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A REVIEW OF RENEWABLE ENERGY SOURCES, SUSTAINABILITY ISSUES

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Abstract: To satisfy human social and economic development, welfare and health, the need for energy and its related services is increasing. Since the earth cannot change its form and due to increase in daily requirement of energy, the world is becoming a global village by all population across the world. In order to meet energy demand of future generations, returning to renewable is an excellent approach which needs to be sustainable. India is world's 3rd largest consumer of electricity and world's 3rd largest renewable energy producer with 38% of energy capacity installed in the year 2020 (136 GW of 373 GW) coming from renewable sources. Besides the opportunities associated with renewable energy sources which includes: Energy Security, Energy Access, Social and Economic development, Climate Change Mitigation, and reduction of environmental and health impacts, there are challenges like market failures, lack of information, access to raw materials for future renewable resource deployment, and our daily carbon footprint that hinder the sustainability of renewable energy sources. Some measures and policy recommendations helped to achieve the goal of renewable energy thus reducing emissions, mitigate climate change providing a clean environment as well as clean energy for all and future generations.

Keywords: Renewable energy sources and sustainability, Renewable energy sources and technology, sustainability issues, clean energy,

Introduction:

In our everyday life, as a way of improving human development leading to economic growth and productivity, energy is one requirement. In order to ensure a sustainable future and bequeath future generations to meet their energy needs, return-to-renewable is an excellent way but needs to be sustainable. Regarding the interrelations between sustainable development and renewable energy the studies are limited. Through this study, the opportunities associated with renewable energy sources; energy security, energy access, social and economic development, climate change mitigation and reduction of environmental and health impacts are brought into light.

To satisfy human social and economic development, welfare and health, the need for energy and its related services is increasing. To meet basic human needs such as: health, lighting, cooking, space comfort, mobility and communication, all societies call for the services of energy and serve as generative processes. (Edenhofer et al., 2011). For a sustainable future, the two-over riding challenges of energy sector on the road are securing energy supply and curbing energy contribution to climate change (Abbasi & Abbasi, 2010; Kaygusuz, 2012). In today's world 1.4 billion people lack access to

electricity, while 85% of them live in rural areas. As a result of this, the number of rural communities relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 (Kaygusuz, 2012).

History says that the first recorded commercial mining of coal occurred in 1,750, near Richmond, Virginia. Due to its more energy carrying capacity than corresponding quantities of biomass-based fuels (firewood and charcoal) momentarily, coal became the most preferred fuel for steam engines . In the past centuries it was observed that coal was comparatively cheaper and a much cleaner fuel as well (Abbasi, Premalatha, & Abbasi, 2011). Due to exponential increase in population for the past decades, the dominance of fossil fuel-based power generation (Coal, Oil and Gas) have led to a growing demand for energy resulting in global challenges associated with a rapid growth in carbon dioxide (CO2) emissions (Asumadu-Sarkodie & Owusu, 2016a). Climate change has become one of the greatest challenges of the twenty-first century. To displace greenhouse gas emissions from fossil fuel-based power generating and thereby mitigating climate change (Edenhofer et al., 2011), renewable energy sources hold the key potential. Sustainable development has become the centre of recent national policies, strategies and development plans of many countries. The United Nations General Assembly proposed a set of global Sustainable Development Goals (SDGs) which included 17 goals and 169 targets at the UN in New York by the Open Working Group. In addition, a preliminary set of 330 indicators was introduced in March 2015 (Lu, Nakicenovic, Visbeck, & Stevance, 2015). The SDGs place greater value and demands on the scientific community than did the Millennium Development Goals. a coordinated global monitoring and modeling of many factors which are socially, economically and environmentally oriented In addressing climate change, renewable energy, food, health and water provision, a coordinated global monitoring and modeling of many factors which are socially, economically and environmentally oriented is required. (Hák, Janoušková, & Moldan, 2016; Owusu, Asumadu-Sarkodie, & Ameyo, 2016).

To achieve sustainability, it is evident in literature that fossil fuel-based energy sources are replaced with renewable energy sources like bio energy, direct solar energy, geothermal energy, hydropower, wind and ocean energy (tide and wave). In today's world, the Governments, intergovernmental agencies, interested parties and individuals look forward to achieve a sustainable future due to the opportunities created in recent decades to replace petroleum-derived materials from fossil fuel-based energy sources with alternatives in renewable energy sources.

