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Decarbonizing Global Industries: Future Scenarios and Policies for Achieving Net Zero Emissions

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Abstract: ***Global energy is slowly becoming the main discussion topic among many scholars concerned with saving the world from the effects of global warming. To stabilize the climate and keep global warming to 2 °C, the global industry must completely decarbonize and achieve net zero greenhouse gas emissions by 2050–2070. As the world attempts to decarbonize the different industries that lead to increased carbon waste, they must consider how energy can be regulated to prevent it. This involves evaluating the current trends in energy use and the scenarios that are likely to take place in the future. This paper comprehensively looks at the different scenarios the World Energy Council presented and relates them to the demand and supply side development of decarbonization policies. It further indicates the inevitability of energy use in a world seeking development, especially in developing countries where development is spiking.***

Keywords: Global Energy, Decarbonization, Net Zero Emissions, Climate Change, Energy Policies

1. Introduction

The discussion of global energy is vibrant and often entails three major themes. These themes include discussing the possible future trends as accurately as possible to enhance decision - making, determining the different alternatives that organizations and countries have in the decision - making process to make sure that they choose the best outcome, and finally, identifying the most sustainable decision and investment to get the best future outcomes. [1] According to the World Energy Council, two major scenarios have been defined to describe the global energy scenario by 2050. These include the jazz scenario and the symphony scenario. [23] The Jazz scenario refers to a situation where equity in individual access to energy is enhanced through economic growth. Just like in the music itself, the musicians (the head of the capitalist system) would have the freedom to improvise the laws that best fit, while the rest of the band (the global citizens) would follow the lead of the musicians. The symphony scenario encourages the fulfillment of environmental equitability through coordinating policies and practices. Just like in a symphony, the contribution and coordination of each member would be relevant to achieving the goal. [4] This paper defines global energy trends and scenarios by looking at global energy trends and scenarios, decarbonization policies, renewable energy sources, the security of supply and demand, and energy and development.

1.1 Global Trends and Scenarios

Large amounts of uncertainty surround the future supply and demand for energy, and it is challenging to forecast the patterns of impacting elements such as energy costs, global economic growth rates, demographic shifts, technology advancements, governmental regulations, and consumer behavior. [5] The World Energy Council's scenario projections show that, in contrast to past developments, the next several decades will see a more modest increase in overall energy consumption, with a further rise in the share of electricity in final consumption. [6] Over the next forty years, the world's electricity usage doubles. [7] Fossil fuels have significantly met the world's rapidly increasing energy demand during the last forty years. In 2018, the world's primary energy consumption was accounted for by oil, coal, natural gas, hydroelectric power, nuclear energy, and renewable energy sources at 33.6, 27.2, 23.9, 6.8, 4.4, and 4%, respectively. [8] One of the most significant advances in science and politics is the realization that we need global solutions that produce less carbon waste than fossil fuels. [9]

[1] Jim, Skea, Renée van Diemen, Joana Portugal-Pereira, and Alaa Al Khourdajie, "Outlooks, Explorations and Normative Scenarios: Approaches to Global Energy Futures Compared," *Technological Forecasting and Social Change 168* (2021): 1, https://doi.org/10.1016/j.techfore.2021.120736.

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[6] Oxford Institute for Energy Studies, "Key Themes for the Global Energy Economy in 2024" (January 2024), https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/01/2024-Key-Themes-Global-Energy-Economy-in-2024.pdf

