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A Review of Energy Security in The Face of Climate Security: Matching the Country Priorities with International Policies

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Abstract

This paper presents a synthesis of the review and analysis of the relationship between climate change and the country's needs to embrace socioeconomic growth from the perspective of energy services. On one hand, energy security is essential in providing sustainable economic growth and meeting human needs for flourishing. On the other hand, climate security is also vital in safeguarding the sustainability of the planet and its people. Amid these two important but conflicting parameters, countries need to meet their energy demand, which is growing exponentially. These parameters are also affected by increased economic growth and improved human standards and civilization of the global south. The world increasingly faces geopolitical tensions and political instability that affect the meeting of international climate goals. In this paper, I provide a systematic review of the two conflicting sides of the sustainability aspects in line with the energy sector; how to match the national priorities with international climate policies remains a crucial question whose practical answer remains a challenge.

Keywords: Energy Security, Climate Security, Climate Policy, Decarbonization.

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1. Introduction

Energy security and climate security are increasingly intertwined and, thus, can no longer be treated as separate priorities. Energy security, on one hand, is essential to support economic growth and maintain the standard of living of the global community. Threats in climate security underpin the threat in energy security; thus, these two discourses go beyond politics.[1] Climate security is increasingly becoming evident due to the impacts of climate change that are witnessed in different regions. Climate change has direct impacts on energy availability and, ultimately, affordability. Climate change has evident impacts on the primary energy sources such as hydropower both in terms of reduced water availability caused by draught from increased global warming and floods that damage infrastructure.[2] Traditionally, many countries in the global south have been dependent on hydropower; the region hosts the Nile, Congo, and Zambezi Rivers, three of the world's largest rivers. Protracted droughts and unpredictable weather patterns have significantly impacted hydropower sources in these countries.[3] Drought is one of the causes of anthropogenic climate change impacts caused by the increasing use of unsustainable energy sources such as biomass and fossil fuels. Energy and climate security can be linked to various attributes that affect the well-being of both people and the planet. Geopolitics and global pandemics like COVID-19 are also affecting the global energy and climate security space.[4]

[1] Jonna Nyman, "Rethinking Energy, Climate and Security: A Critical Analysis of Energy Security in the US," *Journal of International Relations and Development* 21, no. 1 (January 1, 2018): 118–45, https://doi.org/10.1057/jird.2015.26.
[2] Shan-e-hyder Soomro et al., "How Does the Climate Change Effect on Hydropower Potential, Freshwater Fisheries, and Hydrological Response of Snow on Water Availability?," *Applied Water Science* 14, no. 4 (March 7, 2024): 65, https://doi.org/10.1007/s13201-023-02070-6.
[3] Simon Trace, "The Impact of Climate Change on Hydropower in Africa," Oxford Policy Management, September 2019, https://www.opml.co.uk/blog/the-impact-of-climate-change-on-hydropower-in-africa.
[4] *The Global Energy and Climate Security Challenge*, 2022, https://www.youtube.com/watch?v=tyeQKHs1R_8.

This paper highlights the issues that are in line with addressing energy security while considering environmental sustainability. It has always been a challenge for countries to balance their economic priorities and the international policies that require measures to be taken to address climate change impacts from the energy value chain perspective. The economics behind energy investments usually take less consideration of the externalities of technology options in addressing energy security. Energy and climate security are affected by technology, policies, country's political, and regional and geopolitical landscape.

2. Methodology

The methodology deployed in this paper is a systematic literature review from various sources in line with the issues related to energy and climate security. The review included books, journal articles, internet sources, and news media. The data gathered has been analyzed to provide insight into energy issues, looking at local and international policies to address the essential matters of energy in the notion of sustainability of human beings and the planet they live on.

3. The Energy Security: Why It Matters

While there is no global definition of energy security,[5] it is universally related to having energy at the time, place, and quantity needed for a particular application at an affordable rate, be it social, economic, or even lifesaving hospital services.

Properties or attributes of energy security include stability of the systems to provide reliable services, resilience against any shocks, systems adaptability, the flexibility of different scenarios such as sudden changes of demand or supply and other proactive characteristics; the services should also be affordable so as it is accessible to all. Energy security becomes important due to inherent fears of resource depletion, changes in energy pricing and the potential effects of climate change.[6]

In totality, energy security matters for economic activities for individuals and nations, and the public and private sectors. Energy security is affected by internal and external policies related to investment in energy infrastructure. Since energy is a crosscutting sector, it is necessary to make it secure at all times. The decision of the European bloc to depend on a single supply source (Russia) for a long time has costed it, as now it is affected by the geopolitical landscape resulting from Russia's invasion of Ukraine. The European bloc is now energy insecure as it approaches winter, and it will need a substantial energy supply to cool homes. The reduced energy supply from Russia has also affected the economic activities of European countries. Germany, for instance, which imports more than half of its energy from Russia, is the hardest-hit nation in the bloc. This has provided clear evidence that countries should embrace *energy self-sufficiency* so as to reduce their exposure to the price and supply volatility of imported energy.[7] The recent agreement made by the European Union (EU) together with G7 countries and Australia to impose a price cap of USD 60 per barrel on Russian oil, aiming at weakening its economy in response to its invasion of Ukraine, might further affect the energy availability and affordability for these countries. Russia is looking to supply alternative markets, such as India and China, in response to this agreement.[8]

