



PROGRESS IN RENEWABLE ENERGY RESEARCH FOR SUSTAINABILITY: A MOVEMENT TOWARDS LOW CARBON WORLD

Dr.Purva Mange¹, Dr.Nandini Kulkarni², Anish Kumar Bhunia³,
Prasanna Titarmare⁴, Dr.Shrikant Burje⁵

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Abstract

Aim and objectives: The current study has been developed to find out the progression of renewable energy for the purpose of sustainability which leads to the movement towards a lower carbon world. In that objectives have been set like transformation with renewable energy use, future scope generating from lower carbon world, and current uses of renewable energy use. **Major findings:** Changes that are happening in the process of transformation of energy source uses are noticed. Country-wise changes in the use of renewable energy sources and their impact on the environment, economic and health perspective are observed. Compared with non-renewable sources the leading adverse impact of limiting scope by renewable energy is observed. **The novelty of the work:** Current research is not focusing on the types of renewable sources or their scope of its. Research showcasing the state of progression has been developed for renewable energy sources and their impact on the lower carbon world. Specification and discussion dimensions are unique for the current study.

Keywords: Renewable energy source, lower carbon world, sustainability, non-renewable energy sources.

¹Associate Professor and HOD, Symbiosis School of Planning, Architecture & Design (SSPAD) Symbiosis International (Deemed University) (SIU), Mauza Wathoda, Nagpur, Maharashtra, India Email: purva.mange@sspad.edu.in Orcid id- 0000-0002-8796-8393

²Professor and Dy Director, Symbiosis School of Planning, Architecture & Design (SSPAD) Symbiosis International (Deemed University) (SIU), Mauza Wathoda, Nagpur, Maharashtra, India Email: deputydirector@sspad.edu.in Orcid id 0000-0001-9575-9113

³ PhD Reseach Scholar, National Institute of Technology, Arunachal Pradesh anisbhunia@gmail.com

⁴ Professor of Electrical Engineering, Suryoday College of Engineering & Technology, Nagpur pptelect@gmail.com

⁵ Dept of Electronics and Telecommunication, Christian College of Engineering & Technology, Bhilai, CG. India, Email -shri97397@gmail.com

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1. Introduction

Practices of using non-renewable sources for electric generation purposes make the worldwide threat of industrial air pollution. Now if looking for the specific reason for having disadvantages or else consequences for electric generation is because non-renewable sources are responsible for environmental damage. Comparing it with renewable energy sources the main identified difference is their ability to electricity generation without even producing CO₂. In a detailed investigation of the growing concern for the repeated use of non-renewable energy sources are include the following

After looking at the negative aspect and having a concern for sustainability knowledge need is to be shared about what potential benefits can be gained through non-renewable energy sources. Through the current developing research, every aspect that can be generated through renewable energy has been measured and discussed. In the process of developing sustainable energy challenges are underlying in this path. Looking for the specific factors that causing the impact for the development of sustainable energy are include threat of spontaneous growth of energy demand and the impact of green house gas impact. Development sustainable goal for energy include accession growth for electricity and reduction the impact of energy subsidies.

2. Aim and Objectives

Aim: Current research is aimed at finding out the progression of renewable energy for the sustainability movement towards low carbon world.

Objectives:

- To analyse the scope of sustainability gained through the transformation with renewable energy sources.
- To analyse the future scope of the lower carbon world movement to enhance sustainability.
- To analyse current practices of renewable energy sources to facilitate the path of a lower carbon world.

