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CONTRIBUTION OF RENEWABLE ENERGY IN MITIGATION OF GLOBAL WARMING CAUSED BY FOSSIL FUEL

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Abstract
The temperature of the earth which is gradually increasing is a threat to the existence of the planet. Emissions of greenhouse gases (GHG) are mainly responsible for the present scenario. Concentration of GHG in the atmosphere which lasts for a long time generated from fossil fuel (oil, gas, coal) burning causes global warming putting the world to rethink of the future energy solutions. The excessive uses of fossil fuel due to competitive economic growth among the nation's releases GHG beyond to consumption by the atmosphere warms the earth that have many adverse effects to the environment and ultimately creates the world vulnerable. The alternative source of energy considered as the renewable energy can contribute largely to reduce this GHG emission and solve the energy crisis simultaneously. This paper is focusing on the uses of traditional energy that warms the globe and in addition gives an overview of the renewable energy that will mitigate the warming. From the analysis it is observed that Bio-energy can reduce 80% to 90% GHG emissions caused by fossil fuel.

Keywords: Global warming, Greenhouse gas, Renewable energy, Environment

1. INTRODUCTION

To achieve the sustainable environment, holding the earth's temperature which is gradually increasing is unequivocal. Emission of the GHG in the atmosphere causing global warming has many bad impacts like climate change, extreme weather, flood, draught, cyclone/hurricane, sea level rising, melting ice, deforestation etc. Using the traditional fuel is nothing but destroying the future of world. Climate scientists are at least 95% confident that human activities are responsible for this climate change (IPCC, 2014). Temperature was risen by 10 C due to rise of Carbon dioxide (CO_2) concentration and emission of other GHG since 1950 (IPCC, 2014). Renewable energy is an attractive alternative energy in reducing GHG emission and global warming (Panwar et al., 2011). Bio-fuels can reduce the CO2 emission as it is carbon neutral (Hanaki & Portugal-Pereira, 2018). Bio-methane as bio-fuel has high potential for anaerobic digestion and ultimately reduces the GHG emission (Tilche & Galatola, 2008). Palm oil has very less impact to the environment (John et al., 2012). Bio-fuels are net zero CO2 emission for its shot term carbon cycle (Ingenito et al., 2012). CO2 abatement significantly depends on best baggage technology. Encompassing CO2 capture and storage (CCS) also depends on yielding plant and using fuel (Dennis et al., 2014). 100% renewable energy is achievable, and it is not only cost effective but also protective for the environment from the impact of global warming (Brown et al., 2018). 100% renewable energy is 62% low-cost for electricity production if the externalities are considered. Cost is also varied with the environment and method used (Wesly, 2018). General Circulation Models apprehended that at the end of the 21st century, CO_2 may go up to 700 ppm which causes 1.50 to 50C rise of earth's surface temperature and sea level may rise up 0.60-1.0 m (El-Sharkawy, 2014). Emissions of CO_2 during the decades 1980-2010 does not give a significant addition of global sea level (GSL) with increase of global mean surface temperature (GMST) (Ekwurzel, 2017). Rapid reduction of GHG emission after 2020 is vital (Niklas Höhne et al. 2012). Emission of CO_2 will be at maximum around 2030 (Exxon Mobil, 2017). Keeping the existing infrastructure CO_2 emission would be 496 (282-701ranges of scenarios) gigatonnes by combustion of fossil fuel between 2010 to 2060 with average mean temperature 1.30C above the pre-industrial level unless the exceptional infrastructure is not introduced for alternative energy sources (Davis et al., 2010). It is predicted that 658 gigatonnes of CO_2 will be emitted in the atmosphere of which 50% will come from electricity generation with major share from China (41%) and USA (9%), 28 member countries of European Union (7%) by

the current infrastructure of power generation and ultimately threaten the 1.50C climate target (Tong et al., 2019). Cost of renewable energies will lower in future as the capacity is doubling by every 3 years and wind power is most economical (Donal & Swift-Hook, 2016). In implementing the renewable energies certain impediments such that market failure, inadequate information and most crucially human activities for renewable energies uses need to be addressed (Owusu & Sarkodie, 2016). Applying quick budget for CO2 will play a great role in reducing emission by 2030 and renewable energy will take the major load for de-carbonization (Gerbaulet et al., 2019). CO2 emission is reduced greatly with a percentage of biodiesel increase (Coronado et al., 2009).