Countries can adopt appropriate policies to assist in keeping abreast with energy security.[9] Regional cooperation can assist in addressing the issue of energy insecurity, such as the six regional power pools in Africa. However, their operationalization has been facing some challenges as they have to fulfill three key conditions, namely, *cross-border interconnection infrastructure*, *a common legal and regulatory framework* and *a multi-country*

[5] Raphael Jingura and Reckson Kamusoko, "The Energy - Development Nexus in Sub-Saharan Africa," in *Handbook on Africa: Challenges and Issues of the 21st Century*, 2016, 25–46.
[6] Jeffrey Kucharski and Hironobu Unesaki, "A Policy-Oriented Approach to Energy Security," *Procedia Environmental Sciences* 28 (2015): 28.
[7] Manfred Hafner and Simone Tagliapietra, eds., *The Geopolitics of the Global Energy Transition*, vol. 73, Lecture Notes in Energy (Cham: Springer International Publishing, 2020), 159, https://doi.org/10.1007/978-3-030-39066-2.
[8] Alexander Gale, "EU Imposes Price Cap on Russian Oil at $60 Per Barrel," *GreekReporter.Com* (blog), December 2, 2022, https://greekreporter.com/2022/12/03/price-cap-oil-russia-eu/.
[9] Bruce G. Miller, "The Future Role of Coal," in *Clean Coal Engineering Technology*, ed. Bruce G. Miller, 2nd ed. (Butterworth-Heinemann, 2017), 757–74, https://doi.org/10.1016/B978-0-12-811365-3.00016-8.

organizational structure to oversee the planning, harmonize rules and develop a commercial framework for cross-border power trade.[10] Strategic cooperations, such as the European Energy Platform,[11] are also essential.

Decentralization can help in energy security as it avoids geopolitical risks and can offer some level of guarantee to a supply should regional systems have some technical issues. Along with decentralization, there should be strategies for a backup system should one supplier encounter some issues, the so-called *N-1 principle*. However, the "N-1 takes no account of the probability of such outages, and fails to distinguish between which, and the magnitude of, areas that may be impacted by power losses."[12] In this case, the use of more than one source, *diversification*, can provide some level of security should one source fail. For the countries that do not have local resources, it would be vital to embrace regional interconnectedness so as to gain the advantage of the available energy at cross borders. On a similar note, dealing with cross-border energy trades can be insecure; thus, stringent contracts need to be established to reduce the possibility of the supplier weaponizing energy services. Energy security relates to the sovereignty of a country.[13]

Addressing potential climate impacts resulting from global warming is increasingly becoming part of energy security measures; investing in renewable energy makes the energy supply more secure by avoiding increasing climate change impacts. This, coupled with energy efficiency measures that reduce energy consumption and necessary additional investments to meet demand, could be a quick and short-term measure to address energy security while at the same time embracing climate resilience.

The policy-oriented approach to energy security should consider systems of systems rather than looking at individual components attributed to insecurity: risks and uncertainty, ambiguity, ignorance, source controllability and temporality, as well as systemic risks.[14]

4. The Climate Security: Why It Matters

Climate change entails the change of weather patterns in relation to the solar system that affects global ecosystems. In recent days, the world has seen adverse climate change impacts sporadically happening across the globe; this includes the *sea level rise* that threatens the life and livelihoods of the small islands, which are threatened to be swamped and disappear from the earth's face. Severe *droughts* have been seen in many parts of sub-Saharan Africa, threatening the survival of humans and other living things.[15] There has been an increase in **weather whiplash** resulting in *extreme weather events* that have been prevalent in many parts of the world; the recent flooding in Asia and the United States of America (USA) are some of many events of that nature that can be attributed to the adverse impacts of climate change. In the tropics, there has been an increase of *malaria parasites* in areas where they did not exist because of the warming effect that creates a conducive environment for the survival and breeding of mosquitoes, increasingly for areas which are at high altitudes that used to be malaria-free are now prominent with the disease due to increasing temperature rise.[16] One example is that malaria is now prevalent in areas at the foot of Mount Kilimanjaro in Tanzania, which used to be cold and did not have mosquitoes.

