A Review on Renewable Energy Sources & It's Sustainability

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***Abstract*— In the present literature, a study reveals a status of renewable energy research specific to the Indian context. A majority of the communities around the world is depending upon the heavily on oil, natural gas and coal for their day to day life energy needs. These fuels draw on lots of resources that will eventually diminish, which in turn makes them too expensive or too environmentally damaging to recover. This review article discusses the different advantages and disadvantages of these renewable energies. On the basis of the benefits of the renewable energy resources, the use of these renewable energies, instead of fossil fuels will be a good solution for the control of the environmental, social and economical problems of our communities.**

Keywords:- Sustainability, solar energy, wind energy, hydro-energy, Future Potentials.

1. Energy Scenario and it's introduction

Any physical activity in this world, whether carried out by human beings or by nature, is cause due to flow of energy in one form or the other. The word 'energy' itself is derived from the Greek word 'en-ergon', which means 'in-work' or 'work content'. The work output depends on the energy input. Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them.

Energy can be classified into several types based on the following criteria:

1. Primary and Secondary energy
2. Commercial and Non commercial energy
3. Renewable and Non-Renewable energy
4. Conventional and Non-conventional energy

1.1 Primary and Secondary Energy: Primary energy sources are those that are either found or stored in nature. Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earth's gravity. The major primary and secondary energy sources are shown in Figure. 1 Primary energy sources are costly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.

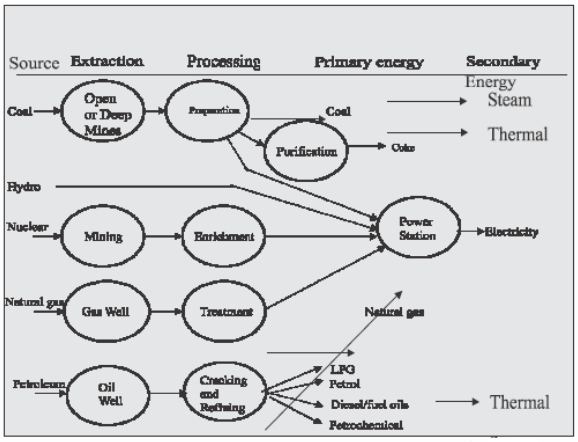

Fig 1. Major Primary and Secondary Sources

1.2. Commercial Energy and Non Commercial Energy

1.2.1 Commercial Energy

The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population.

Examples: Electricity, lignite, coal, oil, natural gas etc.

1.2.2 Non-Commercial Energy

The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting. Example: Firewood, agro waste in rural areas; solar energy for water heating, electricity generation,

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for drying grain, fish and fruits; animal power for transport, threshing, lifting water for irrigation, crushing sugarcane; wind energy for lifting water and electricity generation.

1.3. Renewable and Non-Renewable Energy

Renewable energy is energy obtained from that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power as shown in fig 2 & 3.The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants. Non-renewable energy is conventional fossil fuels such as coal, oil and gas which are likely to deplete with time.

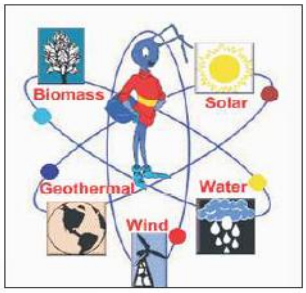


FIG.2.RENEWABLE

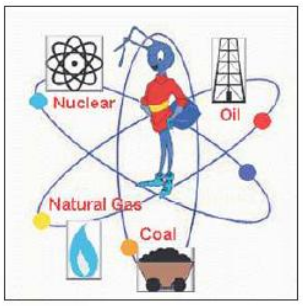


FIG.3.NON-RENEWABLE

1.4. Conventional and Non-conventional Energy:

1.4.1 Conventional Energy:

Conventional energy resources which are being traditionally used for many decades and were in common use around oil crisis of 1973 are called conventional energy resources, e.g., fossil fuel, nuclear and hydro resources.

1.4.2 Non-conventional energy

Non-conventional energy resources which are considered for large scale use after oil crisis of 1973 are called non-conventional energy sources. Examples are solar, wind and biomass etc.

2. BACKGROUND

Based on annual report from 2016 by the India, Ministry of new & Renewable energy, power installed capacity by source and sectors were [1].

Source of energy	% use	Consumption by sector	% use
Coal	69.4	Industry	42.30
Water	13.9	Domestic	23.86
Nuclear	1.9	Agriculture	17.30
Renewable	14.8	Commercial	8.59
		Traction & Railway	1.95
		Other	6

Table:-1. Energy sources for different sectors of the society in the India

The above data shows almost 85% of source of energy in the India were non renewable; therefore it would be beneficial to employ renewable energy resources (wind, solar, geothermal, wave and biomass energy) because of their availability and cleanliness. The selection of energy has global crime that affect greenhouse gas emissions, water resource distribution, mineral consumption, and equipment manufacturing and transportation. The school of thought is that renewable energy technologies are more sustainable than many current sources of energy.