1.1 GOALS AND OBJECTIVES OF THE STUDY

The earth is warming continuously mainly caused by human activities. Human activities are highly depended on energy. People around the world are supposed to use traditional energy (fossil fuel). Since we are highly depended on traditional energy, it is little bit tough to switch. Here we discuss the prospect of renewable energy on the other side how dependence on traditional energy produces GHG that warms the planet and consequently destroys the planet. In this research, it is found that net zero emission is possible and that will be a great for the existence of the planet. This paper tries to give a brief idea on adverse impacts of using fossil fuel to the environment and necessities to switch immediately to the renewable energy for stake holders of the nations, organizations, policy makers, energy producers or consumers as well as individual.

1.2 METHODOLOGY

Prior to the research work a good number of related research papers were studied including different agreements and working papers on climate change. Data was collected from different online access like WMO, NASA, IRENA, IEA, IPCC, EIA, NOAA etc. and some research papers. After collecting data different parameters were analyzed to give the scenarios of warming. Then GHG emissions from fossil fuel scenarios were discussed and at the same time prospect of various renewable energy sources were also analyzed that mitigate the global warming. Finally, a set of recommendations were proposed that need to be addressed in no time.

2. GLOBAL ENERGY DEMAND

With the continuously increasing population (projected population 10.9 billion (approximately) at the end 2100 (Factank, 2019), the demand of energy will be increased is very relevant. Primary energy has increased 2.9% in 2018 which is almost double of the average growth rate (1.5%) for last 10 years where natural gas alone shares 40% of this increase (BP, 2019).

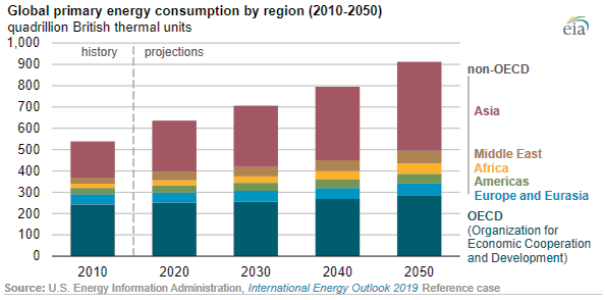

Fig. 1: International energy projection (EIA, 2019)

Figure 1 shows that global energy consumption will be increased about 50% during 2018-2050 mainly increase in Asia and in 2050 demand of energy is more than 900 quadrillion BTU.

3. PROSPECT OF RE (RENEWABLE ENERGY) IN CLIMATE MITIGATION

Renewable energy is the energy which is constantly replenishing. Renewable energy is also called clean energy or green energy for its very low carbon emission to the atmosphere and free of other types of pollution. As renewable energy adds significant amount of electricity, access of power in developing or least developed countries, creating new jobs and some of them are also low cost ensuring the future energy solution undoubtedly. Mainly seven types of renewable energy viz. solar, hydropower, bio energy, geothermal, wind and ocean is already consumed around the world.

Solar energy:

By capturing and converting the heat from the sun into electric or thermal energy is solar energy. This is treated as one of the clean energy and huge renewable energy sources. Solar energy can be used for light, hot water, electricity, cooling water for the sectors of both residential and industrial. Solar energy can be used in varieties of form such as photovoltaic, concentrating solar, solar thermal heating and cooling etc. Solar energy is treated as one of the best renewable energy for its various potentialities with its availability, accessibility, less costing, job creation and efficiency (Kannan & Vakeesan, 2016; Green, 2015; Renewables 2019). According to IEA the solar PV will share 60% of the 50% growth of all renewable power energy between the years 2019-2024 (IEA, 2019).

Hydropower:
Hydropower or hydroelectricity is an energy produced by revolving the turbine with the force of stream or river. This is a renewable energy as river flow is constantly renewed. Hydro power initially started for yielding mechanical energy. In general, free of GHG (Renewable Energy World, 2011) but some negligible amount of GHG such as CH_4 and CO_2 may emit large scale of hydro power plants (Chiyembekezo et al., 2012; Rosa et al., 2004; Raadal et al., 2011). Hydro power is efficient in some developed countries depending only on it for power generation but it needs huge investment to set up the plant and environmental deterioration may occur in the catchment area (Chiyembekezo et al., 2012) According to the International Hydropower Association (IHA), 1292 GW hydropower capacity was installed in 2018 (IHA, 2019). Hydropower is reliable and matured renewable energy source which can play a significant role in abatement of GHG emissions (Belqasem, 2016).