With scientific evidence and other diplomatic interventions, there has been an increasing call for the international community to take necessary actions to limit global warming through instituting measures such as deploying clean

[10] Alfonso Medinilla, Bruce Byiers, and Karim Karaki, "African Power Pools: Regional Energy, National Power," Discussion Paper, 244 (Political Economy Dynamics of Regional Organisations in Africa, February 2019), www.ecdpm.org/dp244.
[11] "EU Energy Platform," European Commission, accessed December 2, 2022, https://energy.ec.europa.eu/topics/energy-security/eu-energy-platform_en.
[12] Oddbjørn Gjerde, "Electricity Supply Security – N-1 Isn't Always Enough," *#SINTEFblog* (blog), January 20, 2017, https://blog.sintef.com/sintefenergy/energy-systems/electricity-supply-security-n-1-isnt-always-enough/.
[13] Murodbek Laldjebaev, Benjamin Sovacool, and Karim-Aly Kassam, "Energy Security, Poverty, and Sovereignty: Complex Interlinkages and Compelling Implications" (London and New York: Routledge, 2016), 97–112, https://www.researchgate.net/publication/289377766_Energy_security_poverty_and_sovereignty_Complex_interlinkages_and_compelling_implications.
[14] Kucharski and Unesaki, "A Policy-Oriented Approach to Energy Security," 30.
[15] Stephen Adaawen et al., "Chapter 2 - Drought, Migration, and Conflict in Sub-Saharan Africa: What Are the Links and Policy Options?," in *Current Directions in Water Scarcity Research*, ed. Everisto Mapedza et al., vol. 2, Drought Challenges (Elsevier, 2019), 15–31, https://doi.org/10.1016/B978-0-12-814820-4.00002-X.
[16] Steve Connor, "Climate Change Is Increasing the Risk of Malaria for People Living in Mountainous Regions in the Tropics," The Independent, March 6, 2014, https://www.independent.co.uk/news/science/climate-change-is-increasing-the-risk-of-malaria-for-people-living-in-mountainous-regions-in-the-tropics-9174448.html.

energy technologies.[17,18] The report by the Intergovernmental Panel on Climate Change (IPCC) calls for halving greenhouse gas (GHG) emissions by 2030 to make the climate secure;[19] the recent IPCC assessment report argues that if no action is taken now, some impacts will cause a release of additional greenhouse gases and some will be irreversible, even if global warming is reduced.[20]

The adverse impacts caused by climate change are impeding economic growth as they disrupt means to engage in economic activities and threaten human existence and the entire ecosystem of the planet Earth; it is then paramount to make climate secure.

5. Correlation of Energy Security and Climate Change

5.1 The Context

As highlighted in previous chapters, energy security does not have a standard definition, and its approaches depend on various dimensions, including local, national, and international; it can, however, universally be agreed to focus on the reliability of supply, accessibility, and affordability of the energy services. At the same time, while fossil-based energy sources provide most of the energy security aspects, they result in a rebound effect causing increased global warming and climate change impacts; there is an ecological effect that would otherwise safeguard the guarantee to extract hydrocarbon for many years. Climate change also results in threats to damaging energy infrastructure that may be caused by extreme weather events.

Energy security has been of high priority in recent times and, thus, has set climate targets at a roadblock: the case of the European bloc, which has been largely dependent on fossil fuel supply from Russia, is now faced with energy insecurity as the bloc approaches winter seasons; this has also affected other sectors like education and health and the economies at large. Maintaining the standard of living would require some sort of measures that include running fossil-based power stations. As energy security has now become the topmost priority for European countries, it has affected the Paris objectives as the thinking would reverse to addressing immediate energy shortages, which will mean reinvesting in fossil-based energy solutions as renewables have some technical limitations and entail high investment costs. It is possible to argue that renewable energy investments will now gain traction as a long-term solution to the energy security of European countries. However, in the medium term, the bloc will rely more on natural gas to navigate the inherent energy shortages.[21] This also has a spillover effect as there have already been negotiations for the European bloc to secure natural gas from the Middle East and Africa, encouraging more investments into that space.

5.2 Policy Alignment to Energy Security

The guarantee of supply and the support to economic growth may mean embracing resource diversification. However, this may have a rebound effect as it could favor more carbon-intensive sources to speed up economic growth, resulting in increased GHG emissions, which in turn impacts the sustainability of the energy supply.

The dilemma of embracing both energy security and achieving climate objectives is evident. This can be witnessed referring to the situation in the European Union bloc that depends mainly on energy supply from Russia. The ongoing war in Ukraine, which triggered suction on Russia, has threatened energy security for the bloc, which may derail them from achieving their climate commitments in line with the objectives of the Paris Agreement.[22] It

[17] United Nations, "UN Secretary-General at COP26: 'Either We Stop It — or It Stops Us.,'" United Nations Western Europe, November 1, 2021, https://unric.org/en/un-secretary-general-at-cop26-either-we-stop-it-or-it-stops-us-2/.
[18] United Nations, "UN Secretary-General's Remarks to High-Level Opening of COP27," United Nations, November 7, 2022, https://www.un.org/sg/en/content/sg/statement/2022-11-07/secretary-generals-remarks-high-level-opening-of-cop27-delivered-scroll-down-for-all-english-version.
[19] Nathan Cooper and Amy White, "IPCC Report: Urgent Climate Action Needed to Halve Emissions by 2030," World Economic Forum, April 6, 2022, https://www.weforum.org/agenda/2022/04/ipcc-report-mitigation-climate-change/.
[20] Hans-Otto Pörtner et al., eds., "Summary for Policymakers," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK and New York, NY, USA: IPCC, Cambridge University Press, 2022), 19.
[21] Caroline Kuzemko et al., "Russia's War on Ukraine, European Energy Policy Responses & Implications for Sustainable Transformations," *Energy Research & Social Science* 93 (November 1, 2022): 102842, https://doi.org/10.1016/j.erss.2022.102842.
[22] "EU Warns of Fossil Fuel 'Backsliding' as Countries Turn to Coal," Al Jazeera, June 21, 2022, https://www.aljazeera.com/news/2022/6/21/brussels-worried-about-eu-countries-shift-back-to-coal.