3. Renewable Energy the Way of Securing Sustainability

3.1 Energy security

Looking back on previous updated report about the worldwide energy scarcity it has been observed that 1.4 billion suffering lack of

electricity. It makes sense about the falling balance of demand and supply in electricity generation. After that phases and changes for the electricity generation showed the positive impact for improving universal electricity access for Asia specific. Changes are processed through integrating other sources without generating the risk for the negative impact for the energy subsidies. Information that is identified from 2012 published report, traditional energy production source that is biomass only for that age of electricity generation. Fuel diversification and supplier reliability make the need for developing a dependency on the use of energy security provided by renewable energy sources. The scope of generating the research on the diversification of renewable sources limited the pressure on fossil fuels. The availability of renewable energy sources is comparatively higher which is quite obvious in that considering the need for fuel importing got reduced [1]. The benefits of conservation of natural resources are possible by generating the use of renewable energy use.

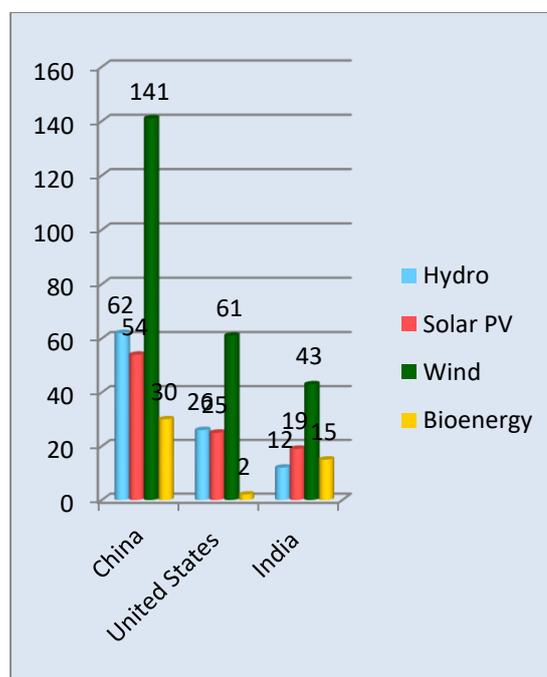


Figure 1: Renewable Energy Generation Tendency in Different Country

(Source: [16] Güney, Taner 2019)

From the above figure fuel diversification about renewable energy sources has been analysed for measuring the growth of use. Hydro, solar PV, wind and bioenergy are the

sources for developing evaluation. It has been noticed that China is competitive in more use of these sources rest of the others countries are taken for measuring [2]. Progression and working with renewable energy are happening which makes the hope for sustainability gain at the end of the transformation. Among these four renewable energy sources the main gap is found for bioenergy. In a positive sense, the change in sustainability stability is happening. Apart from these diversification benefits, others benefits that are supportive of sustainability have been measured here.

3.2 Economical Changes that are underlying Transformation

Collaboration study of DOE (Department of energy) and EIA (Energy Information Administration) of US transformative change that is linked with the involvement of renewable sources used in energy production then following transformation can result [3]. Below is delivered information about the potential changes in only about 10% use of renewable energy. Lack of accession issue and affordability for the high rise pricing makes the need for choosing for alternative energy sources. From more gnarl sense having better light and electricity infrastructure provide the advantage of better economical support formation. It needs to be understood that working with strengthening of the electricity makes the higher scope of improving the outcome for world population. Reaching out to the specific or basic rights of electricity and the presence of affordability complication makes the negative consequences to dealing with other consequences makes the need of bring change for renewable energy sources integration.

2020 Practices of Renewable energy causing Transformative changes		
Benefits for consumers	for	The reduction of the electricity bill is noticed to be dropped from \$21.6 to \$36.6 billion[4].
Socio-economical		The opportunity for the job is increased to 91,221.
Economical		Generating scope

	for newer investment is increasing for 41.5 billion additions to its local tax revenue is generated up to \$2.9 billion.
Environment	Global warming reduction.

Table 2: Transformation that is linked with Renewable energy sources

(Source: [15] Nižetić, Sandro, et al. 2019)

From the above table, only 10% transformation-induced change for the releasing benefits has been measured for multiple dimensions [5]. It makes the scope for understanding the value of integrating renewable energy sources. Sustainability is the term that is linked with the operation state and that leading circumstance If looking at the statistical scale of using non-renewable energy sources then it can cause a direct impact the scarcity which is not limited to electricity generation but also for the surroundings [5,6]. The standard of sustainability that is led by the use of renewable energy has been discussed in the future hope-creating aspect.