Bio energy:
Bio energy is another renewable energy that has huge potential to play a significant role in replacing the fossil fuel. This is also a renewable energy as it has great resource that is continuously regenerated. Bio-energy is produced from organic matter– plants, municipal solid waste, agricultural waste, food waste, animal manure, human excreta, and landfill. In all forms of bio energy -liquids, gases, solids imparts a great role for future energy crisis (Nielsen, 2019). Bio energy shares maximum renewable energy sources with 70% consumption in 2017 (WBA, 2019). A small amount of GHG is emitted from all types of bio energy (Jungmeier & Spitzer, 2001). Bio-energy can reduce 80% to 90% GHG emissions with comparing fossil fuel (Mirjam & Andrew, 2019).
Some of the form of bio energy

(i) **Biogas:** Biogas whose main component is methane with CH_4 more than 60% (Ernest & Ivan, 2004) is produced from organic materials under the anaerobic digestion process. This is one of the most promising renewable energy sources as its raw materials are huge (municipal solid waste, landfill, cow manure, food waste, plants etc.) and continuously regenerating. Biogas will be the most attractive solution of energy for its accessibility, affordability, cost effective and efficiency, flexibility. Production of biogas plays great role in waste management sector also. Biogas can be used as a kitchen fuel and production of electricity. According to IRENA biogas production has increased by 90% (46,108GWh to 87,500GWh) between 2010 and 2016 (WBA, 2019). Biogas is one of the good renewable energy sources which reduces GHG emissions enormously but at the same time special care is needed to reduce the undesired emissions of methane and nitrous oxide (N_2O) while biogas is produced (Paolini et al., 2018).

(ii) **Biomass**: Biomass is another form of bio-energy comes from organic material such that plants, animals. When biomass is burnt the chemical energy in it (plants contain the sun's energy through photosynthesis) produces heat.

$$6H_2O+6CO_2+\text{radiant energy} \rightarrow C_6H12O_6+6O_2$$

Actually biomass is a fuel derived from plants where it can be used to produce ethanol, methanol and vegetable oils by some chemical process. It is a renewable energy as it has great resources like agricultural residue, native plants as well as woody plants. 50% percent of the global population depends on biomass either for kitchen or heating and this also causes a health hazard especially to the women (Geoffrey et al., 2017).

(iii) **Biodiesel**: Biodiesel is a renewable energy source produced from vegetable oil or animal fats through some chemical process called transesterification. B20 blend is the most accepted biodiesel that can be directly used in the conventional diesel engine. According to the EIA combustion of biodiesel discharges small amounts of air pollutants like carbon monoxide (CO), sulfur dioxide (SO_2), hydrocarbons and air toxic where Nitrogen oxide (NO) emissions from biodiesel is insignificant amount than petroleum diesel (EIA, 2020). Accordingly EIA Minimum 9.3 billion gallons of biodiesel were consumed by 56 countries in 2016 (EIA, 2020).

Geothermal:
Geothermal energy is extracted from the earth which is stored from the sun's heat and earth itself. It is one of the uninterrupted sources of clean energy that can be used for heating/cooling, electricity production etc. GHG emissions from geothermal energy are negligible (Fridriksson et al., 2016). Geothermal power capacity was 12.7 gigawatts at the end of 2016 globally (IRENA, 2017).
Wind energy: Wind energy is a great source of power production. GHG emissions from wind power are very low comparing with those from fossil fuel related electricity production (Raadal et al., 2014). Wind energy can be sustainable power energy and can reduce 90% emission of CO_2 by 2050 (IRENA, 2019). Global wind energy capacity was 467GW at the end of 2016 (Erik, 2017)

Ocean energy:
Among all the renewable energies, ocean energy is in the most initial stage. This is derived from ocean. Mainly two types of energy we can get from ocean: thermal energy from temperature difference (sun's heat) and the mechanical energy from wave/tide. Both energies can be used to produce electricity. Since 70% of the earth is covered by the ocean and sun's heat is accumulated on it so it can be one of the promising source of future energy. According to the IEA Ocean energy is increased by 16% in 2018 (IEA, 2019).

