

Summer Training Report

on

A review of renewable energy sources, sustainability issues and climate change mitigation

By

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1 Introduction

The world is fast becoming a global village due to the increasing daily requirement of energy by all population across the world while the earth in its form cannot change. The need for energy and its related services to satisfy human social and economic development, welfare and health is increasing. Energy and climate change are often rightly linked by policymakers and politicians because, since the industrial revolution, the fossil fuels that have powered the global economy have also altered the atmosphere and are highly likely to cause climate change that may be difficult and expensive to adapt to. Energy accounts for two-thirds of total greenhouse gas, so efforts to reduce emissions and mitigate climate change must include the energy sector.

Returning to renewables to help mitigate climate change is an excellent approach which needs to be sustainable in order to meet energy demand of future generations. Promoting sustainable development and combating climate change have become integral aspects of energy planning, analysis and policy making. 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 and bequeath future generations to meet their energy needs.

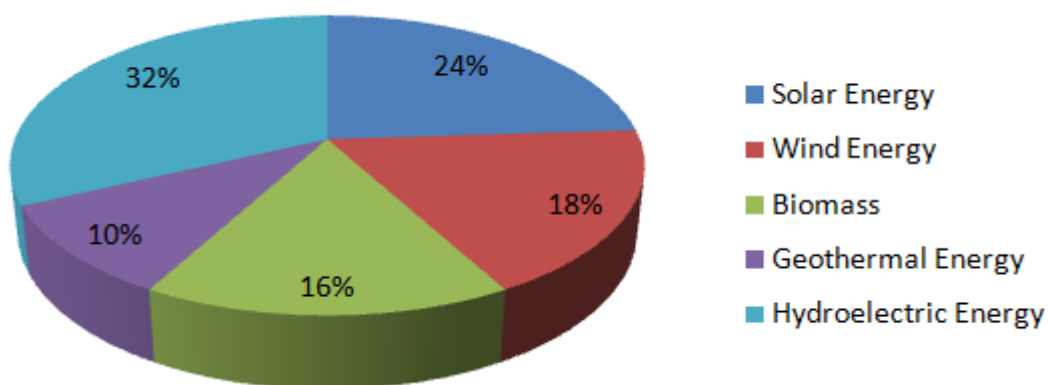


Figure 1 Percentage distribution of renewable energy in India

Despite these opportunities, there are challenges that hinder the sustainability of renewable energy sources towards climate change mitigation. These challenges include Market failures, lack of information, access to raw materials for future renewable resource deployment, and our daily carbon footprint. The study suggested some measures and policy recommendations which when considered would help achieve the goal of renewable energy thus to reduce emissions, mitigate climate change and provide a clean environment as well as clean energy for all and future generations. Knowledge regarding the interrelations between sustainable development and renewable energy in particular is still limited.

Development of power resources is pre-requisite for development of any region. Power resources of Rajasthan play a key factor in the modern agricultural, industrial and economic development. While, chronically Rajasthan has been power hungry state, the discovery of petroleum and natural gases resources in west Rajasthan and solar power potential has given new hope in converting Rajasthan into a power surplus state. Currently the state's renewable energy production capacity is 1,600 MW and around 3,300 tonnes of coal is required for generating 1MW electricity through traditional sources, but now due to renewable energy production, the state is saving 5 lakh tonne coal every year.

The aim of the paper is to ascertain if renewable energy sources are sustainable and examine 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 peer-reviewed papers in the area of study. The study reviewed 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. This 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.

2 Objectives of the study

- To review Renewable energy sources and technology
- To review the role of renewable energy sources in mitigating climate change and its impact.

3 Methods and Materials

Systematic Literature review

Systematic Literature review have foremost been developed within medical science as a way to synthesize research findings in a systematic, transparent, and reproducible way and have been referred to as the gold standard among reviews (Davis et al., 2014, Snyder, Witell, Gustafsson, Fombelle, & Kristensson, 2016; Verlegh & Steenkamp, 1999; Witell, Snyder, Gustafsson, Fombelle, & Kristensson, 2016). A qualitative research was employed by reviewing papers in the scope of the study. The aim of a systematic review was to identify all empirical evidence that fits the pre-specified inclusion criteria to answer the research questions of the study.