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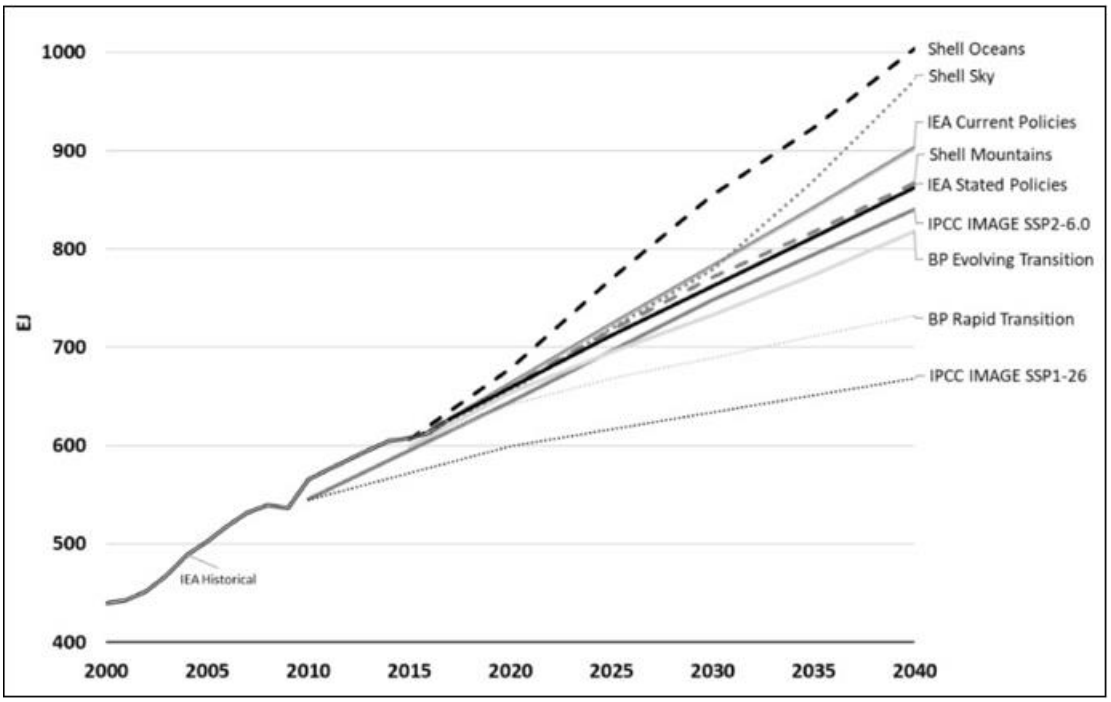
[9] Ibid

As defined in the introduction, the World Energy Council has tapped into music to help interpret the different scenarios that are expected in the future regarding energy use. Contemporary Jazz adopts a market - driven strategy. [10] The globe is incredibly productive, with robust technical advancement and rapid economic expansion. Sustainability is addressed by innovative, digitally enabled technology and new business strategies. Unfinished Symphony uses a government - led strategy to achieve sustainability via global collaboration. There is supposed to be a vast global network of fiscal incentives, including green subsidies and convergent and efficient carbon pricing. [11]

In Hard Rock, national interests obstruct efficient international cooperation, with little focus on mitigating climate change. The technologies that are required depend on what resources are available locally. The dominant force is protectionism rather than free trade. [12] Not all states will have the same model scenario. States can have different outcomes depending on the decision - making process and the interventions for handling issues such as sustainability. If the solutions created are done so through the optimization of regulation, then this is related to the unfinished symphony scenario. Where there is a solid commitment to the individual action of a nation or national unilateralism, the scenario most likely to happen is the hard rock. Finally, if future trends are shaped by innovation in the private sector, then the modern jazz scenario will take place. [13]



The graph above indicates the likely trends that are likely to take place when it comes to the demand for energy. As the world becomes more industrialized, the global energy market is expected to keep rising. For example, the 2020 forecasts have changed to account for COVID - 19 and the ever - changing expectations surrounding renewable energy. [14] In contrast to 2019 projections, the IEA predicts a decrease in renewable energy investment in the mid - 2020s but an increase in 2030 due to anticipated lower costs. In seven of the eight scenarios, the consumption of fossil fuels increases as 2040 draws near, averaging 19% over a range of 7% to 32%. [15] In the same seven scenarios, oil use increases by an average of 16%, ranging from 9% to 26%. Natural gas utilization is growing at an average rate of 43%, ranging from 28% to 56%. [16] Nuclear and hydropower expand by around 39% and 49% on average, respectively, yet still contribute only slightly to the total primary energy supply. [17] The ExxonMobil Outlook for Energy scenario shows a modest decline in bioenergy despite an average growth rate of 24%. [18] The most notable aspect is the rapid expansion of

[10] Kober, T., H-W. Schiffer, M. Densing, and E. Panos, "Global Energy Perspectives to 2060–WEC's World Energy Scenarios 2019," *Energy Strategy Reviews* 31 (2020): 1, https://doi.org/10.1016/j.esr.2020.100523.
[11] Ibid
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[17] Ibid
[18] Ibid

alternative renewable energy sources, primarily solar and wind power.