Renewable energy sources and sustainability:

Without being depleted in the earth, naturally renewable energy sources replenish themselves. These sources include bio energy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy. The main renewable energy forms and their uses are presented in Table 1.

In all economies, reliable energy supply is essential for heating, lighting, industrial equipment, transport, etc. (International Energy Agency, 2014).If replaced with fossil fuels, renewable energy supplies reduce the emission of greenhouse gases significantly .Since renewable energy supplies are obtained naturally from ongoing flows of energy in our surroundings, it should be sustainable. For renewable energy must be limitless and provide non-harmful delivery of environmental goods and services to be sustainable. A sustainable bio fuel should not increase the net CO_2 emissions, should not unfavorably affect food security, nor threaten biodiversity (Twidell & Weir, 2015).

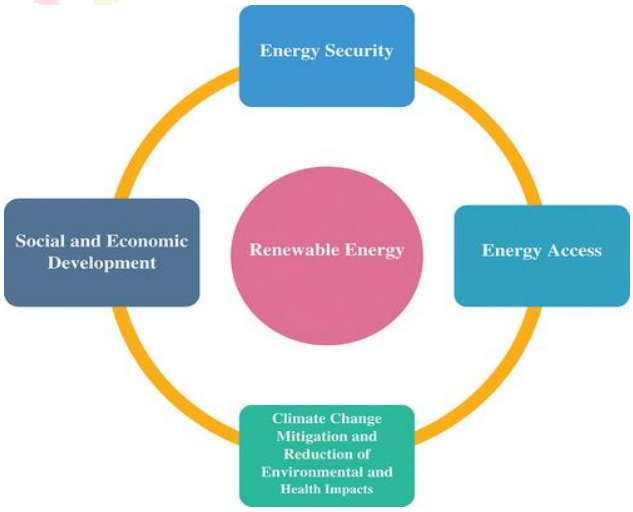
Table 1. Renewable energy sources and their use (Panwar et al., 2011)

Energy sources	**Energy conversion and usage options**
Hydropower	Power generation
Morden biomass	Heat and power generation, pyrolysis, gasification, digestion
Geothermal	Urban heating, power generation, hydrothermal, hot dry rock
Solar	Solar home systems, solar dryers, solar cookers
Direct solar	Photovoltaic, thermal power generation, water heaters
Wind	Power generation, wind generators, windmills, water pump
Wave and tide	Numerous design, barrage, tidal stream

Besides advantages of renewable energy sources, some short coming exists such as: the discontinuity of generation due to seasonal variations as most renewable energy resources are climate-dependent, and hence its exploitation requires complex design, planning and control optimization methods. The continuous technological advances in computer hardware and software are permitting scientific researchers to handle these optimization difficulties using computational resources applicable to the renewable and sustainable energy field

Opportunities of renewable energy sources:

To the world at large presently, the term "climate change" is of great interest, in scientific as well as political discussions. Since the beginning of creation, climate has been changing but the speed of change in recent years is what alarming and it may be one of the threats facing the earth.



Renewable energy and climate change:

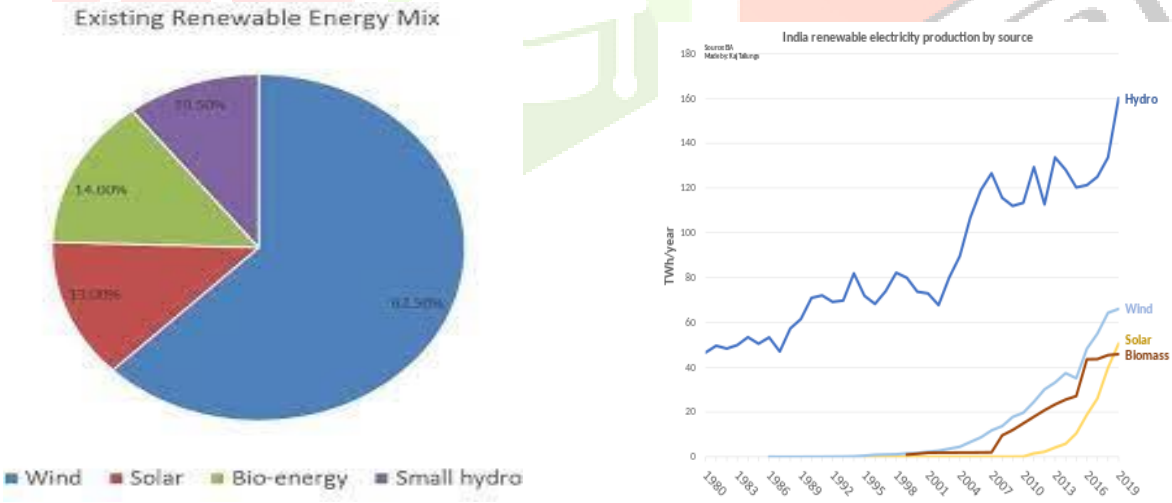
Over the past 36 years, the growth rate of carbon dioxide has increased "averaging about 1.4 ppm per year before 1995 and 2.0 ppm per year thereafter" (Earth System Research Laboratory, 2015). According to the United Nations Framework Convention Climate change is being attributed directly or indirectly to human activities that alters the composition of the global atmosphere and it in turn exhibits variability in natural climate observed over comparable time periods.