In this study we have thoroughly referred all the relevant literature and reports that were available on platforms such made available by government and non government agencies, research articles, news publications etc to gain a significant insight to address the objectives of the report.

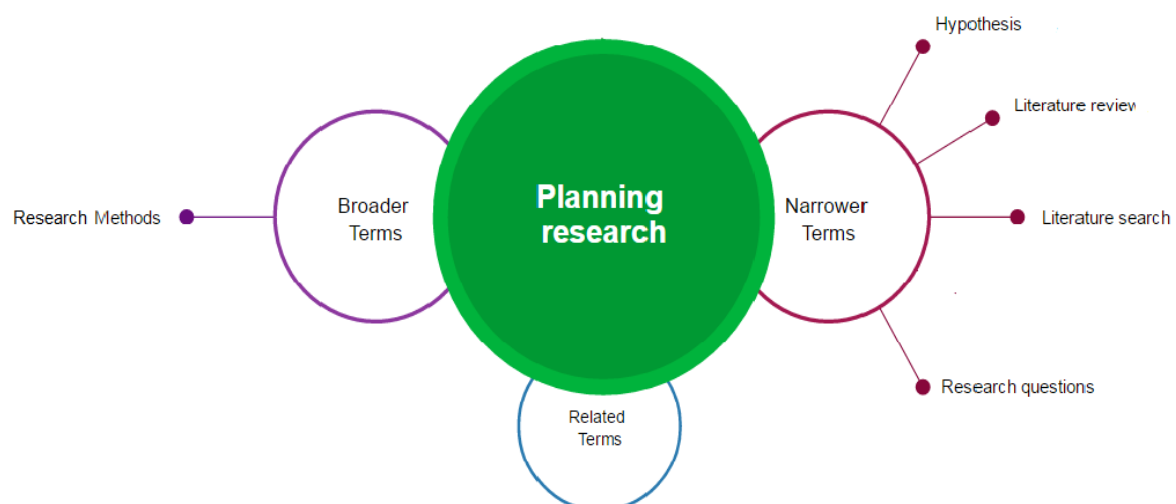


Figure 2 Key aspects of the methodology used

4 Results and Discussion

4.1 Why do we need renewable energy?

Renewable energy sources replenish themselves naturally without being depleted in the earth; they include bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy.

Tester (2005) defines sustainable energy as, “a dynamic harmony between the equitable availability of energy-intensive goods and services to all people and preservation of the earth for future generations”.

The world's growing energy need, alongside increasing population led to the continual use of fossil fuel-based energy sources (Coal, Oil and Gas) which became problematic by creating several challenges such as: depletion of fossil fuel reserves, greenhouse gas emissions and other environmental concerns, geopolitical and military conflicts, and the continual fuel price fluctuations. These problems will create unsustainable situations which will eventually result in potentially irreversible threat to human societies (UNFCCC, 2015). Notwithstanding, renewable energy sources are the most outstanding alternative and the only solution to the growing challenges (Tiwari & Mishra, 2011). In 2012, renewable energy sources supplied 22% of the total world energy generation (U.S. Energy Information Administration, 2012) which was not possible a decade ago.

Reliable energy supply is essential in all economies for heating, lighting, industrial equipment, transport, etc. (International Energy Agency, 2014). Renewable energy supplies reduce the emission of greenhouse gases significantly if replaced with fossil fuels. Since renewable energy supplies are obtained naturally from ongoing flows of energy in our surroundings, it should be sustainable. For renewable energy to be sustainable, it must be limitless and provide non-harmful delivery of environmental goods and services. For instance, a sustainable biofuel should not increase the net CO₂ emissions, should not unfavourably affect food security, nor threaten biodiversity (Twidell & Weir, 2015). Is that really what is happening today? I guess not.