There is a need for verification of the sustainability of renewable energy, which can easily be done by resource-use optimization, techno-economic feasibility and cost analysis, life cycle assessment, environmental externalities analysis, cost benefits analysis, manufacturing cost analysis, research and development targets and barrier identification and water requirements and distribution analysis. [2]

Application of any renewable energy requires a sustainability analysis, which has dependency on three main components: environmental effects, externalities costs, and economics and financing. Each one of these variables has a major impact on the application of renewable energies; therefore before committing communities to different sorts of renewable energies, a thorough research must be done in order to have an assurance that no social, environmental or economical problems arise or are compromised because of them. [2]

3. SUSTAINABLE DEVELOPMENT

After World War-II; the need for conserving non-renewable and natural resources was realized based on the rapid population and economic growth, which initiated the concerns towards the necessary requirements of future generations. Along with economic growth, social problems were considered as an important dimension as it represented the growth of human welfare. As the concept evolved it was actualized that to meet the demands of the future generations, the natural resources should be considered as capital rather than an income source. Further researchers argued that every development should have a guided approach with defined sustainable vision and goals (International Institute of Sustainable Development, 1996). Recent ambiguity among the usage of terms Sustainability and Sustainable development was cleared, stating that these are interchangeable terms as sustainability provides the guiding values that are reflected in the sustainable development through policies and programmers initiated [3]. The universally accepted definition of Sustainable development is defined as "Ability of humanity to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generation to meet their own needs" [4].

Another definition of sustainable development is defines 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" [5]. Renewable energy has a direct relationship with sustainable development through its impact on human development and economic productivity [6]. Renewable energy sources provide opportunities in energy security, social and economic development, energy access, climate change mitigation and reduction of environmental and health impacts [4] Figure 4. shows the opportunities of renewable energy sources towards sustainable development. Reliable energy supply is essential in all economies for heating, lighting, industrial equipment, transport, etc. 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.

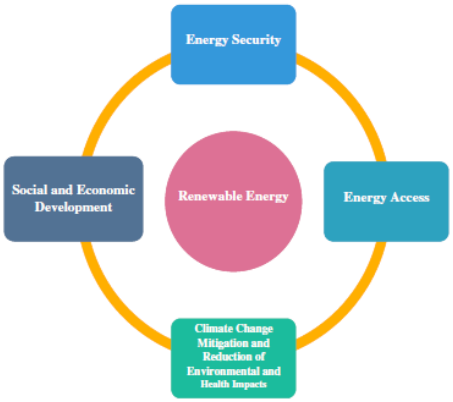


Fig 4.Opportunities of renewable energy sources

3.1. Renewable Energy Sources

Renewable energy is generated from natural processes that are replenished constantly. In its different forms, it generate directly from the sun, wind, rain, tides of ocean, biomass and geothermal resources from heat generated deep within the earth.

The total potential for renewable power generation in the country is estimated at 1198856 MW (Table 2). This includes wind power potential of 102788 MW (8.57%) at 80m hub height, wind power potential of 302235 MW (25.21%) at 100 m hub height, SHP (small-hydro power) potential of 19749 MW (1.65%), Biomass power of 17,538 MW (1.46%), 5000 MW (0.42%) from biogases-based cogeneration in sugar mills, 2556 MW (0.21%) from waste to energy and solar power potential of 748990 MW (62.48%).

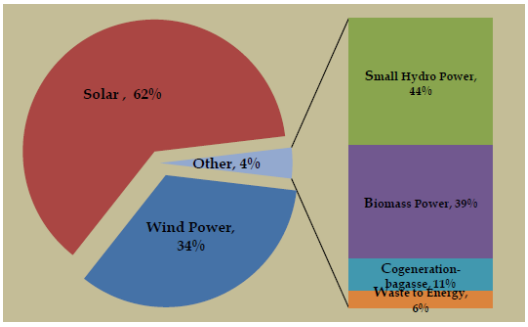


Fig.5 Source wise estimated potential of renewable power in India

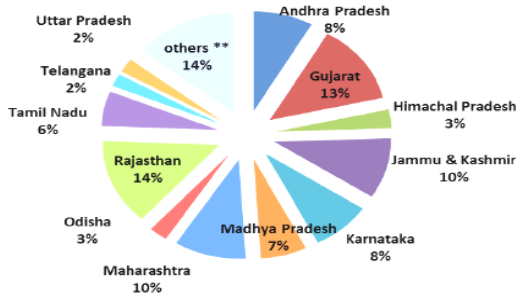


Fig.6. State wise estimated potential of renewable power in India

Table.2. Different source renewable power in India

All India Total /Renewable Energy	Wind Power		Small Hydro Power	Biomass power
	80m	100m		
Power in mw	102788	302235	19749	175358
Distribution (%)	8.57	25.21	1.65	1.46
All India Total /Renewable Energy	Co-Generation	Waste to Energy	Solar Energy	Total Estimated Reserve
Power in mw	5000	2556	748990	1198856
Distribution (%)	0.42	0.21	62.48	100

Fig.6 shows the geographic distribution of the estimated potential of renewable power reveals that Rajasthan has the highest share of about 14% (167276 MW), followed by Gujarat with 13% share (157158 MW) and Maharashtra with 10% share (119893MW), mainly on account of solar power potential.