is highly likely that the European countries might resort to going back to fossil-based energy options to attain a supply guarantee, especially on the verge of the winter season coupled with the prevailing souring economic situation.

The lessons of existing energy insecurity in the global north have cemented the claim that the global south should invest in locally available resources such as coal and natural gas. Many countries will likely redefine their energy policies and institute strategies to include hydrocarbons in their investment targets.

5.3 Energy Security and Net-Zero Future

In order to achieve a net-zero economy while embracing energy security, it will be paramount to address the energy trilemma: accessibility, affordability, and sustainability. To balance the three dimensions is challenging; analysts project that the use of fossil fuels will remain in the energy mix for the next decade and start going down by the mid-century; that means countries will take the approach of diversification to address both energy security from the social-economic angle while addressing environmental concerns, that is to say, by the mid-century, investments in fossil fuels like in coal, gas, and oil will be reduced to favor low-carbon energy solutions such as renewables and nuclear energy. With technological advancement, it is also possible that the cost of cleaning fossil-based solutions such as integrating Carbon Capture Utilization and Storage (CCUS) would reduce costs and make such investments clean. In this case, there is a possibility of increasing investments in hydrocarbons.

6. Global Governance and International Climate Policy Landscape

6.1 Global Response to Climate Action

The world is faced with climate challenges due to increasing evidence of climate change impacts that were forecasted by scientific methods. IPCC has been producing scientific papers related to predicting climate change impacts, their causes, and their mitigation potential. The world has remained with a limited **carbon budget** towards achieving the Paris Agreement goals of limiting the global temperature rise by 1.5 degrees Celsius come 2050. The concept of carbon budget refers to "the total amount of anthropogenic carbon dioxide that can still be emitted into the atmosphere while holding the global average temperature increase to the limit set by the Paris Agreement."[23]

Analysis shows that if appropriate measures are considered, there is an 80 percent possibility of achieving the 1.5 degrees Celsius limit.[24] "The implications of carbon dioxide (CO_2) budgets are profound, and international climate policymakers have a role to play in translating the implications into financial and economic decision-making."[25] The manifestation of the power of science has led the global community to institute some measures that countries will jointly need to take in order to control the climate impacts and remain secure. At the international level, advocacy is being made at the United Nations Conference of Parties (CoPs), the conventions that are meant to bring together global stakeholders to agree on the steps to take to limit global warming and achieve sustainable development goals. Since its inception, the most significant milestone was achieved in the twenty-first convention (COP21) convened in Paris in 2015, where countries anonymously agreed to take the bottom-up approach and come up with specific Nationally Determined Contributions (NDCs) to curbing climate change impacts. Among other contributors to GHG emissions, energy has contributed about three-quarters of global emissions.[26] This cuts across the entire supply chain from energy generation to transition and end uses. The issue of balancing countries' economic growth priorities and climate objectives has been the biggest challenge. The global south claims to be excused for phasing out plans to invest in fossil-based systems, especially coal and natural gas, in order to leapfrog their economic growth.[27] Discussions on a complete phasing out of coal have been facing stumbling blocks due to emerging economies like India and China advocating for a gradual reduction of the use of fossil fuels rather than

[23] Joeri Rogelj et al., "Estimating and Tracking the Remaining Carbon Budget for Stringent Climate Targets," *Nature* 571, no. 7765 (July 2019): 335, https://doi.org/10.1038/s41586-019-1368-z.
[24] Bob Ward, "Unburnable Carbon 2013: Wasted Capital and Stranded Assets," *Carbon Tracker & The Grantham Research Institute, LSE)*, 2013, 10.
[25] Ward, 13.
[26] Hannah Ritchie, "Sector by Sector: Where Do Global Greenhouse Gas Emissions Come From?," Our World in Data, September 18, 2020, https://ourworldindata.org/ghg-emissions-by-sector.
[27] African Energy Chamber, "Africa Should Be Allowed to Use Its Resources," November 29, 2019, https://energychamber.org/africa-should-be-allowed-to-use-its-resources/.

instituting measures to completely phase them out. [28] At the same time, large economies such as the USA continue to invest in natural gas, which has proven to be the cheapest option after the discovery of shale oil.[29,30]