Renewable energy sources used in energy generation helps to reduce greenhouse gases which mitigates climate change, reduce environmental and health complications associated with pollutants from fossil fuel sources of energy. The sustainable development goal seven (affordable and clean energy) seeks to ensure that energy is clean, affordable, available and accessible to all and this can be achieved with renewable energy source since they are generally distributed across the globe. Access concerns need to be understood in a local context and in most countries there is an obvious difference between electrification in the urban and rural areas, this is especially true in sub-Saharan Africa and South Asian region (Brew-Hammond, 2010).

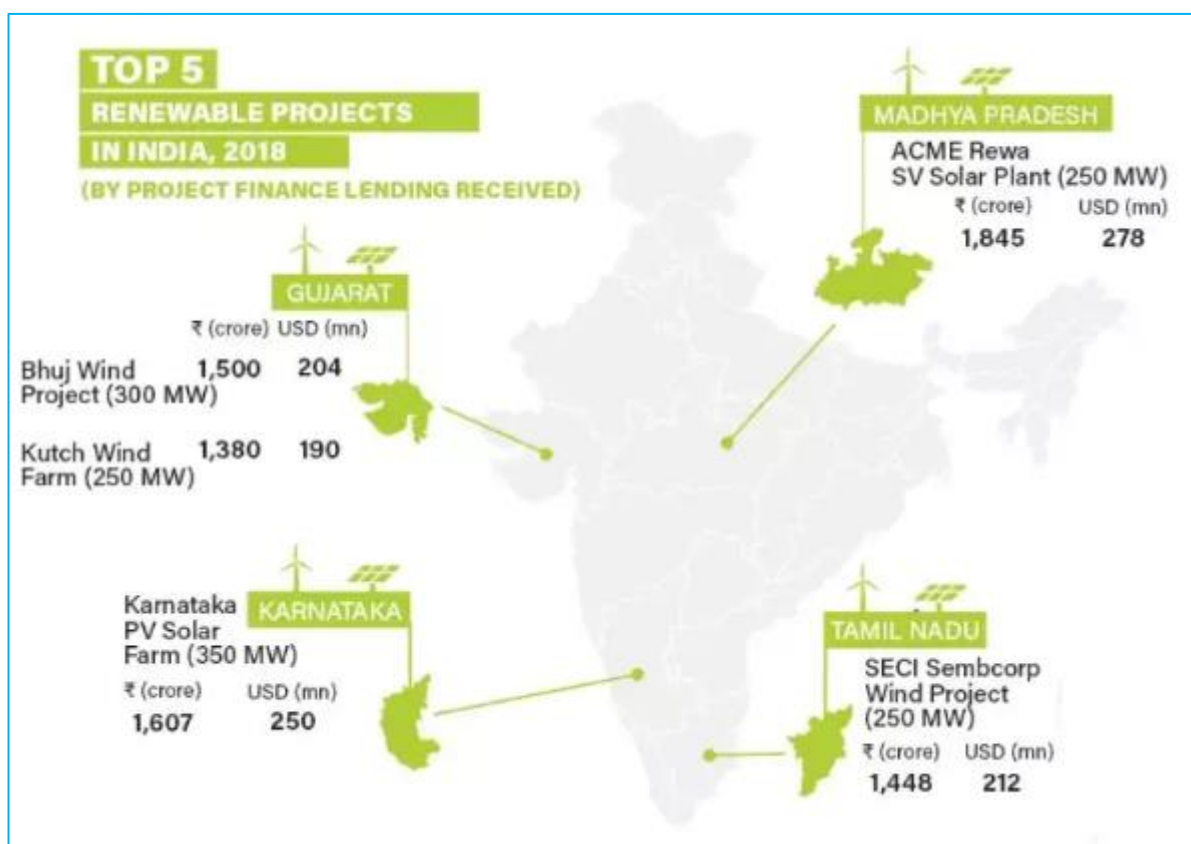


Figure 3 Renewable energy projects in India

4.2 Renewable energy and climate change

Presently, the term “climate change” is of great interest to the world at large, scientific as well as political discussions. Climate has been changing since the beginning of creation, but what is alarming is the speed of change in recent years and it may be one of the threats facing the earth. The growth rate of carbon dioxide has increased over the past 36 years (1979–2014) ,