1.2 Policies of Decarbonization and Renewable Energy Sources

As noted in the discussion above, future trends are defined by the policies created in the current global situation. A worldwide agreement has been reached on the interconnected need to stop climate change caused by humans and to achieve sustainable development, as outlined in the Paris Agreement on Climate Change and the 17 Sustainable Development Goals (SDGs). [19] Rapid decarbonization of our global economy and an expansion of new technology to satisfy the demands of a modernized and expanding population are the fundamental shifts required to accomplish the 1.5°C target outlined in the Paris Agreement and the Sustainable Development Goals. [20] To stabilize the climate and keep global warming to 2 °C, global industry must completely decarbonize and achieve net zero greenhouse gas emissions by 2050–2070. [21]

Industry types usually referred to as "heavy, " "hard - to - abate, " or "hard - to - transition, " like steel, cement, and chemicals, account for 70% of worldwide CO_2 emissions from combustion and process sources. Approximately one - third of these emissions come from such industries. To keep +1.5°C within reach, the Paris Agreement committed to net - zero emissions by 2055 and consequently demanded an equal decrease in greenhouse gas (GHG) emissions from heavy industries. [22] This made for a significant shift in emission reduction measures. Decarbonizing heavy industry through policies and initiatives that employ a "one - size - fits - all" approach is impossible. [23] Instead, they must integrate various technologies and solutions that can be customized to each region's specific industrial structure, resource availability, political climate, and economic circumstances. [24]

The policies created to handle decarbonization can focus on both the demand and supply side dimensions of energy use. [25] The demand side covers the demand for materials that produce energy and their circularity. In contrast, the supply side considers energy efficiency, electrification, and new technologies, changing production activities to encourage using technologies that release less greenhouse gases and managing the carbon already released in the atmosphere. [26] Therefore, when considering the demand side, some of the policies that could be established include eliminating the subsidies placed on fossil fuels, incorporating stricter standards of fossil fuel use, having carbon pricing mechanisms in place, and promoting technologies that encourage low emissions of GHGs. On the supply side, there is a need for increased recycling rates, encouraging the return of waste to industries for processing, creating eco - friendly designs, and enhancing the recyclability of waste. [27]

The modern world is driven by capitalism, which thrives under mass production. This mass production is meant to handle the demands made by people and fulfill other demands made by the current civilization. [28] For example, the construction industry[29] is a significant part of modern civilization and involves carbon - intensive products such as cement, steel, and plastics. [30] The long - term decarbonization policies on the demand side would require that this demand be decarbonized by having policies that encourage alternative building methods. For example, the industry could rely more on Adobe bricks and glass and use minimal cement. [31] [32]The policies created on the demand side should promote minimal use of the products and the recyclability of the products.

In the same way, decarbonizing supply involves encouraging people and finding pathways to recycle products. In addition to promoting energy and material efficiency, recyclability, circularity, and innovation in the production and consumption of materials, these policies can also help to restructure the

[19] Rissman, Jeffrey, Chris Bataille, Eric Masanet, Nate Aden, William R. Morrow III, Nan Zhou, Neal Elliott et al, "Technologies and Policies to Decarbonize Global Industry: Review and Assessment of Mitigation Drivers Through 2070," *Applied Energy* 266 (2020): 114848, https://doi.org/10.1016/j.apenergy.2020.114848

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market. The ability of existing technology to eliminate emissions is restricted unless they are electric. Therefore, through research, development, and commercialization, policies should encourage the creation of next - generation, ultra - low - emitting techniques.

1.3 Renewable Energy

Many policies related to decarbonization point to energy use that does not support excessive carbon waste. About 156 nations and areas have enacted laws encouraging renewable energy as a critical first step in mitigating global warming. [33] Renewable portfolio standards (RPS) and feed - in tariffs (FIT) are the most often utilized schemes. The Feed - in Tariff (FIT), a price - based fiscal policy, requires the government to buy electricity generated by renewable energy sources at a specific price for a preset amount of time. For several years, this approach has been successfully adopted in several nations, including Germany, Denmark, and Spain. [34] There has been much discussion and disagreement on the effectiveness of various programs designed to promote renewable energy. Most academics[35] [36]agree that the FIT plan considerably lowers investment uncertainty in renewable energy projects, encouraging the deployment of renewable energy compared to the RPS program. [37] However, because of the high cost of subsidies, implementing the FIT plan has also presented substantial hurdles to the budgets of many countries.

Policymakers are still concerned that renewable energy sources won't be able to supply the growing electricity demand promptly. [38] But there's plenty of evidence to suggest that this is a mistake. The advancement of technology and declining costs have led to a surge in renewable energy investment: China currently possesses the most extraordinary capacity for solar, wind, hydropower, and biogas. In contrast, South Korea leads the world in tidal energy production, while Mexico, Indonesia, and Kenya are the top geothermal energy producers. Costs for renewable energy have decreased dramatically in recent years: from 2015 to 2020, prices for solar PV were down 56%, onshore wind was down 45%, and prices for battery storage were down 64%. [39] This indicates that renewable energy forms a significant part of modern development, especially in making sustainable development.