Price stability is high enough to make its need for the process of transformation. It has been observed that year-wise changes in the use of diverse fuel sources of renewable energy lead to secure stability for pricing. There is the reason for its price lowering is because of availability which further is not a demand for importing. It makes the different levels of flexibility dimension upon which the scope of generating sustainability has become more functional. The flexibility of supplying makes the scope of offering flexible prices that they can use to bring the change for non-renewable sources causing limitations [7]. Concern of growing higher pressure from carbon di-oxide make the chances facing the dealing threat of global warming. As well as changes for the climate changing is observed in more effective form. It makes sense for bring the change of working with CO₂ controlling through energy generating activity. Responsibility of CO₂ for 60% production of GHG s noticed that need to be preventing for make any concern for the

future concern. Without having the electricity generating sustainability by renewable energy sources a chance of working with better scope is get limited.

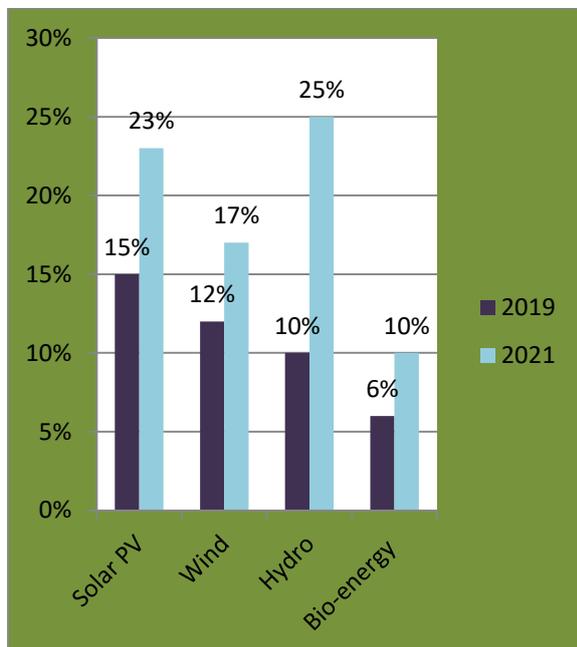


Figure 2: Year-wise Renewable Energy Usage Growth

(Source: [12] Vaka, Mahesh, et al. 2020)

The above figure is the reflection of the changes happening in the use of renewable energy which adds the scope for gaining advantages for the outcome impact [8]. The increasing rate of involvement is decreasing the threat to the world. Even the discussed benefits like pricing, and environment all get covered as the chances of stimulating the impact for the bright future of sustainability can be generated through the end of these changes.

3.3 Scope for Environment and Electricity Balance

Just a glance over the existing reports about traditional electricity generation it has been clear that the emission of that system is not even healthy for the environment and human health also. Established statistics about the responsibility of CO₂ releases by traditional electricity generation is near about 38%, not a negligible percentage at all [9]. The threat of climate change is another area of concern. Just a change for the using resources eventually makes the scope for generating a better outline

for electricity generation followed by lesser consequences.

Looking at other parameters that are contributed through the use of traditional electricity generation can make sense of how much the value is lying for the renewable energy source. 66% SO₂ is released and if observing their consequences then the severity of posing environmental and human health hazards can be measured [10]. Around 40% of mercury is released from the traditional process of electricity generation which continuously raises the concern for making the scope for enhancing the need of replacing non-renewable energy sources [11]. Observing the other parameters that are released through the traditional system is repeatedly affecting the security of sustainability. It needs to be well managed so at least future scope can be formed.