“averaging about 1.4 ppm per year before 1995 and 2.0 ppm per year thereafter” (Earth System Research Laboratory, 2015). The United Nations Framework Convention on Climate Change defines climate change as being attributed directly or indirectly to human activities that alters the composition of the global atmosphere and which in turn exhibits variability in natural climate observed over comparable time periods

Renewable technologies are considered as clean sources of energy and optimal use of these resources decreases environmental impacts, produces minimum secondary waste and are sustainable based on the current and future economic and social needs. Renewable energy technologies provide an exceptional opportunity for mitigation of greenhouse gas emission and reducing global warming through substituting conventional energy sources (fossil fuel based) (Panwar, Kaushik, & Kothari, 2011).

4.3 Renewable energy sources and technology

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

4.3.1 *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.

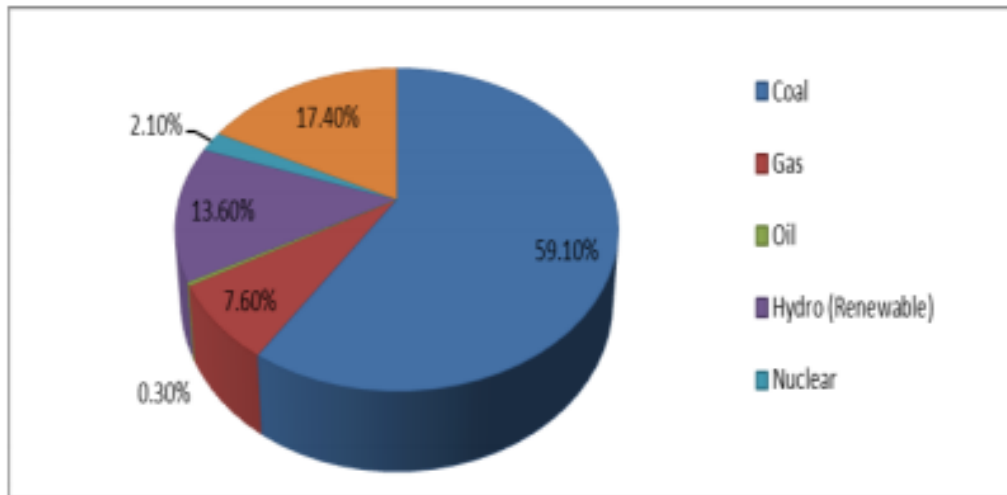


Figure 4 Different types of energy used in power generation

- *Hydropower source potential*

Hydropower generation technical annual potential is 14,576 TWh, with an estimated total capacity potential of 3,721 GW; but, currently the global installed capacity of hydropower is much less than it's 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). The resource potential of hydropower could be altered due to climate change.

- *Hydropower environmental and social impact*

Hydropower generation does not produce greenhouse gases and thus mostly termed as a green source of energy. Nonetheless, it has its advantages and disadvantages. It improves the socio-economic development of a country; but, also 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 exploitation of the sites for hydropower such as, reservoirs that are often artificially created leading to flooding of the former natural environment. In addition, water is drained from lakes and watercourses and 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).

4.3.2 Bioenergy

Bioenergy is a renewable energy source derived from biological sources. Bioenergy is an important source of energy, which can be used for transport using biodiesel, electricity generation, cooking and heating. Electricity from bioenergy attracts a large range of different sources, including forest by-products such as wood residues; agricultural residues such as sugar cane waste; and animal husbandry residue such as cow dung. One advantage of biomass energy-based electricity is that fuel is often a by-product, residue or waste product from the above sources. Significantly, it does not create a competition between land for food and land for fuel

- *Bioenergy source potential*

Biomass has a large potential, which meets the goal of reducing greenhouse gases and could insure fuel supply in the future. A lot of research is being done in this area trying to quantify global biomass technology. According to Hoogwijk, Faaij, Eickhout, de Vries, and Turkenburg (2005) the theoretical potential of bioenergy at the total terrestrial surface is about 3,500 EJ/year.