3.1 GLOBAL WARMING SCENARIOS

The global annual temperature has increased at an average rate of 0.07^0C per decade since 1880 (NOAA, 2020). The global average surface temperature is increased by 0.74^0C in 19th century (IPCC, 2007).

Table 1: Ten warmest year (NOAA, 2020)

Rank 1 = Warmest Period of Record (1880-1919)	Year	Anomaly ^{0}C
1	2016	0.99
2	2019	0.95
3	2015	0.93
4	2017	0.91
5	2018	0.83
6	2014	0.74
7	2010	0.72
8(tied)	2005	0.67
8(tied)	2013	0.67
10	1998	0.65

Table 1 shows that in 140 years of record nine warmest years, out of ten is after 2000 just 1 year is before 2000 (1998). 2016 is the warmest during the period and the world has experienced a strong El Niño effect in that year which is shown in Figure 2. 2019 is the 2nd warmest year just behind 2016.

Ocean Heat Content:
Table 2 shows ocean heat content (OHC) was highest (228ZJ) in the year 2019 with reference of average value of 1981-2010 in the range of 0-2000m. Year 2019 Ocean contents are 25ZJ heat more than that of 2018. More than 90% of the heat is accumulate on it and some of the remaining heat back to the atmosphere melting some ice.

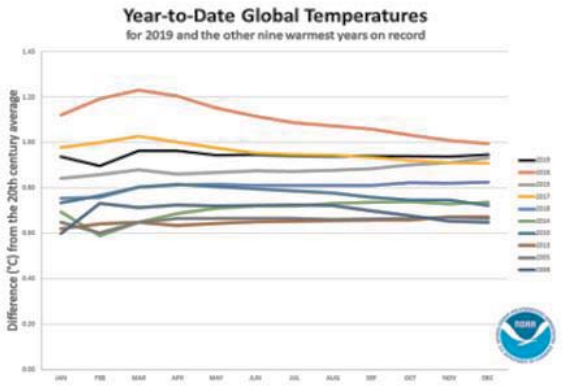

Fig. 2: Global year to date temperature anomalies (NOAA, 2020)

Table 2: Top five warmest year since 1955 Data (anomalies) given in ZJ ($1ZJ=10^{21}J$) units (Cheng, et al., 2020).

Rank	Year	IAP	NOAA/NCEI
1	2019	228	217
2	2018	203	196
3	2017	193	189
4	2015	185	180
5	2016	180	164

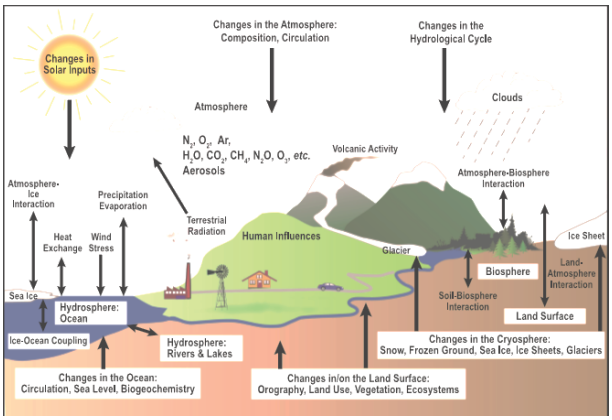

Fig. 3: Schematic view of the components of the climate system, their processes and interactions (Le Treut et al., 2007).

Green House Gases:
Some gases can absorb infrared radiation emitted from the earth's surface. Certain GHG causes global warming by trapping in the atmosphere. GHG where CO_2 plays a major role in global warming, table 3 shows that concentration of these gases are increasing continuously after 2000; Annual GHG Index (AGGI) is in highest level in the same period. Table 3 shows that in 2018, AGGI is 1.43 representing the warming influences 43% comparing base year 1990. More than 50% radiative

force is increased by CO_2 alone. CH_4 is the 2nd (29% nearly) responsible for that increase. Global GHG forecasts to grow up 50% from 2012 to 2050 mostly for increasing energy demand for economic advancement (OECD, 2012).

Table 3: Annual GHG index and PPM CO_2.