4. Identification of the Transformation Towards Lower Carbon World

4.1 Overview of Lower Carbon World

The threat of climate change and the leading vulnerability of global warming makes the need to initiate the changes that can make it safe for the future. In that consideration, the main is reasonfor happening these worldwide changes is just because of the increasing rate of releasing CO₂ [12]. The need of lowering the rate of releasing carbon has become an essential initiative for every industry in the world. It is because without sustainability there is no meaning of working for industrial growth. Before going to the main part of developing a lower carbon world glance over country-specific emission records can make the realization easier.

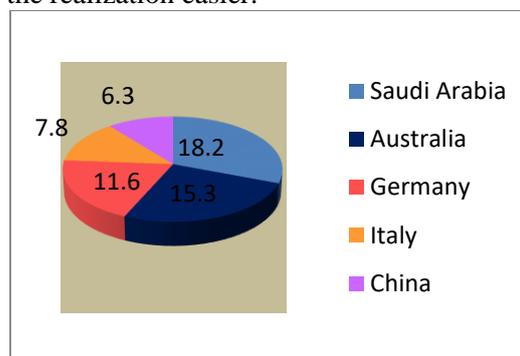


Figure 3: Country Wise Emission Rate (Source: [10] Hao, Lin-Na, et al. 2020)

From the above figure, the emission rate has been presented to highlight the sensitivity for making the move for a lower carbon world. It is not only essential for economic benefits but

also crucial from environmental and human health perspectives. It needs to be understood that different country already understands the crisis and make a change to the activity associated with lower carbon emission [13]. Just look at the above figure where it can be observed that China is comparatively in a better position than Saudi Arabia and the rest of the others. It is essential to look that awareness is spreading and active participation can ensure the possibility of having a better sustainable future.

It has been noticed that a complete change can be initiated with the use of renewable energy and that stimulates the reduction of cost and energy requirements [14,15]. The barrier which is still affecting the full phase growth is policymakers it needs to be considered as essential as it enhances the chances of smoothening the process and making the support for a lower carbon world. The Target of 2050 for making the global CO2 emission reduction up to 99.7% is noticed and the use of 80% renewable energy is expected within 2030 [16].

4.2 Still Now Occurred Changes of Using Renewable Energy

Changes that are happening with the passing year are compared with the future scope generation. Fossil fuel is the most usual electricity-generating source that causes negative consequences widely. Here the comparison has been developed with passing years of changes happening for the use of fossil fuel and replacing it with renewable energy sources. Year-wise changes in direction have been measured through the use of the graphical presentation below.

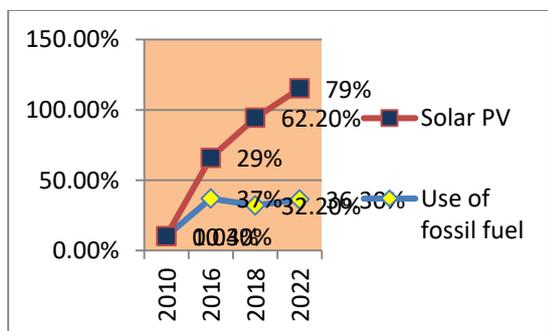


Figure 4: Year-wise happening Change of Replacement

(Source: [8] Li, Li, et al. 2022)

From the above figure, it has been observed that fossil fuel leading consequences makes people aware of the leading harm. Apart from

this pricing and availability that is also day by day become a concern. Understanding this severity a comparison of several years of gapping changes has been presented in the above graph. It shows the changing pattern that is developed because of the potential of sustainability. The initiation value of 2010 is covered which predicts that in that phase fossil fuel was quite higher than renewable energy sources [17]. The change that happened for this application started in 2018 and the impact of changes in the environment protection act, and government involvement started to create pressure to ensure the sustainability that is reflected in year-wise happening change.

Raise challenges from commodity pricing increases in 2021 to make the scope for reducing the choice for fossil fuel [18]. It has been noticed that the high pricing of fossil fuel and the volatility of the economy is continuously shifting the focus to better choices of alternatives. A change of 63% is noticed for the replacement of energy sources with solar PV [19]. Looking at the strength and generating potential hope for having a better outcome is on the way.