- *Bioenergy environmental and social impact*

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 around the world in deprived countries. 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).

4.3.3 Solar energy

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 on the earth and converted to the other forms. Solar energy technology is obtained from solar irradiance to generate electricity using photovoltaic (PV) (Asumadu-Sarkodie & Owusu, 2016d) 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 (Edenhofer et al., 2011). 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" (Urban & Mitchell, 2011).

Dharnai: story of one solar village



Since 2000 citizens of Dharnai, a small village near Bodhgaya in the eastern Indian state of Bihar achieved access to electricity for the first time in 30 years as a result of installation of solar power facility . the lives of women in Dharnai changed drastically with the advent of the micro-grid. Not only did access to energy act as a catalyst that drives other socio-economic improvements but lighting up a village like Dharnai created opportunities for women and girls by increasing access to both public and personal spaces after dark. Children studied late into the night, and women no longer needed to finish preparing meals before the sun set.

4.3.4 Geothermal energy

Geothermal energy is obtained naturally from the earth's interior as heat energy source. The origin of the heat is linked with the internal structure of the planet and the physical processes occurring there. Although heat is present in the earth's crust in huge quantities, not to mention the deepest parts, it is unevenly distributed, rarely concentrated, and often at depths too great to be exploited mechanically.

4.3.5 Wind energy

The emergence of wind as an important source of the World's energy has taken a commanding lead among renewable sources. Wind exists everywhere in the world, in some places with considerable energy density (Manwell, McGowan, & Rogers, 2010). 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) (Asumadu-Sarkodie & Owusu, 2016e). Onshore wind energy technologies are already being manufactured and deployed on large scale (Edenhofer et al., 2011). Wind turbines convert the energy of wind into electricity.

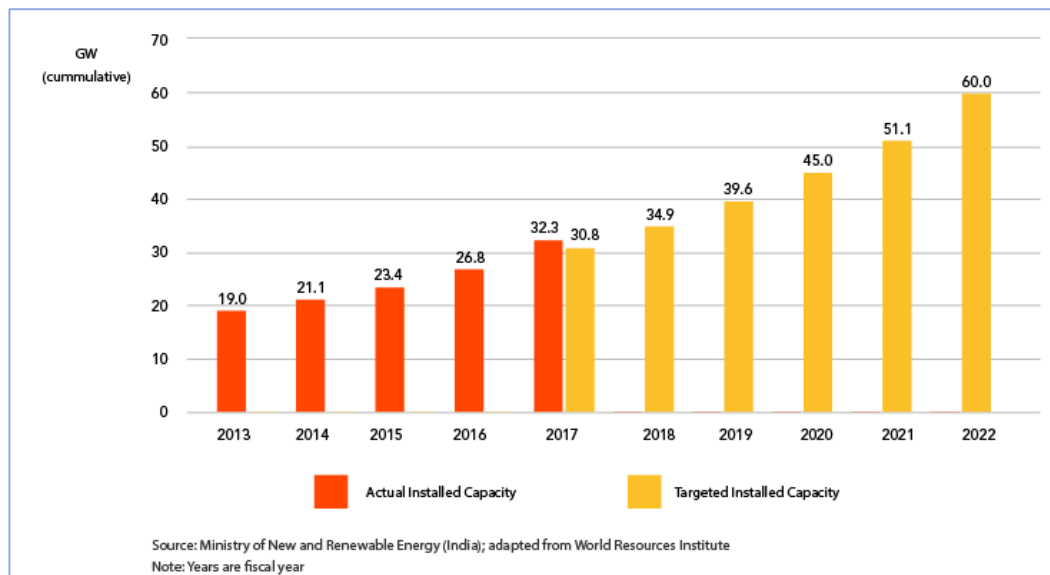


Figure 5 Future goals for wind power in India

4.3.6 Ocean energy (tide and wave)

Surface waves are created when wind passes over water (Ocean). The faster the wind speed, the longer the wind is sustained, the greater distance the wind travels, the greater the wave height, and the greater the wave energy produced (Jacobson & Delucchi, 2011). The ocean stores enough energy to meet the total worldwide demand for power many times over in the form of waves, tide, currents and heat. The year 2008 saw the beginning of the first generation of commercial Ocean energy devices, with the first units being installed .