6.2 Investment and Strategy in Response to Low-Carbon Economy

The global challenges caused by the COVID-19 pandemic and the Russian invasion of Ukraine have resulted in an energy price hike and security uncertainty. This has caused countries to rethink strategies to have a secure supply of energy; at the same time, there has been an increasing response to shifting from fossil-based power supply to clean energy sources as a means to address both energy and climate insecurity. The positive trend can be seen as countries are increasingly adopting international targets by instituting various measures to achieve the global objectives of a carbon-neutral society by 2050. Most European countries have phased out most of the fossil-based energy generation systems and have also set up targets to reduce fossil fuels' end uses, such as the introduction of electric vehicles, clean hydrogen generation, and renewable energy generation. The global south does not have a clear and unified strategy to reduce dependence on fossil fuels. It can be argued that these countries do not have many options as their economies are weak to invest in renewable energy and high technology in support of carbon-neutral fossil-based energy generation systems. While it is fallacious to let the Global South continue to invest in fossil fuels to catch up with its economic growth, it is the duty of the developed nations to support the Global South in investing in clean energy options.

There has been a positive response to international policies addressing climate change in the energy sector. Investments across the sector have been recording an increase in power, electricity, transmission, and distribution infrastructure. While investment in fossil-based power generation is projected to remain flat in 2022 at the tune of USD 100 billion across all technologies, the same amount is projected to be spent on solar photovoltaic technologies alone.[31] In comparison to fossil fuels, renewable energy investment is seven-fold higher.[32] However, these investments are not evenly distributed across the globe; a global partnership is required to even out the wide investment gap between developed, emerging, and developing economies.

7. Integrating Energy and Climate Policies

7.1 The Rationale for Integration

By and large, energy and climate policies have long been treated separately, although they are interdependent in many ways. The decisions made on energy investments impact the climate and vice versa. Traditionally, institutional setup and governance structure for the energy and climate-related issues/environment are treated separately; countries have different policies and governance structures for the two. This makes it challenging to be effective. Integrating them will be essential to bringing effectiveness regarding environmental benefits and energy interventions.

7.2 The Challenges

While energy and climate are interlinked in many ways, they are not always in favor of each other, and usually, one policy may damage the other.[33] Rational transformation to a clean and sustainable development pathway is always challenging as some policies to compact climate change contradict the energy investment policies and the economic growth at large. In any case, trade-offs should be identified so that energy policies can be in sync with climate policies. This can be achieved through the decompartmentalization of the two policies and enhanced international cooperation.

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[28] Lucas Niewenhuis, "COP26 Agrees on 'Phase-down' of Coal after Last-Minute Deal between U.S., China, EU, and India," SupChina, November 16, 2021, https://supchina.com/2021/11/15/cop26-agrees-on-phase-down-of-coal-after-last-minute-deal-between-u-s-china-eu-and-india/.

[29] "The U.S. Shale Revolution," The Strauss Center, accessed December 3, 2022, https://www.strausscenter.org/energy-and-security-project/the-u-s-shale-revolution/.

[30] Stephen P.A. Brown and Mine K. Yücel, "The Shale Gas and Tight Oil Boom: U.S. States' Economic Gains and Vulnerabilities" (New York, USA: Council on Foreign Relations, 2013), https://www.jstor.org/stable/resrep00303.

[31] IEA, "World Energy Investment 2022" (Paris: International Energy Agency, June 2022), 33, https://www.iea.org/reports/world-energy-investment-2022.

[32] Felicia Jackson, "Global Renewables Investment Return 7 Times Higher Than Fossil Fuels," Forbes, March 19, 2021, https://www.forbes.com/sites/feliciajackson/2021/03/19/global-renewables-investment-return-7-times-higher-than-fossil-fuels/.

[33] IEA, "Africa Energy Outlook 2022" (Paris: IEA, June 2022), https://www.iea.org/reports/africa-energy-outlook-2022.

7.3 Opportunities

Opportunities are available to integrate energy and climate policy. Opportunities are found in both local and international spaces. Locally, it is possible to design strategies for energy investments in terms of the climate impacts, for instance, local subsidies for investing in renewable energies and introducing a polluter pay framework for carbon-intensive energy systems. This applies to both the energy supply and demand side. Energy consumption patterns can be guided by the principles of energy efficiency such that consumers are encouraged/incentivized to be efficient; this includes the use of efficient appliances for households and equipment with improved power factors for industrial applications. There is also an opportunity for institutional and regulatory reforms to support joint regulatory activities backed by political will.

There are existing opportunities for international cooperation to encourage clean energy investments through bilateral and other means of collaboration. Developed nations should be incentivized to support clean energy investments in the global south. The mechanisms should follow economic principles of **effectiveness** and **comprehensiveness**.

Pragmatic ways of broadening energy and climate policy can be viewed to include avoiding trade-offs, identifying synergies, enhancing response capacity, developing institutional linkages, and mainstreaming energy and climate policies within the broader perspective of sustainable development policies.