The objective of keeping global warming below 2 °C has been a key focus of international climate debate for more than a decade, (Asumadu-Sarkodie, Rufangura, Jayaweera, & Owusu, 2015; Rogelj, McCollum, Reisinger, Meinshausen, & Riahi, 2013). Since 1850, leading to a rapid growth in carbon dioxide emissions, the global use of fossil fuels has increased to dominate energy supply. According to data, by the end of 2010 confirmed that consumption of fossil fuels accounted for the majority of global anthropogenic greenhouse gas (GHG) emissions, where concentrations had increased to over 390 ppm (39%) above preindustrial levels (Edenhofer et al., 2011).

The optimal use of these renewable resources decrease not only environmental impacts and produce minimum secondary waste but also provide an exceptional opportunity for mitigation of greenhouse gas emission and reduce global warming through substituting conventional energy sources. Based on the current and future economic and social needs, renewable technologies are considered as clean sources of energy and are sustainable. Through substituting conventional energy sources based on fossil fuels, renewable energy technologies provide an exceptional opportunity for mitigation of greenhouse gas emission and reduce global warming (Panwar, Kaushik, & Kothari, 2011).

Renewable energy sources and technology:

Renewable energy sources like bioenergy, direct solar energy, geothermal energy, hydropower, wind and ocean energy (tide and wave).are energy sources from natural and persistent flow of energy happening in our immediate environment.



India renewable electricity production by source.

Global rank:

India ranks the second position in terms of population that accounts to 17% of the world's overall population. India is globally ranked 3rd in consumption of energy. In terms of installed capacity and investment in renewable energy, the EY's Renewable Energy Country Attractiveness Index (RECAI) ranking in July 2021 is as follows.

Country	Score	Recai rank
USA	70.7	1
China	68.7	2
India	66.2	3

The government has announced that no new coal-based capacity addition is required beyond the 50 GW under different stages of construction likely to come online between 2017 and 2022 .As fossil fuels are depleting and creating more pollution causing global warming, and also since energy demand is increasing day by day, energy production from renewable energy resources becomes the best solution in present condition as renewable energy resources are not exhaustible, clean, and green energy.

Hydropower:

Hydropower is an essential energy source harnessed from water moving from higher to lower elevation levels, primarily to turn turbines and generate electricity. Hydropower projects include Dam project with reservoirs, run-of-river and in-stream projects and cover a range in project scale. Hydropower technologies are technically mature and its projects exploit a resource that vary temporarily. The operation of hydropower reservoirs often reflects their multiple uses, for example flood and drought control (Asumadu-Sarkodie, Owusu, & Jayaweera, 2015; Asumadu-Sarkodie, Owusu, & Rufangura, 2015), irrigation, drinking water and navigation (Edenhofer et al., 2011). The primary energy is provided by gravity and the height the water falls down on to the turbine. The potential energy of the stored water is the mass of the water, the gravity factor ($g = 9.81\ ms^{-2}$) and the head defined as the difference between the dam level and the tail water level. The reservoir level to some extent changes downwards when water is released and accordingly influences electricity production. Turbines are constructed for an optional flow of water (Førsund, 2015). Hydropower discharges practically no particulate pollution, can upgrade quickly, and it is capable of storing energy for many hours (Hamann, 2015).

Future targets:

The government has announced that no new coal-based capacity addition is required beyond the 50 GW under different stages of construction likely to come online between 2017 and 2022. As fossil fuels are depleting and creating more pollution causing global warming, and also since energy demand is increasing day by day, energy production from renewable energy resources becomes the best solution in present condition as renewable energy resources are not exhaustible, clean, and green energy.