4.3 Future of this Happening Changes towards Lower Carbon World

Renewable energy sources are considered one of the cheapest options in the world. 2010 to 2020 updated reports about the fall of electricity pricing are noticed for 85% just because of using solar PV [20]. Fall is also noticed for the other sources of renewable energies like offshore and onshore wind are gradually 48% and 56% [21]. Having this pricing flexibility enhances affordability and produces the benefits of wider accession. It has been expected that within 2030 renewable energy will become able to produce 65% of the world's electricity.

Matter of Concern	Responsible
Growth of acid rain frequency American Lung Association indicates the direct threat of respiratory illness.	Release of SO₂ from electric generation
Mixed with sunlight creates the probability of smog Lowering the immunity against infection.	The NO_x reaction that comes from electric generation

Ground-level formation	smog	O3 is responsible.
Global warming is the most affected concern.		CO2 is causing this tendency.

Table 2: Non-renewable Energy Sources Leading Consequences

(Source: [22] George et al. 2021)

The reason for putting that emphasis on renewable energy sources is because of making the knowledge of the increasing rate of coal and gas prices. The last 2018 report on Fossil fuel leading health consequences reveal the fact of \$2.9 trillion in death occurred from this [22]. The loss of economical scale per day was \$8 billion. Changes by the inclusion of renewable energy can make the safety for working with better future sustainability. It needs to be understood that switching to renewable energy will not only ensure a clean environment et but also safety for the economy and human health. Apart from this aspect, it has been noticed that each spending on renewable energy sources causes three times more job opportunities. It has been estimated that within 2030, 14 million new jobs will be created [23]. Comparing the need for investment it has been noticed that for fossil fuel there was a \$5.9 trillion investment whereas, for renewable energy sources, it is near about \$4 trillion [24].

5. Observation of the Worldwide Practices for Renewable Energy

5.1 Comparing the Changes in Using Renewable Energy Sources

Switching the use of non-renewable energy makes the potential for outcome changes in the lower carbon world movement. Different sources are there under the renewable energy sources category that can work at their best to ensure the safety and well-planned balance for the economy, environment and human health [25]. In North America super grid formation to overcome the poor availability of energy production scope and align it with world demand for energy production is getting matched. In this leading path of change initiation need of working in collaboration with policy makers, and engaged organization is useful.

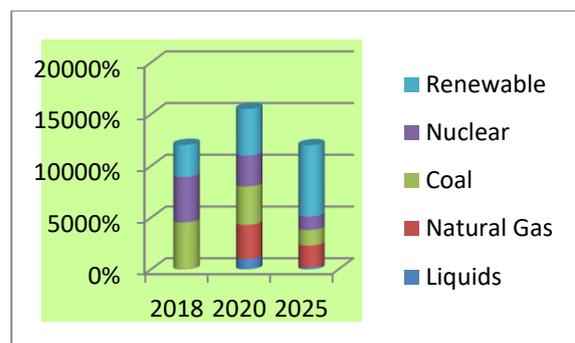


Figure 5: Year-wise Changes in World (Source: [5] Sovacool, Benjamin 2021)

From the above figure, it has been observed that working with updated knowledge and active participation for moving forward lower carbon world then needs to change initiation required. It has been identified that the passing year leads to the fall of using non-renewable ones and looking forward to renewable sources. It makes the scope for having control of emissions. The reason is for presenting this aspect to make a view about the perception towards a lower carbon world which enhances stability and well-balanced sustainability.

A cut-off potential for pollution control is another leading way to have the change in favour which can work best for human health. Emissions get reduced along with clean environment can be developed that can work best for the world. It needs to be understood that fossil fuel is causing tremendous hazards for the future aspect that can be overcome. Constant vulnerability hazards for the human and economical state can be changed through the use of transformation by the use of non-renewable energy sources.