1.4 Energy and Development

Energy infrastructure can support development and economic progress in several ways. First, companies use electricity as a critical factor in their operations. Research indicates that electricity is not easily substituted with other production inputs, which could limit output if it is absent. [40] Second, the state uses energy to provide essential public services like education and health. Third, using electricity can lead to efficiency advantages in areas like communication, time savings, and educational investments, as well as a direct improvement in the well - being of the household. Infrastructure must be in place to guarantee that energy can be used effectively. Collaboration is required throughout the entire electrical grid, which is a network of infrastructure consisting of wiring, metering, distribution, transmission, and generating. Any step can have a weak link that prevents productive utilization.

The challenge facing developing nations is how to best acquire and use these much more significant amounts of energy in a way that is sustainable and encourages ongoing economic progress. In this sense, the need for increased supply is primarily driven by the rising demand for and usage of energy for local consumerism. Developing nations' decisions to address the twin issues of rising supply and demand will significantly affect markets, geopolitics, the global economy, and the dynamics of climate change. Meanwhile, despite recent notable economic progress in emerging nations, many people still live in extreme poverty and lack access to clean cooking or electricity.

Energy, whether in the form of nuclear power, renewable energy sources, fossil fuels, or energy efficiency, has been essential to the efforts of developing country governments and people to improve living standards. [41] Although there are various approaches to identifying and characterizing development, people have been moving out of poverty and, in some cases, closer to prosperity across a range of spectrums (political systems, economic structures, income, geography, and other factors), and energy has been a crucial input in the production of those goods and services.

What remains abundantly clear is that energy is an essential element of development. As the world strives to achieve sustainable development, it must also ensure that energy use is sustainable. The shift to a new energy paradigm that can handle the three global concerns of environmental

[33] Li, Li, Shuai Wang, Jiaqi Wu, and Zhenqing Sun, "Exploring The Efficacy of Renewable Energy Support Policies in Uncertain Environments: A Real Options Analysis," *Energy Economics* 132 (2024): 107467, https://doi.org/10.1016/j.eneco.2024.107467

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preservation, energy security, and socioeconomic development depends on sustainable energy. Sustainable energy and renewable energy are closely related concepts. Thus, it's crucial to remember that to comprehend sustainable energy, it must also be inexpensive and used efficiently. Every industry is supported by a robust energy system, including commerce, healthcare, education, infrastructure, agriculture, communications, and advanced technologies. Poorer nations' access to power has started to pick up speed, energy efficiency is improving, and renewable energy is progressing remarkably. However, increased work is required to increase accessibility to safe and clean cooking fuels.

Sustainable development involves considering all the themes in this paper: the current trends and future energy use scenarios, decarbonization policies, and the supply and demand policies of energy use. Decarbonizing the energy supply is primarily dependent on sustainable energy. Additionally, it lessens reliance on fossil fuels and has created millions of jobs globally. Sustainable energy is clean and environmentally benign from the source to the manufacturing process, and it goes hand in hand with economical use. We can only guarantee that the demands of future generations are not jeopardized by our current energy usage in this way.

Energy efficiency and renewable energy complement each other. When combined, they can result in a quicker decrease in energy intensity and cheaper energy bills. Synergies between energy efficiency and renewable energy examine how these factors work together to reduce technological and energy system costs, reduce air pollution, and prevent harmful health consequences from pollutants. Improving the interaction between energy efficiency and renewables can significantly affect the environment and society. One is less air pollution, which is a true killer. Another recent study revealed that the increased use of solar and wind energy in the US has, for instance, saved about 13, 000 lives.

2. Conclusion

Energy infrastructure will be in tremendous demand due to the acceleration of climate change over the next century. Natural catastrophes will become more frequent and severe, making infrastructure susceptible. Furthermore, a rise in the number of hot days would probably lead to a need for more cooling in homes, which will increase energy consumption due to climate change. Improving energy services could also lead to a rise in greenhouse gas emissions. [42] To lessen the effects of energy consumption on climate change, which promotes energy consumption, energy infrastructure must facilitate the switch by lower - income families from conventional to modern fuel sources and from fossil fuels to renewable energy for grid electricity.

By emphasizing energy - efficient behaviors, investing in renewable energy resources, and implementing clean energy technology and infrastructure, nations may hasten the transition to an inexpensive, dependable, and sustainable energy system. Companies can pledge to source all their operational electricity needs from renewable sources and maintain and safeguard ecosystems. Renewable energy sources are essential to the energy sector's future since they are economical, secure, and respond to climate change. They provide LMICs with a cheap, plentiful, clean, and readily available energy supply that protects them from fluctuating and high fossil fuel costs, reliance on energy - exporting nations, and a negative trade balance with the rest of the world. Renewables offer enormous future promise, even in countries that depend on the export of gas and oil.

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