Hydropower source potential:

According to the World Energy Council Report, about 50% of hydropower installed capacity is among four countries namely China, Brazil, Canada and USA (World Energy Council, 2013).Due to climate change theresource potential of hydropower could be altered.

The estimated total capacity potential of hydropower generation is 3,721 GW; with a technical annual potential 14,576 TWh, but currently the global installed capacity of hydropower is very much less than its potential.

Globally, the alterations caused by climate change in the existing hydropower production system are estimated to be less than 0.1%.

Target year	Renewable energy capacity target (GW)	Comments
2030	500	Includes nuclear and large hydro power. Set in 2019 at United Nations Climate Change conference,[] with 15 times solar and 2 times wind power capacity increase compared to April 2016 installed capacity.
2022	175	Excludes nuclear and large hydro power. Includes 100 GW solar, 60 GW wind, 5 small hydro, 10 GW Biomass power, and 0.168 GW Waste-to-Power.

Hydropower environmental and social impact:

The mostly termed green source of energy is hydropower generation which does not produce greenhouse gases. It improves the socio-economic development of a country; besides considering the social impact, it displaces a lot of people from their homes to create it, though they are compensated but are not enough. The sites for hydropower such as, reservoirs that are often artificially created leading to flooding of the former natural environment are exploited. In addition, water is drained from lakes and watercourses are transported through channels over large distances and to pipelines and finally to the turbines that are often visible, but they may also go through mountains by created tunnels inside them (Førsund, 2015).

Largely, hydroelectric structures river body's ecology can be affected by inducing a change into its hydrologic characteristics and by disturbing the ecological continuity of sediment transport and fish migration through the building of dams, dikes and weirs (Edenhofer et al., 2011). In countries where substantial plants or tree covers are flooded during the construction of a dam, there may be formation of methane gas when plants start rotting in the water, either released directly or when water is processed in turbines (Førsund, 2015).

Bio energy:

The renewable energy source derived from biological sources is Bio energy an important source of energy, which can be used for transport using biodiesel, electricity generation, cooking and heating. Different sources from which electricity is produced include forest by-products such as wood residues; agricultural residues such as sugar cane waste; and animal husbandry residue such as cow dung. In biomass energy-based electricity, fuel is often a by-product, residue or waste product. Significantly, it does not create a competition between land for food and land for fuel (Urban & Mitchell, 2011). Although global production of biofuels is comparatively less, it is continuously increasing (Ajanovic, 2011).

In 2006,the annual biodiesel consumption in the United States was 15 billion litres but has been growing at a rate of 30–50% per year to achieve an annual target of 30 billion litres at the end of year 2012 (Ayoub & Abdullah, 2012).

Year wise renewable energy generation in GW as of 3 May 2019

Source	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Large Hydro	129.2	121.4	122.3	126.1	135.0	156.0
Small Hydro	8.1	8.4	7.73	5.1	8.7	9.4
Solar	4.6	7.5	12.1	25.9	39.3	50.1
Wind	28.2	28.6	46.0	52.7	62.0	64.6
Bio mass	15.0	16.7	14.2	15.3	16.4	13.9
Other	0.4	0.3	0.2	0.4	0.4	0.4
Total	**191.0**	**187.2**	**204.1**	**228.0**	**261.8**	**294.3**[1]
Total utility power	1,105	1,168	1,236	1,303	1,372	1,385

Solar energy technology is obtained from solar irradiance to generate electricity using photovoltaics(PV) and concentrating solar power (CSP), to produce thermal energy, to meet direct lighting needs and, potentially, to produce fuels that might be used for transport and other purposes. According to the World Energy Council (2013), "the total energy from solar radiation falling on the earth was more than 7,500 times the World's total annual primary energy consumption of 450 EJ Caribbean (47–221 EJ/year), sub-Saharan Africa (31–317 EJ/year) and the Commonwealth of Independent States (C.I.S) and Baltic states (45–199 EJ/year). The yield of biomass and its potential varies from country to country, from medium yields in temperature to high level in sub tropic and tropic countries.

Source	**Total Installed Capacity (GW)**
SPV Systems	0.94
Biomass Gasifiers	0.17
Waste to Energy	0.19
TOTAL	**1.20**
Other Renewable Energy Systems	
Family Biogas Plants (individual units)	50,28,000
Water mills / micro hydel (Nos.)	2,690/72

Bio energy source potential:

In future, Biomass has a large potential, which meets the goal of reducing greenhouse gases and could insure fuel supply.