7.4 Comprehensive Policy Framework for A Just Energy Transition

Balancing climate and energy security requires a comprehensive policy framework that looks at issues related to the choice of investment countries make to cater to both countries' economic growth and safeguard the environment. Need for a holistic policy framework balancing energy, economy, society, and the planet. The policies need to create a conducive environment for deploying clean energy technologies and replace fossil-based energy sources. The deployment policies for renewable energy mean working on crowding in investments in the sector while disincentivizing fossil fuels. There is also a need for a structural change in the institutional sector governance so as to attract investments and provide a level playing field for stakeholders to participate in the energy markets.[34]

8. Energy Options in The Carbon-Constrained World

8.1 Fossil Fuels in The Carbon-Constrained World

The future of the energy scenario depends on the demand derived from increased population and economic activities. These factors, among others, will depend on reliable energy supply options. In this case, fossil fuels will play a critical role in the future energy mix; however, with increased concerns and evidence on climate change impacts, countries will be forced to reduce their dependence on fossil-based energy.

There will be an increase in the use of renewables and the cleaning up of fossil fuels, such as the use of CCUS technology. Technology advancement will be central to embracing this transformation. With the increased share of intermittent renewables, grid integration techniques supported by superconductivity will be vital. Countries will be constrained with options and thus forced to resort to policies that address both energy security and reliability as well as the concerns on climate change impacts.

In most countries that rely on fossil-based solutions, their fleets (e.g., coal-fired power plants) still have a long lifetime; hence, abandoning them in the next decade will entail adverse economic consequences. Nuclear, much as it has inherent controversy in terms of threatening global security and health concerns at a local level, can be said to be one of the energy technologies that cater to both the projected demand and the climate change goals. Appropriate policies will need to be put in place to make nuclear safe and affordable.

Looking at the global trends in climate change and economic growth, the future of energy in the carbon-constrained world will see a mix of fossil-based sources and renewables alongside nuclear technology. The world will see a

[34] IRENA and ILO, "Renewable Energy and Jobs - Annual Review 2022" (Abu Dhabi and International Labour Organisation, Geneva: International Renewable Energy Agency, September 2022), 72, https://www.irena.org/publications/2022/Sep/Renewable-Energy-and-Jobs-Annual-Review-2022.

continued policy shift to adapt to the changing dynamics regarding climate concerns, geopolitics, and local situations.

Overall, with increased technological advancements such as in CCUS and increased energy efficiency on both the supply and demand side and considering the current energy infrastructure, fossil fuels will play a critical role in energy services in the foreseeable future towards the mid-century.

8.2 Renewable Energy for Energy Security and Supporting Climate Actions

Renewable energy is at the center of addressing energy security and combating climate change. Renewable energy is decentralized in nature, making it less prone to geopolitical risks that are involved in the international energy markets. Renewables are also less susceptible to resource depletion, making them reliable for an extended future. At the same time, renewable energy sources are clean and support the climate action agenda of limiting global warming that causes climate change impacts. Renewable energy plays a critical role in achieving sustainable development goals, the Paris Agreement objectives, and a race towards a carbon-neutral society by the mid-century. With advancing technology and the reduction of their associated costs, it will be possible for the future energy mix to be dominated by renewable energy resources. Projections show that with appropriate policies and strategies, the share of renewable energy will reach the levels to achieve international climate objectives; the share of renewables needs to increase from 17.7 percent (2019)[35] to two-thirds of the total global energy supply by 2050.[36]

Energy and climate security have a direct impact on a nation's economic activities. Renewable energy supply benefits both the economies of the countries that are net energy importers and those that are energy exporters. For the net-energy exporters, increased uptake of renewable energy reduces the forex expenses, thus improving their economy and increasing their capacity to import more goods that can not be produced locally. Conversely, for energy exporters, promoting renewable energy will reduce dependence on a fossil-based economy and extend the life of their fossil resources, thus prolonging the time to diversify the scope of economic activities.[37]

8.3 Nuclear in Place of Energy and Climate Security

Nuclear power is one of the sources considered clean and can also provide the necessary energy for the baseload as opposed to renewables. As we move towards decarbonizing the economy, nuclear has a great chance to play a significant role in the equation.[38] Much as nuclear energy is not renewable, it is a cleaner source of energy than fossil fuels such as natural gas and coal. Nuclear has a high energy content; a single kilogram of uranium produces about two million times more energy than one kilogram of coal.[39]

However, nuclear has some drawbacks. Nuclear is still expensive to build and has a long lead time to completion, as much as ten years. Dealing with radioactive waste as a byproduct at power stations is still challenging; it is not yet certain how to deal with this waste that lasts for many years, and slight mishandling of them will lead to health catastrophes.[40] The cost of building nuclear power stations is high due to the fact that these are traditionally high-capacity power plants to the tune of a thousand megawatts. The world is also concerned about nuclear safety in terms of proliferation, that is, the possibility of the bearers using it as a weapon for mass destruction.[41] It is also prone to use by terrorists.

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[35] IEA et al., *Tracking SDG 7: The Energy Progress Report* (Washington DC: World Bank, 2022), 12, https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf.

[36] IEA, "Net Zero by 2050: A Roadmap for the Global Energy Sector" (France: International Energy Agency, October 2021), 57, https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

[37] Jayant Sathaye et al., "Renewable Energy in the Context of Sustainable Development," in *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change*, ed. Christoph von Stechow et al. (Cambridge: Cambridge University Press, 2011), 726, https://doi.org/10.1017/CBO9781139151153.013.

