as warm as CO_2 when it is in the upper atmosphere. In recent times, black carbon (BC) has also gained popularity because it is extremely small and harmful. The major sources of BC are due to incomplete combustion of different fossil fuels, and they are infinitesimal, ranging from 10µm to 2.5 µm. Due to its small size, BC can be suspended in the air and is capable of passing through the walls of the human lung and into the bloodstream. It also absorbs the sun's heat millions of times more effectively than CO_2 [5]. Likewise, the commonly underscored GHGs are CO_2, Methane (CH_4), Nitrous oxide (N_2O), fluorinated gases, and sulphur hexafluoride (SF_6) with their global warming potential (GWP) are highlighted in **Table 1**. The emitted greenhouse gases from different sources form as a blanket and trap the sun's heat. As a result, Mother Earth is warming faster than before, recording warmer temperatures and creating vicissitudes in weather patterns, disrupting nature's usual balance and changing ecosystems. Countries like China, the USA, India, the European Union, the Russian

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Federation, and Brazil were recorded for the largest greenhouse gas emissions, accounting for 63% of global emissions in 2023.

Table 1. Common GHGs and GWP

S. No	Common GHGs	Sources and GWP
1	Carbon dioxide	Formed when something is burned, and GWP is 1.
2	Methane	Formed in anaerobic decomposition and produced in many combustions. The GWP range is 28-36.
3	Nitrous oxide	Formed as a byproduct of fertilizer production and combustion of certain materials. The GWP range is 265-298.
4	Fluorinated gases	Manmade refrigerants. The GWP range is 1800 to 8000
5	Sulphur hexafluoride	Used as insulators in high voltage applications. The GWP is of 22800.

3. Decarbonization Goals Formulation

Decarbonization goals have emerged to regulate these global climatic changes and to restrict carbon dioxide and greenhouse gas emissions. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) marked the first global agreement to combat climate change, and nations agreed to stabilize GHG concentrations. The first legally binding international treaty (Kyoto Protocol 1997) required developed nations to reduce emissions by an average of 5% below 1990 levels by 2012. At the Conference of Parties-COP21 (The Paris Agreement 2015), 196 countries pledged to regulate global warming and emphasized Net Zero emissions by the mid-21st century. At COP26 (Glasgow Climate Pact 2021), pledged to achieve Net Zero by 2050, phase down fossil fuel use, and promote renewable energy and green technology. In recent times (Nov 13, 2024) at Baku, Azerbaijan, a COP29 event titled “Innovation Ecosystems for Climate Action: Digital Technologies, Industrial Solutions, and Governance” was held, and a key highlight of this event was the agreement to triple the finance to developing countries, from the previous goal of USD 100 billion annually to USD 300 billion annually by 2035. These significant steps aim to help developing nations adapt to and mitigate climate change [6].

4. Domino Effect

Due to these initiatives, we are now witnessing the encouragement and promotion of the development of sustainable energy like solar [7]–[11], biofuels [12]–[18], wind [19], tidal [20], [21] and hydropower [22]. The European Union reported a 30% reduction in greenhouse gas emissions between 1990 and 2020, and countries like Denmark and Sweden shifted to renewable energy to cut down carbon emissions. Set a target of 30% by 2030, global electricity must be achieved from renewable sources, which is less than 5% in the 1990s. The investments in renewable energy are eye-catching, with record-breaking installations of solar and wind turbines. Similarly, the adoption of energy-efficient technologies in different sectors like transportation, building, and industry has reduced energy consumption. This has resulted in a global improvement in energy intensity of over 2% annually since 2010. One of the most significant practical achievements in the transportation sector is the rise of electric vehicles and a statistical report reveals in 2023, 14% of new vehicles sold globally are electrical, and countries like Norway lead with over 80% of the new car sales are electric. Most of the developed countries have reduced their reliance on coal utilization, and between 2012 and 2022, coal power generation declined by 30% in Europe. Technological advancements like carbon capture and storage (CCS) are giving fruitful results by capturing millions of tons of CO_2 annually.

5. Conclusion

Greenhouse gas emissions impact the atmosphere uniformly, regardless of whether they originate from developed, developing, or underdeveloped nations. Nature operates on a give-and-take principle, making it clear that isolated efforts by individual countries will fall short without collective global action. Addressing global challenges requires global solutions. Raising awareness, ensuring equitable distribution of funds, fostering collaborative and strategic commitments, and enforcing stringent measures against major emission sources are critical steps. Together, these efforts will pave the way toward achieving Decarbonization goals and securing a sustainable future for all.

References

[1] M. Setiyo *et al.*, "Industry 4.0: Challenges of Mechanical Engineering for Society and Industry," *Mechanical Engineering for Society and Industry*, vol. 1, no. 1, pp. 3–6, 2021, doi: 10.31603/mesi.5309.

[2] M. Setiyo and M. L. Rochman, "The role of mechanical engineering in the era of industry 4.0 and society 5.0," *Mechanical Engineering for Society and Industry*, vol. 3, no. 2, pp. 54–56, Dec. 2023, doi: 10.31603/mesi.10786.

[3] A. Kolakoti, P. Bobbili, S. Katakam, S. Geeri, and W. G. Soliman, "Applications of Artificial Intelligence in Sustainable Energy Development and Utilization," in *Computational Intelligence in Sustainable Reliability Engineering*, Wiley, 2023, pp. 129–143.

[4] H. Long and G. Feng, "Does national ESG performance curb greenhouse gas emissions?," *Innovation and Green Development*, vol. 3, no. 3, p. 100138, Sep. 2024, doi: 10.1016/j.igd.2024.100138.

[5] Z. Shu *et al.*, "Analysis of black carbon in environmental and biological media: Recent progresses and challenges," *TrAC Trends in Analytical Chemistry*, vol. 169, p. 117347, Dec. 2023, doi: 10.1016/j.trac.2023.117347.