Year	Radiative forcing (Wm^{-2})	CO_2-Eq PPM	AGGI
2000	2.466	441	1.139
2005	2.626	454	1.213
2010	2.792	468	1.290
2015	2.974	485	1.374
2018	3.101	496	1.433

Data source: NOAA,(56)

Global Warming Potentiality (GWP) of Green House Gases: The global warming potential is defined by

$$GWP = \frac{\int_0^{TH} \Delta F_{GHG}(t) f_{GHG}(t) dt}{\int_0^{TH} \Delta F_{CO_2}(t) f_{CO_2}(t) dt} \quad [57]$$

Where $\Delta F(t)$ =radiative force, $f(t)$ =fraction of gas mass existent in the atmosphere.

CO_2 once emitted in the atmosphere lasts more than a century even more in the ocean. Concentration of this gas is gradually increasing which is increased by 46% from the pre-industrial level.

Table 4: Effect on climate of main GHG (Panwar et al., 2011; Aebischer et al., 1989; WDCG, 2019).

Gas	Chemical Formula	GWP Time Horizon (over 100 years)	Atmospheric life time	Growth rate (%) (yearly)	Concentration (ppm)	
					Pre-industrial	In 2018
Carbon dioxide	CO_2	1	50-200	0.4	280	407.8
Methane	CH_4	25	12	1.0	0.7	1.869
Nitrous Oxide	N_2O	298	120	0.2	0.27	0.331
CFC-11	$CFCl_3$	4,750	50	5.0	0	-
CFC-12	CF_2Cl_2	10,900	102	5.0	0	-

Table 5: Energy related CO_2 emissions in gigatonnes (Gt) (IEA, 2020)

Year	Advanced Economies	Rest of World	Total
1990	11.3	09.2	20.5
1995	11.7	09.7	21.4
2000	12.6	10.5	23.1
2005	12.9	14.0	26.9
2010	12.4	18.0	30.4
2015	11.7	20.5	32.2
2019	11.3	22.0	33.3

Table 5 shows that energy related CO_2 is increased by 62% during the time 1990 to 2019.

Carbon Dioxide:

CO_2 one of the long lived gases is mainly responsible for global warming besides this methane also plays a significant role. The atmospheric concentration of CO_2 is currently (January 2020) 413ppm whereas it was 280ppm before the starting of industrial revolution and it is continuously increasing (NOAA, 2020) and if this trend is continuing and reach between 430-480ppm in 2100 temperature may below 2^0C and if the range is 480-530ppm the temperature may exceed 2^0C above the preindustrial level. Anthropogenic CO_2 emitted in the atmosphere 2040 ± 310 GtCO2 during 1750 to 2011 of which some 40% i.e. 880 ± 35 GtCO2 staying in the atmosphere and rest of the CO_2 extracted from the atmosphere and accumulated on the land (in plants or soil) (IPCC, 2014).

Fossil Fuel and CO_2 Emission:

Fossil fuel is formed by decomposing of carbon-based organism under the ground for millions of years ago. Mainly three types of fossil fuels are used

like coal, oil and gas. During the time 2002-2011 CO_2 emissions from fossil fuel combustion and cement production was 89% and rest of the emissions 11% responsible for the land use change of which 43% was from coal, 34% from oil, 18% from gas and remaining 5% from cement and gas flaring (Le Quéré et al., 2013). World's coal production was increased by 3.2% (10mtoe) in 2017 from previous year which was fastest growth rate since 2011 (BP, 2018). Scientists believe that effect of coal burning in global warming is very serious. Its share is 0.30C in 1oC global warming since late 1800s, in 2018 emissions from all fossil fuels increased and power related emissions share nearly two-thirds of this growth and coal use in power sector alone exceeds by 10Gt CO2, 30% of global emissions by coal-fire based electricity production. 85% emissions are from China, India and USA (IEA, 2019). Table 6 shows amount of CO2 emissions increase in 2018.

Table 6: Percentage of CO_2 emissions increase in 2018 comparing with 2017(IEA, 2019).

Countries/Region	Emissions increase in 2018 comparing with 2017
India	4.8%
USA	3.1%
China	2.5%
Europe	-1.3% (decrease)

3.2. TRENDS IN DIFFERENT ENERGY SOURCES

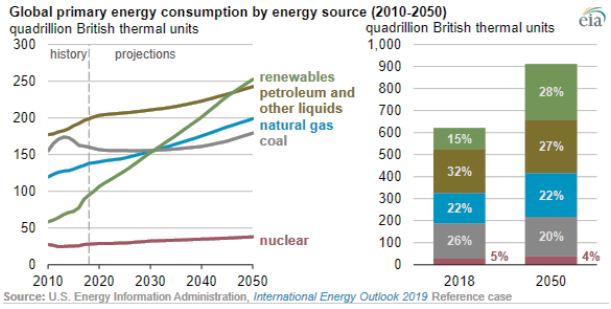

Fig. 4: Projection of global primary energy consumption (EIA, 2019)

Figure 4 shows that renewable energy will increase remarkably with 3.1% growth rate per year.