[38] Andrea Galindo, "What Is Nuclear Energy? The Science of Nuclear Power," Text, IAEA (IAEA, August 31, 2022), https://www.iaea.org/newscenter/news/what-is-nuclear-energy-the-science-of-nuclear-power.

[39] Kevin Lee, "Nuclear Energy Vs. Fossil Fuel," Sciencing, October 16, 2018, https://sciencing.com/about-6134607-nuclear-energy-vs--fossil-fuel.html.

[40] Geoffrey Lewis, "Fossil Fuel vs. Nuclear Energy," Stanford University, March 3, 2017, http://large.stanford.edu/courses/2017/ph241/lewis1/.

[41] Thomas R. Sadler, *Energy Economics: Science, Policy, and Economic Applications* (Lanham, Maryland: Lexington Books, 2020), 238–39.

In the recent past, countries were thinking of embracing increasing investments in nuclear as a source of energy for the decarbonizing economy; this has been ruined by the ongoing conflict between Ukraine and Russia, where it is seen that nuclear war is very close to reality. For nuclear energy to be appropriate in supporting carbon neutrality, many dimensions must be considered. It will also be important to consider the entire lifecycle assessment of the resource as there might be emission leakages resulting from massive infrastructures built for nuclear power stations.

Reduction of the size of the power plants will be vital for the cost and flexibility angle; already, there is an ongoing effort to adapt modular nuclear reactors of the size below 30MW[42] that can be deployable at the local levels to serve decentralized energy needs. Floating[43] or mobile reactors are also another interesting development; however, these are yet to be able to be deployed to scale.

Despite its controversy, nuclear presents a promising case to cater to both the growing energy demand and address climate change concerns. With technological advancement and tightening of global policies to control the source, nuclear power is strategically positioned to help in sustainable future development pathways.

9. The Carbon Budget and Economics of Energy Sector Decarbonization

9.1 The Carbon Budget

Combating climate change will require ambitious policies and implementation thereof. It is projected that by 2030, with the current policy landscape and actions, the temperature rise will be around 2.7 degrees Celsius; pledges and targets will limit the same to around 2.0 degrees Celsius. The projected optimistic scenarios average around 1.8 degrees Celsius.[44] The remaining carbon budget[45] requires stringent measures. The carbon Tracker analysis shows that the pace of expansion of Liquefied Natural Gas (LNG) threatens the required global warming limits. Looking at the LNG infrastructure, including the existing ones and those on the pipeline, The emissions from LNG alone will be around 40 gigatons of carbon dioxide equivalent; this equals 10 percent of the remaining carbon budget to limit the temperature rise to 1.5 degrees Celsius.[46]

9.2 Economics Behind Decarbonization

Decarbonizing the energy sector will require more use of clean energy solutions to reduce the carbon emissions resulting from the energy sector, which accounts for around three-quarters of the global GHG emissions. Implementing low-carbon energy solutions means deploying more renewable energy solutions and phasing out the hydrocarbons. With global economic sluggishness, the path faces unprecedented challenges. Most of the actions that will support the decarbonization of the energy sector will come from the Global South; unfortunately, these countries are faced with financial constraints, which makes them prioritize the options that have high economic yields. The most promising technology in terms of curbing negative environmental impacts is capital-intensive. Fossil-based technologies are mature and thus tend to have lower investment cost intensity. Apparently, Natural gas, with the discovery of the fracking extraction method, has a capital cost of around United States Dollars (USD) 917 per kilowatt (kW) installed; this is far incomparable with renewable energy options, which are comparatively high: Biomass combined cycle USD 8,180 per kW; Wind offshore USD 6,230 per kW; solar photovoltaic (PV) USD 3,873 per kW and solar thermal electric USD 5,067 per kW. Comparing different sources with different capacity factors and looking at the cost of producing the same amount of energy for a continuous operation, one finds that natural gas is around USD 1,019 per kW installed and that of solar PV becomes USD 19,365.[47] All these costs are real-world costs that do not consider the environmental externalities of the technology options. Adding to the damage the cheaper options, that is, fossil fuels cause in the environment, will make them much more expensive, as the current state of play tends to ignore the cost to the environment. Based on the analysis in Europe, the externality costs of coal range between 2- and 15-euro cents per kilowatt hour. Conversely, the eternality costs

[42] Sadler, 247.
[43] Thomas Wellock, "Floating Nuclear Power Plants: A Technical Solution to a Land-Based Problem (Part I)," NRC Web, September 23, 2021, https://www.nrc.gov/reading-rm/basic-ref/students/history-101/floating-nuclear-power-plants.html.
[44] Climate Action Tracker, "Warming Projections Global Update November 2022" (Climate Action Tracker, November 10, 2022), ii, https://policycommons.net/artifacts/3153102/cat_2022-11-10_globalupdate_cop27/3950927/.
[45] Rogelj et al., "Estimating and Tracking the Remaining Carbon Budget for Stringent Climate Targets," 335.
[46] Climate Action Tracker, "Warming Projections Global Update November 2022," i.
[47] David Timmons, Jonathan M. Harris, and Brian Roach, "The Economics of Renewable Energy," *Global Development and Environment Institute, Tufts University*, 2014, 22.

associated with renewables are less than one euro cent per kilowatt hour.[48] Clearly, looking at climate security, coal or natural gas is much more expensive than any other form of renewable energy source. Translating externality costs into actual investments will require policies that penalize the use of energy sources that cost the planet and reward those that are abating the pollution.