Bio energy environmental and social impact:

Around the world in deprived countries, the use of biological components (plant and animal source) to produce energy has always been a cause of worry especially to the general public and as to whether its food produce are to be used to provide fuel since there are cases of food aid needed. About 99.7% of human food is obtained from the terrestrial environment, while about 0.3% comes from the aquatic

domain. Most of the suitable land for biomass production is already in use (Ajanovic, 2011). Diversion of crops or land into bio energy production can induce food commodity Proper operational management, can bring about some positive effects which includes enhanced biodiversity.

Various Types of Agro field /Industrial Residues

Geothermal energy:

The energy obtained naturally from the earth's interior as heat energy source is geothermal energy. Although heat is present in the earth's crust in huge quantities, it is unevenly distributed, rarely concentrated, and often at depths too great to be exploited mechanically.

Geothermal gradient averages about 30 °C/km. Heat is mined from geothermal reservoirs using wells and other means. Reservoirs that are naturally adequately hot and permeable are called hydrothermal reservoirs, while reservoirs that are satisfactorily hot but are improved with hydraulic stimulation are called enhanced geothermal systems (ESG). The fluids of various temperatures can be used to generate electricity and other purposes that require the use of heat energy at the surface. (Edenhofer et al., 2011).being manufactured and deployed on large scale. Wind turbines convert the energy of wind into electricity.

No	Type of Agro residues	Quantity(Million Tones / annum)
	Total	350.00
1	Straws of various pulses & cereals	225.502
2	Bagasse	31.003
3	Rice Husk	10.004
4	Groundnut shell	11.105
5	Stalks	2.006
6	Various Oil Stalks	4.507
7	Others	65.90

Wind energy:

Among renewable sources, the emergence of wind as an important source of the World's energy has taken a commanding lead. In the world, wind exists everywhere, and in some places with considerable energy density. Wind energy harnesses kinetic energy from moving air. The primary application of the importance to climate change mitigation is to produce electricity from large turbines located onshore (land) or offshore (in sea or fresh water) Onshore wind energy technologies are already being manufactured and deployed on large scale. Wind turbines convert the energy of wind into electricity.

The largest wind farm of India in Muppandal, Tamil Nadu

Direct solar energy:

on the earth and converted to the" The word "direct" solar energy refers to the energy base

for those renewable energy source technologies that draw on the Sun's energy directly. Some renewable technologies, such as wind and ocean thermal, use solar energy after it has been absorbed

Energy security:

The concern in energy security is based on the idea that there is a continuous supply of energy which is critical for the running of an economy (Kruyt, van Vuuren, de Vries, & Groenenberg, 2009). For both developed and developing countries,the interdependence of economic growth and energy consumption, access to a stable energy supply is of importance to the political world and a technical and monetary challenge. For most societies, prolonged interferences would generate serious economic and basic functionality difficulties. (Edenhofer et al., 2011; Larsen et al., 2009). Around the globe, renewable energy sources are evenly distributed as compared to fossils and in general less traded on the market. To enhance energy security across the globe. renewable energy reduces energy imports and contribute diversification of the portfolio of supply options and reduce an economy's vulnerability to price volatility and represent opportunities. To enhance security. a diverse portfolio of energy sources together with good management and system design plays a good role. (Edenhofer et al., 2011).

Grid-connected total including non-renewable and renewable:

Following table has breakdown of existing installed capacity in March 2020 from all sources, including 141.6 GW from renewable sources. Since 2019, the hydropower generated by the under Ministry of Power is also counted towards Ministry of New and Renewable Energy]'s

Type	Source	Installed Capacity (GW)	Share
Non-renewable	Coal	205.1	56.09%
	Gas	25.0	6.84%
	Diesel	0.5	0.14%
	Subtotal Non-renewable	**230.6**	**63%**
Renewable	Nuclear	6.7	1.83%
	Large hydro	45.7	12.05%
	Small hydropower	4.7	1.29%
	Solar power	38.8	10.61%
	Wind power	38.7	10.59%
	Biomass power	0.2	0.05%
	Waste-to-Power	0.2	0.05%
	Subtotal Renewable	**135.0**	**37%**
Total	**Both non-renewable and renewable**	**365.6**	**100.00%**

Social and economic development:

The energy sector has been perceived as a key to economic development with a strong correlation between economic growth and expansion of energy consumption. In general ,per capita incomes are positively correlated with per capita energy use and economic growth can be identified as the most essential factor behind increasing energy consumption in the last decades globally which in turn creates employment; Employment from renewable energy technologies was about 2.3 million jobs which also has improved health, education, gender equality and environmental safety worldwide.