5.2 Current State of Using Lower Carbon

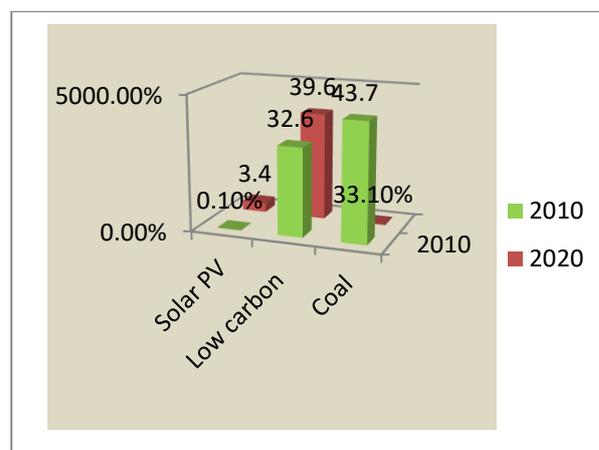


Figure 6: 2010-2020 Changes in Using Pattern of Renewable Sources (Source: [27] Li, Li, et al. 2022)

From the above figure, it has been noticed that working with a changing pattern makes an impact on outcome handling. Looking at 2010 when the coal use rate was 43.7% that become 33.10% after 10 years gap. It is because of the awareness and knowledge spreading for the use of higher coal can decline the stability of living and growth. Compared with lower-carbon uses that are the main part of highlighting eventually grow with the passing year. In 2010 it was 32.6% which turn into 39.6% by 2020 [26]. It indicates that change is happening gradually over the world. Importance of high-quality low carbon as fuel is noticed that causes the direct impact for preventing green house gas emissions. Growing energy demand and the considering impact of electricity generating threat makes the need for going for alternatives. Need of paradigm to ensure the change for transformative of energy system is noticed.

6. Final Findings

The analysis of progress in renewable energy research for sustainability can be conducted by examining the amount of renewable energy generated, the share of renewable energy in the total energy mix, the number of renewable energy projects completed, the cost of renewable energy, and the amount of investment in renewable energy [11]. This type of analysis can also be used to identify the types of renewable energy sources that are being used, such as solar, wind, biomass, and geothermal energy. The analysis also provides insight into the type of renewable energy sources that are being developed and the potential of these sources in terms of their ability to reduce carbon emissions. This type of data analysis can also be used to identify the barriers to the development and use of renewable energy sources. These barriers can include a lack of infrastructure, a lack of investment in renewable energy sources, and the cost of renewable energy compared to traditional sources. In addition, the data analysis can help to identify potential policy solutions that can be implemented to overcome these barriers and encourage the growth of renewable energy sources.

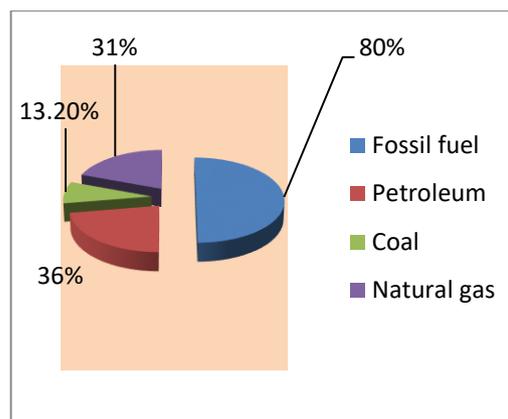


Figure 6: 2018 Electricity producing Sources

(Source: [2] Hoang 2021)

The progress in renewable energy research for sustainability has been a major focus in the past few years, with a strong effort being made to move towards a low carbon world. This effort has been driven by the need to reduce global emissions, which are the primary cause of climate change. The data on the progress in renewable energy research for sustainability can be divided into three main categories: research funding, technology development, and policy development. Research funding is an important indicator of progress in renewable energy research for sustainability. In 2019, the total global investment in renewable energy research and development was estimated to be \$141 billion, an increase of 4% from the previous year. Most of this investment was from the private sector, with the public sector providing only a small fraction of the total [24].