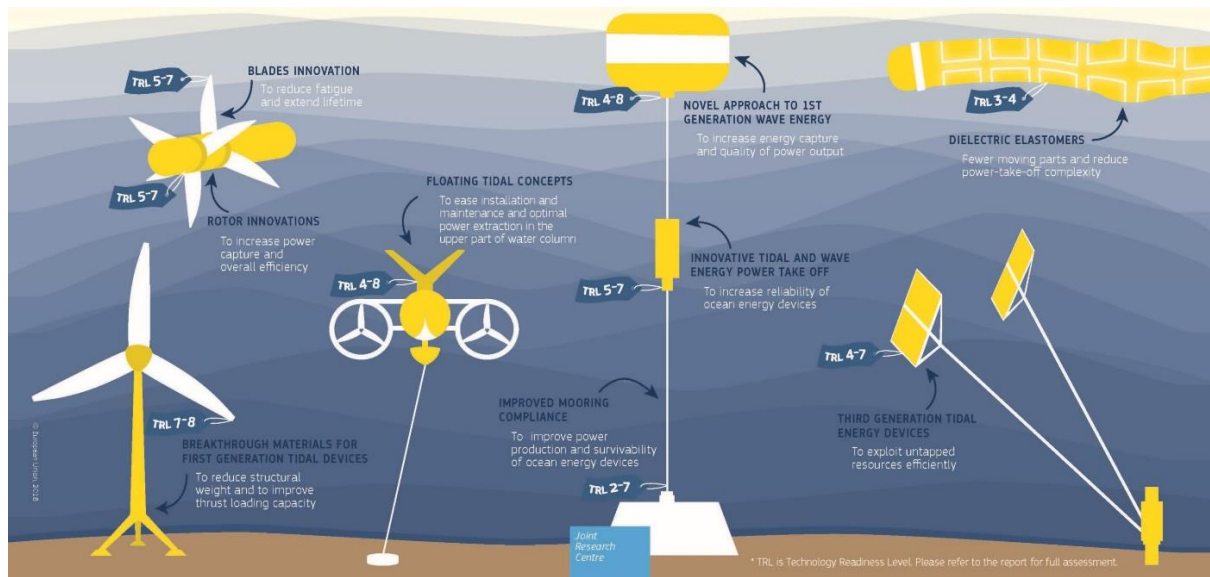


Figure 6 Ongoing research for cost cutting in ocean technology

4.3.7 Renewable energy and sustainable development

Renewable energy has a direct relationship with sustainable development through its impact on human development and economic productivity (Asumadu-Sarkodie & Owusu, 2016b). Renewable energy sources provide opportunities in energy security, social and economic development, energy access, climate change mitigation and reduction of environmental and health impacts (Asumadu-Sarkodie & Owusu, 2016g). Figure 1 shows the opportunities of renewable energy sources towards sustainable development.

4.4 Energy security

The notion of energy security is generally used, however there is no consensus on its precise interpretation. Yet, 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). Given 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 both developed and developing countries, because prolonged interferences would generate serious economic and basic functionality difficulties for most societies.

4.5 Social and economic development

Generally, the energy sector has been perceived as a key to economic development with a strong correlation between economic growth and expansion of energy consumption. Globally, 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. It in turn creates employment; renewable energy study in 2008, proved that employment from renewable energy technologies was about 2.3 million jobs worldwide, which also has improved health, education, gender equality and environmental safety (Edenhofer et al., 2011).