Another economic argument is that it takes energy to generate energy. The **net energy ratio**, which is the ratio that describes the relationship between the energy used to generate energy and the resultant usefulness of the energy use, is much larger in fossil-based sources than in renewable energy options. That means it takes substantial energy to come up with a renewable energy solution to generate useful energy. The higher the number (net energy ratio), the better. Net energy ratio for fossil-based fuels: oil 35, natural gas 10, and coal 80. The net energy ratios for renewables are relatively small: Wind 18, PV cells 6.8, and that of ethanol is as low as 0.8. This translates to the fact that there is some unaccounted energy leakage, which, if considered, results in some renewables accounting for more emissions in their production process.[49]

10. Conclusions

The global energy and climate policy presents a multitude of issues that need to be considered, ranging from technology, resource availability, consumer behavior, global market landscape, and geopolitics, among many others.[50] The utmost focus of the world is to either maintain the status quo of its wealth (global north) or leapfrog to economic growth (global south). Both require substantial energy consumption, meaning that energy demand will increase substantially in the coming decades, with most of it projected to come from the global south. At the same time, the world increasingly realizes that climate change is real, and its impacts are evident. Hesitantly, countries are forced to think of decarbonizing energy systems thus, follow a sustainable economic development path. There are signs of continuing investments in controversial GHG energy-emitting sources like coal in the industrializing world, especially in Africa. The report of Climate Action Tracker of March 2022 argues that "Fossil fuel use is on the rise, with 70 percent of the increase in fossil CO_2 emissions projected to come from natural gas by 2030 if current policies are not strengthened to align with the Paris Agreement goal to limit global warming to 1.5 degrees Celsius."[51] By and large, the growth of renewables in the energy mix in Africa will still be slow because of the lack of readiness for the global north to support the global south, financially and technically, in investing in green energy infrastructure. The major challenge of embracing energy transition for the benefit of climate and energy security lies in the lack of collaboration between the rich and poor nations. Only when there is a genuine will to embrace practical partnerships between the industrialized countries and those trying to industrialize will the planet be saved. Rich countries do what they choose, while the poor do what they must for survival.[52] Instituting and internalizing appropriate policies and strategies for climate actions within countries' economic plans can answer the energy security question on a medium- and long-term basis.[53]

11. Possible Future Research

Energy security and climate security have recently gained global interest due to increased energy demand and other factors such as geopolitical tensions. The dilemma is evident; however, within this context, it is possible to take advantage of the challenges and turn them into opportunities.[54] Despite their close relationship, the two discourses differ in methods of evaluating them; energy security is evidenced primarily through empirical evidence, while the case for climate change adds more scientific methods. Neither of the impacts of the two discourses is the same globally. To some, it might mean the issue of survival and lifesaving, such as those in the small islands; to others, this may mean maintaining the standard of living, human survival, and economic perseverance. In this case, they need to be evaluated and analyzed within specific contexts. Further studies

[48] Timmons, Harris, and Roach, 29–30.
[49] Timmons, Harris, and Roach, 19.
[50] Harald Heubaum, "Global Energy and Climate Policy" (Centre for International Studies and Diplomacy (CISD), SOAS, University of London, 2022), https://www.coursera.org/learn/globalenergyandclimatepolicy.
[51] Climate Action Tracker, "Natural Gas in Africa: Why Fossil Fuels Cannot Sustainably Meet the Continent's Growing Energy Demand" (Climate Action Tracker, May 2022), i, https://climateactiontracker.org/publications/natural-gas-in-africa-why-fossil-fuels-cannot-sustainably-meet-the-continents-growing-energy-demand/.
[52] *Why I Must Speak out about Climate Change*, 2012, https://www.ted.com/talks/james_hansen_why_i_must_speak_out_about_climate_change.
[53] Janetta McKenzie, "Balancing Energy Security and Climate Action in 2022," Canada's National Observer, April 26, 2022, https://www.nationalobserver.com/2022/04/26/opinion/balancing-energy-security-and-climate-action-2022.
[54] Serhan Cevik, "Climate Change and Energy Security: The Dilemma or Opportunity of the Century?," *Environmental Economics and Policy Studies* 26, no. 3 (July 1, 2024): 653–72, https://doi.org/10.1007/s10018-023-00391-z.

undertaking a multidimensional analysis could be interesting, linking up different parameters that can inform appropriate policy directions to achieve energy security in alignment with climate security.

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