Table 7: Projection of primary energy (natural gas, liquids, coal) related CO_2 emissions in billion metric tons (Statista 2019).

1990	2020	2030	2040	2050
21.45	35.34	36.4	38.81	43.09

Table 7 shows that CO_2 emissions will be more than 43 billion metric ton by 2050 if the present trend is continuing.

3.3 RENEWABLE ENERGY SCENARIOS AND TRENDS

To achieve the target of holding the rise of temperature set by IPCC in Paris Agreement the decade 2020-2030 is most vital. More 3000GW capacity renewable energy is required to be installed to meet the agreement by 2030 (Energy Live News, 2020). According to the IEA modern renewable energy share was 11% of total primary energy in 2018 and it will grow up to 15% in 2030 which is far below of 23% for achieving sustainable development goal (SDG) and renewable based electricity production was increased by 56% in the time period 2000-2018 come from major sources hydro, wind and solar PV (IEA, 2019). Electricity production from renewable sources can play key role in abating carbon emission, according to IRENA, 50% electricity production needs to come from renewable energy by 2050 which is presently (2019) 20%, it also predicted that renewable energy will share 66% of primary energy in the same time (IRENA, 2019). China which is the most fossil fuel used nation was the largest contributor in renewable power production with 45% share of global growth rate in 2018 (BP, 2019).

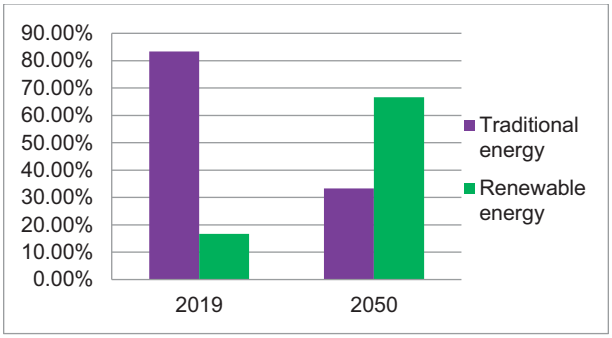

Fig. 5: The global share of renewable energy in primary energy supply (IRENA, 2019).

Figure 5 shows that 66% energy will be renewable in 2050.

4. CONCLUSION

Using fossil fuel is nothing but destroying the planet. To maintain the economic growth the dependence on primary energy will be increased in coming decades and by 2050 energy demands will be double. Nearly 80% of primary energy comes from fossil fuel still now and if the present share is continuing then it will be devastating to the planet. In order to meet the Paris Agreement for holding the

increase of temperature 1.5^0C or well below 2^0C above the preindustrial level by 2100 targeting the reduction of burning of fossil fuel significantly. No new establishment for fossil fuel generation are encouraged for shifting to renewable energy production, energy efficiency, technological improvement for minimizing the emissions, sufficient investment on renewable energy production, CCS (carbon capture and storage) technology, introducing sufficient electrical vehicle to reduce the emissions from transport sector are the key areas needs to be addressed by the nations, NGOs, international organizations as well as individual to achieve the goal to protect the planet. It's reflected in the Fifth Assessment Synthesis Report of IPCC that CCS technology alone can reduce 16% of emissions. Since the electricity production from renewable energy alone can reduce the 60% emissions so more investments and initiatives are needed to familiarize the uses of PV, wind power, hydropower etc. Coal based power plant practiced by some non-OECD countries needs to be stopped or no further installation. The policy maker should rethink to invest in this sector. Uses of traditional biomass either in the developing or least developed countries are to be discouraged as it also creates health hazard especially to the women of those countries. It has a proven record that renewable energy is cost effective, environment friendly, creating employment opportunity, access to power for a section of population. We have no time to transform the traditional energy into renewable /green energy to hold the temperature rising in order to stop the further damage of the planet and at the same time where renewable energy is not a good solution especially the industrial sector (cement and steel), needs to apply CCS technology to minimize the emission and to find an alternative solution.

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