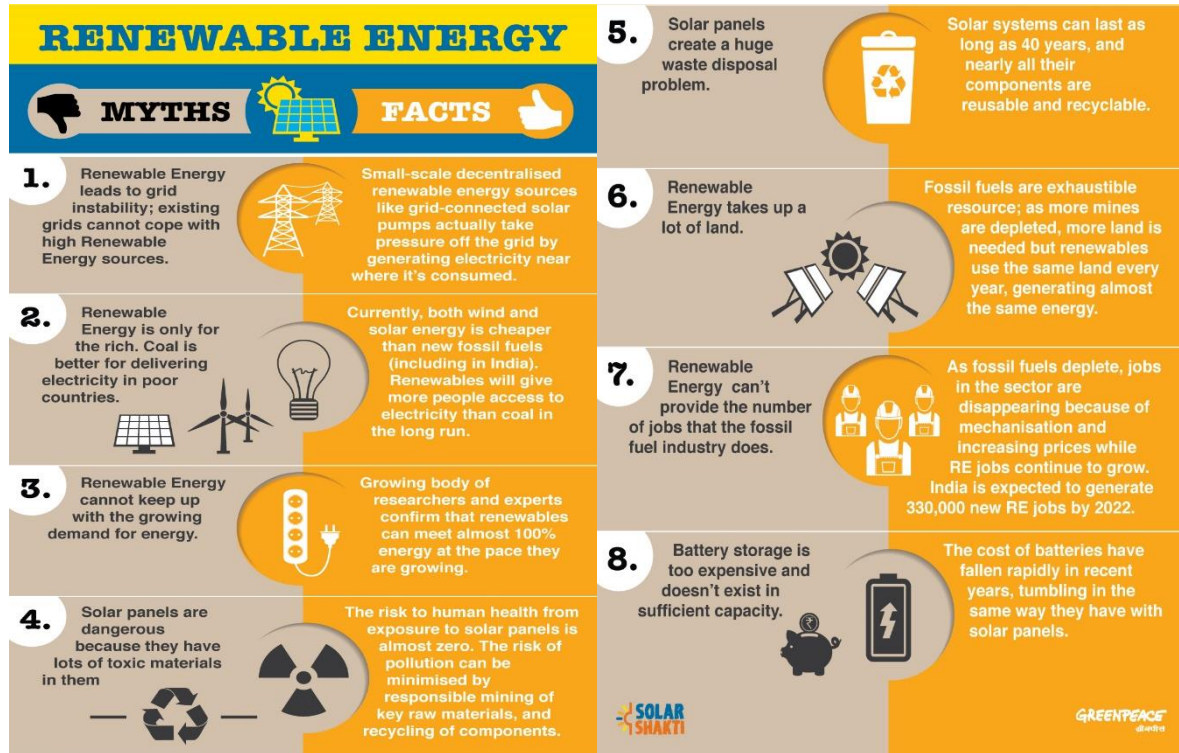


Figure 7 Some facts about renewable energy

4.6 Challenges affecting renewable energy sources

In spite of the outstanding advantages of renewable energy sources, certain shortcoming exists such as: the discontinuity of generation due to seasonal variations as most renewable energy resources are climate-dependent, that is why its exploitation requires complex design, planning and control optimization methods. Fortunately, 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 (Baños et al., 2011).

Renewable energy sources could become the major energy supply option in low-carbon energy economies. Disruptive alterations in all energy systems are necessary for tapping widely

available renewable Energy sources. Organizing the energy transition from non-sustainable to renewable energy is often described as the major challenge of the first half of the twenty-first century that 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.

5 Recommendations and conclusions

The following are policy recommendations emanating from the study that can help mitigate climate change and its impacts:

•	All sectors and regions have the potential to contribute by investing in Renewable energy technologies and policies to help reduce it.
•	Reducing our carbon footprint through the changes in lifestyle and behaviour patterns can contribute a great deal to the mitigation of climate change.
•	Research into innovations and technologies that can reduce land use and also reduce accidents from renewable energy sources and the risk of resource competition, for example in Bioenergy where food for consumption competing with energy production.
•	Enhancing international cooperation and support for developing countries towards the expansion of infrastructure and upgrading technology for modern supply and sustainable energy services as a way of mitigating climate change and its impacts.

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 risks in the future is limited.
•	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.

If these suggestions are implemented, the sustainability of renewable energy resources would be addressed as well as the seventh and thirteenth goal of sustainable development which seeks to ensure access to affordable, reliable, sustainable, modern energy for all and combat climate change and its impact.

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