Technology development is another indicator of progress in renewable energy research for sustainability. In 2019, the total number of renewable energy patents filed globally increased by 16%, and the number of renewable energy projects under construction increased by 8%, indicating an increased focus on technology development. Finally, policy development is also an important indicator of progress in renewable energy research for sustainability. In 2019, 163 countries and regions had renewable energy policies in place, an increase of 7% from the previous year. Additionally, the number of countries that had either implemented or proposed new renewable energy policies is increased by 9% over the same period.

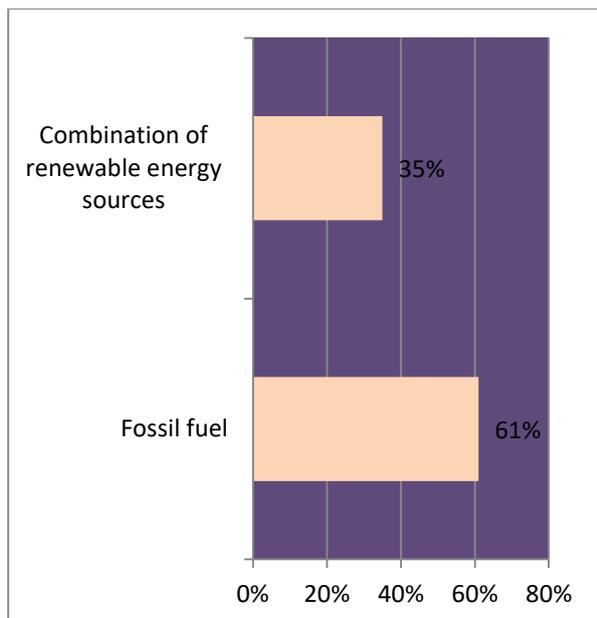


Figure 7: Gap of Renewable Energy Sources Usability

(Source: [10] Hao 2021)

Overall, these data suggest that there has been significant progress in renewable energy research for sustainability in the past few years. The total investment in renewable energy research and development has increased, the number of renewable energy patents filed globally has increased, and the number of countries that have implemented or proposed new renewable energy policies has also increased. This progress is important for the advancement of a low carbon world, and further investments and research efforts are needed to continue to move towards this goal. Overall, progress in renewable energy research for sustainability is essential for understanding how the world is making strides toward a low-carbon future. By examining the data, it is possible to identify areas of progress and potential for further development, as well as areas where more work needs to be done. This data analysis can also be used to identify the types of renewable energy sources that are being used, the cost of renewable energy, and the barriers to the development and use of renewable energy sources. With this data analysis, it is possible to identify potential policy solutions to encourage the growth of renewable energy sources and help the world move towards a low-carbon future.

The need of using renewable energy has become a crucial need to move forward to a lower carbon world. It has been noticed that

diversified sources of renewable energy make a way of better involvement. From figure 1 current state of operations has been observed to understand the transforming choices and their induced benefits for the world. Hydro, solar PV, wind, and bioenergy four categories have been measured to bring the scope of reducing the scarcity of energy production through non-renewable energy sources [27]. It has been identified as the values of using solar PV and wind bio-energy still need to be more developed to gain the expected involvement.