[6] F. A. Plazas-Niño, N. R. Ortiz-Pimiento, and E. G. Montes-Páez, "National energy system optimization modelling for decarbonization pathways analysis: A systematic literature review," *Renewable and Sustainable Energy Reviews*, vol. 162, p. 112406, Jul. 2022, doi: 10.1016/j.rser.2022.112406.

[7] S. Susilawati, A. Nugraha, A. S. S. Buchori, S. Rahayu, F. Fathurohman, and O. Yudiyanto, "Design and implementation of automatic fish feeder (AFF) using microcontroller powered by solar cell: A Contribution to the fish farmers," *Mechanical Engineering for Society and Industry*, vol. 3, no. 1, pp. 47–53, Mar. 2023, doi: 10.31603/mesi.8276.

[8] R. A. Rahman, S. Sulistyo, M. S. K. T. S. Utomo, D. Ragil, and B. M. Suyitno, "Experimental evaluation on the power characteristic of direct-photovoltaic charging for thermal storage equipment," *Mechanical Engineering for Society and Industry*, vol. 4, no. 1, pp. 115–122, Jul. 2024, doi: 10.31603/mesi.11493.

[9] F. I. Abam *et al.*, "Thermodynamic modelling of a novel solar-ORC with bottoming ammonia-water absorption cycle (SORCAS) powered by a vapour compression refrigeration condensate for combined cooling and power," *Mechanical Engineering for Society and Industry*, 2023, doi: 10.31603/mesi.10365.

[10] Y. D. Herlambang *et al.*, "Study on Solar Powered Electric Vehicle with Thermal Management Systems on the Electrical Device Performance," *Automotive Experiences*, vol. 7, no. 1, pp. 18–27, 2024, doi: 10.31603/ae.10506.

[11] A. Supardi and A. H. F. Anisa, "Design of solar-powered automatic plant watering based on Internet of Things," *BIS Energy and Engineering*, vol. 1, pp. V124026–V124026, 2024.

[12] A. Kolakoti, M. Setiyo, and B. Waluyo, "Biodiesel Production from Waste Cooking Oil: Characterization, Modeling and Optimization," *Mechanical Engineering for Society and Industry*, vol. 1, no. 1, pp. 22–30, 2021, doi: 10.31603/mesi.5320.

[13] A. Kolakoti and M. Setiyo, "Sustainable energy for future needs: An imperative for a greener tomorrow," *Mechanical Engineering for Society and Industry*, vol. 4, no. 1, pp. 1–4, 2024, doi: 10.31603/mesi.11728.

[14] A. Kolakoti, B. Prasadarao, K. Satyanarayana, M. Setiyo, H. Köten, and M. Raghu, "Elemental, Thermal and Physicochemical Investigation of Novel Biodiesel from Wodyetia Bifurcata and Its Properties Optimization using Artificial Neural Network (ANN)," *Automotive Experiences*, vol. 5, no. 1, pp. 3–15, 2022, doi: 10.31603/ae.6171.

[15] Suprihatin, Alif Julian, and Muhammad Fikri, "Synthesis of Avocado Seeds Into Biodiesel Using A Catalyst CaO From Blood Cockle Shell," *Advance Sustainable Science Engineering and Technology*, vol. 6, no. 4, p. 0240404, Aug. 2024, doi: 10.26877/asset.v6i4.779.

[16] D. I. Setyanansyach, M. Setiyo, and T. Raja, "Review and Bibliometric Analysis of Biogas Power Plants in Indonesia," *Advance Sustainable Science, Engineering and Technology (ASSET)*, vol. 5, no. 3, p. 2303015, 2023, doi: 10.26877/asset.v5i3.16806.

[17] A. Setiyawan, M. H. Fathan, A. Bahatmaka, D. F. Fitriana, K. Kriswanto, and R. F. Naryanto,

"Characterization of bioethanol from fermented oryza sativa glutinosa as an alternative renewable fuel and blended with gasoline fuel," *BIS Energy and Engineering*, vol. 1, pp. V124034–V124034, 2024, doi: 10.31603/biseeng.71.

[18] K. Winangun, A. Setiyawan, G. A. Buntoro, and B. Sudarmanta, "The impact of adding hydrogen on the performance of a CI engine fueled by palm biodiesel," *BIS Energy and Engineering*, vol. 1, pp. V124024–V124024, 2024, doi: 10.31603/biseeng.75.

[19] E. Achdi, B. F. T. Kiono, S. H. Winoto, and M. Facta, "Improving cross-axis wind turbine performance: A Lab-scale investigation of rotor size and blades number," *Mechanical Engineering for Society and Industry*, vol. 4, no. 1, pp. 82–91, Jul. 2024, doi: 10.31603/mesi.10837.

[20] H. Lu, X. Wang, Z. Bai, N. Jia, and H. Xia, "FVCOM-CFD model-based study of hydraulic turbine arrays in Mount Putuo tidal current energy test site," *Ocean Engineering*, vol. 312, p. 119079, Nov. 2024, doi: 10.1016/j.oceaneng.2024.119079.

[21] E. Roome *et al.*, "Assessing hydrodynamic impacts of tidal range energy impoundments in UK coastal waters," *Renewable Energy*, vol. 237, p. 121601, Dec. 2024, doi: 10.1016/j.renene.2024.121601.

[22] P. Purwantono, B. Amin, A. Aziz, J. Jasman, and A. Kurniawan, "Performance test of Pikohidro Cross flow Water Turbine using multilevel double penstock," *Teknomekanik*, vol. 2, no. 2, pp. 76–80, Dec. 2019, doi: 10.24036/tm.v2i2.4172.