Energy access:

With renewable energy source, the sustainable development goal seven (affordable and clean energy) seeks to ensure that energy is clean, affordable, available and accessible to all since they are generally distributed across the globe. In most countries there is an obvious difference between electrification in the urban and rural areas. Based on the renewable energy, distributed grids are generally more competitive in rural areas with significant distances to the national grid and the low levels of rural electrification offer substantial openings for renewable energy-based mini-grid systems to provide them with electricity access (Edenhofer et al., 2011).

Challenges affecting renewable energy sources:

In low carbon energy economies, renewable energy sources could become the major energy supply. For tapping widely available renewable energy sources, disruptive alterations in all energy systems are necessary. The major challenge of the first half of the twenty-first century is organizing the energy transition from non-sustainable to renewable energy. A major barrier towards the use of renewable energy source depends on a country's policy and policy instrument which in turn affect the cost and technological innovations. In addition, technological innovations affect the cost of renewable energy technologies which in turn leads to market failures and low patronization of the renewable energy technology. In the light of this, an effective renewable energy policy should take the interconnection of factors affecting renewable energy supplies and sustainability into consideration.

Conclusion:

Energy is a requirement in our everyday life as a way of improving human development leading to economic growth and productivity. The return-to-renewables will help mitigate climate change is an excellent way but needs to be sustainable in order to ensure a sustainable future for generations to meet their energy needs. Knowledge regarding the interrelations between sustainable development and renewable energy in particular is still limited. The aim of the paper was to ascertain if renewable energy sources were sustainable and how a shift from fossil fuel-based energy sources to renewable energy sources would help reduce climate change and its impact. A qualitative research was employed by reviewing papers in the scope of the study. Even though, the complete lifecycle of renewable energy sources have no net emissions which will help limit future global greenhouse gas emissions. Nevertheless, the cost, price, political environment and market conditions have become barriers preventing developing, least developed and developed countries to fully utilize its potentials. In this way, a creation of global opportunity through international cooperation that supports least developed and developing countries towards the accessibility of renewable energy, energy efficiency, clean energy technology and research and energy infrastructure investment will reduce the cost of renewable energy, eliminate barriers to energy efficiency (high discount rate) and promote new potentials towards climate change mitigation.

The study brought to light the opportunities associated with renewable energy sources; energy security, energy access, social and economic development and climate change mitigation and reduction of environmental and health impacts. There are challenges that tend to hinder the sustainability of renewable energy sources and its ability to mitigate climate change. These challenges are: market

failures, lack of information, access to raw materials for future renewable resource deployment, and most importantly our (humans) way of utilizing energy in an inefficient way.

From the findings, the following suggestions are made that can help improve the concerns of renewable energy being sustainable and also reduce the rate of the depletion of the ozone layer due to the emissions of GHG especially carbon dioxide (CO2):

- ✓ Formulation of policies and discussions from all sectors towards the improvement of technologies in the renewable sector to sustain them.
- ✓ Changes in our use of energy in a more efficient way as individuals, countries and the world as a whole. Efforts that aim at increasing the share of renewable energy and clean fossil fuel technologies into global energy portfolio will help reduce climate change and its impacts. Energy efficiency programmes should be introduced globally, which give tax exemptions to firms who prove to provide energy efficiency initiatives (energy-efficient homes), product design (energy-efficient equipment) and services (industrial combined heat and power). Introducing the concept of usability, adaptability and accessibility into energy-dependent product design is a way of promoting energy efficient behaviours
- ✓ Increase research in these areas, so that the fear of some renewables posing improve education, awareness-raising and human institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. Developed countries should incorporate decarbonization policies and strategies into the industry, energy, agricultural, forest, health, transport, water resource, building and other sectors that have potential of increasing greenhouse gas emissions. Efforts in developing countries aimed at improving institutional training, strengthening institutions and improving capacity of research on climate change will increase awareness, promote adaptation and sustainable development. Least developed countries should develop and test tools and methods with a global support that direct policy and decision-making for climate change mitigation, adaptation and early warnings. Supporting a global dialogue through international cooperation and partnership with developed, developing and least developed countries will promote the development, dissemination and transfer of environmentally friendly technologies, innovation and technology, access to science, and among others which will increase the mutual agreement towards combating climate change and its impacts r.isk in the future is limited.

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