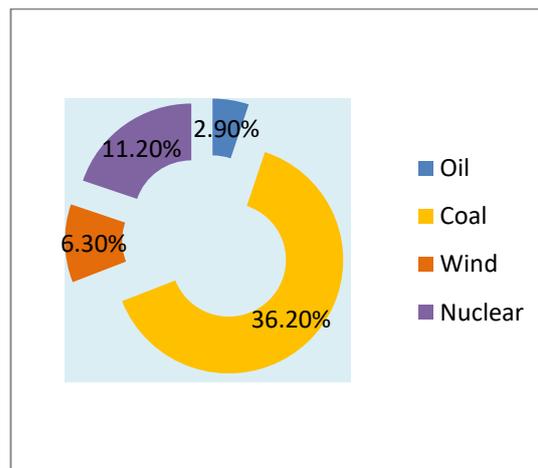


Figure 8: Electricity Generation by Fuel Types
(Source: [4] Temper 2020)

Transformative change that is induced by the integration of renewable energy includes consumer benefits, health and environmental safety along with economic growth. Having better accessibility and lesser need for importing saves the operating cost which provides better operating scope for the use of renewable energy. From figure 2 changes that are happening around the world over the passing year have been observed. It makes sense about the growth of energy sources use especially for renewable sources. Most growth is hit for solar PV and hydro. The rate of affecting from traditional electricity is more concerning for human and environmental considerations [28].

The need of moving towards a lower carbon world need of having information on the current emission rate of countries is essential. From figure 3 it can get clear as the region according to emission has been covered here. Even the generating future scope of having the world of reduction in CO₂ emission within 2050 is noticed. Target setting is the step that brings every industrial activity under this

controlled regulation [29]. An understandable comparison has been presented between the use of solar PV and fossil fuel for electricity generation. It can make sense about awareness is spread in the industry which enhances the possibility of working with better opportunities.

From the interest of observing the future scope that can be developed using renewable energy sources including electricity cost fall as the sources become accessible. 2018 incidents of fossil fuel leading to health concerns and deteriorating economic loss make sense for the change that needs to be implemented to ensure the higher potential of future sustainability [30]. Security and a well-managed future scope through renewable energy can make the ultimate change for the world.

7. Conclusion

From the current research analysis, current state of progression has been measured for renewable energy sources. In the last few decades, research into renewable energy has advanced remarkably. It is now a crucial component of the worldwide drive to cut carbon emissions and transition to a low-carbon world. The cost-effectiveness and dependability of renewable energy sources like solar, wind, and hydropower have increased, enabling their wider adoption and use. Also, customers are becoming more and more drawn to renewable energy because to the development of new technologies like storage and smart grid systems. Many nations are currently introducing laws and incentives to encourage the use of renewable energy as a result.

The study of renewable energy has advanced significantly over the past few decades and has shown to be a workable way to lessen the negative effects of climate change. Fossil fuels might be replaced with renewable energy sources, which would lessen the quantity of carbon dioxide discharged into the atmosphere. Also, the creation of renewable energy sources is more resource-efficient and cost-effective, making them a feasible choice for the production of sustainable energy. For our world to be sustained over the long run, we must switch to renewable energy. Renewable energy sources can offer a dependable and clean source of energy for the future with the help of innovation and technology. This will

assure a more sustainable future for everyone and help us transition to a low-carbon society.

8. Future Scope

- Throughout the past few decades, research on renewable energy for sustainability has advanced significantly. Governments and academic institutes have made significant investments in the study of renewable energy sources as part of a global effort to transition to a low-carbon world.
- Focusing on increasing the effectiveness of already available renewable energy sources as well as looking for and developing new sources is necessary to maintain this development. The future of renewable energy depends on the creation of effective and affordable energy transmission and storage systems. The successful implementation of renewable energy projects relies on the creation of new business models and financial instruments.
- Future research should focus on improving the affordability and dependability of renewable energy sources. This can entail increasing the effectiveness of currently used renewable energy sources like solar and wind in addition to looking into additional possible sources like wave, tidal, and geothermal energy.
- In order to increase the dependability of renewable energy sources, research should concentrate on creating energy storage technologies, such as batteries and other types of energy storage. In order to promote the implementation of renewable energy projects, research should also examine the creation of new financial instruments and business models.
- Research should also concentrate on the creation of new financial instruments and business models, as well as efficient and affordable energy transmission and storage technologies. It will enable the study of renewable energy to advance in the direction of a low-carbon future.

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