3.2. Hydro Power: Hydropower is a clean and renewable energy source. Considering the economic, technical and environmental benefits of hydropower, most countries give priority to its development. For example, China has the richest hydro resources on the planet with a total theoretical hydropower potential of 694GW. Developing hydropower is of great importance to alleviate the energy crisis and environmental pollution resulting from the rapid economic growth of China and other countries in the 21st century. [7] Hydropower is generated using the kinetic energy of flowing water by forcing it through piping called a penstock, which then turns a generator in order to produce electricity. Hydropower has several advantages & disadvantages over most other sources generating electrical power. Advantages include a high level of reliability, high efficiency, very low operating and maintenance costs, and the ability to easily

adjust to load changes. Generally many hydropower plants are located in conjunction with reservoirs, which provide water, flood control, and recreation benefits for the community. Disadvantages of hydropower include high initial costs of facilities; dependence on precipitation (no control over amount of water available); changes in stream regimens (can affect fish, plants, and wildlife by changing stream levels, flow patterns, and temperature); inundation of land and wildlife habitat (creation of reservoir); and displacement of people living in the reservoir area.

3.3. Wind Energy: India is a wind-rich country with quality, harvestable wind potential. Monsoon patterns and geography of India play a major role in the Indian wind climatology structure. Indian geography - a mixture of elevated plateau, hill blocks, passes and coastal plains, aid the monsoons, especially the Southwest monsoon to earn harvestable wind

potential. Due to this, States like Andhra Pradesh, Gujarat, Jammu & Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu are endowed with rich wind energy potential. Wind power is the fastest growing Renewable Energy (RE) source in India [8].

A wind turbine converts the kinetic energy of wind into mechanical energy that is used to generate electricity. The energy is fed through a generator, converted a second time into electrical energy, and then fed into the grid to be transmitted to a power station.

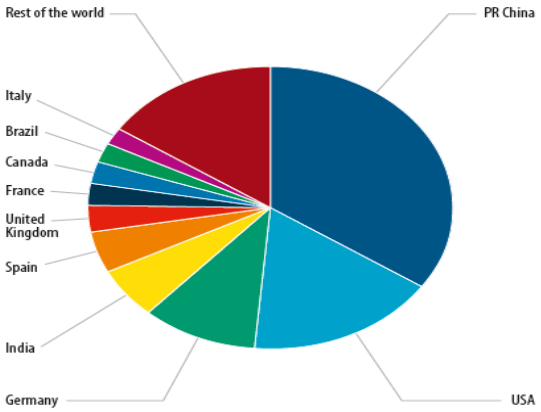


Fig.7. Worldwide Top Ten cumulative wind capacities December 2016

Table: - 3 Top Ten cumulative wind capacities in MW

Country	MW	% Share
PR China	168690	34.7
USA	82184	16.9
Germany	50018	10.3
India	28700	5.9
Spain	23074	4.7
United Kingdom	14543	3
France	12066	2.5
Canada	11900	2.4
Brazil	9257	2.2
Italy	75557	1.9
Total	475989	84.5

3.4 Biomass:- Biomass is one of the most important source of renewable energy derived from numerous sources, counting the by-products from the timber industry, firewood, agricultural residues such as bagases, crop straw, animal dung and wastes generated from agro-based industries and the carbonaceous waste of various human and natural activities. India has an estimated biomass power potential of around 50,068 MW out of which the total installed capacity as of 31st December 2016 was 8,021 MW including bio power & waste to power.

The use of biomass energy has the potential to greatly reduce greenhouse gas emissions, dependence on foreign oil, landfills, and finally supports local agricultural and forest-product industries. The main biomass feed-stocks for power are paper mill residue, lumber mill scrap, and municipal waste. For biomass fuels, the most common feedstock's used today are corn grain (for ethanol) and soybeans (for biodiesel). Long-term plans include growing and using dedicated energy crops, such as fast-growing trees and grasses, and algae. These feed-stocks can grow sustainably on land that will not support intensive food crops. Another benefit of biomass is its capability to convert into a range of valuable fuels, chemicals, materials, and products—much like crude oil: [10]

1. Biofuel – Converting biomass into liquid fuels for transportation
2. Biopower - Burning biomass directly, or converting it into gaseous or liquid fuels that burn more efficiently, to generate electricity
3. Bioproducts - Converting biomass into chemicals for making plastics and other products that typically are made from petroleum.

Besides all of biomass energy advantages, there are also some downsides to it. For example biomass energy is insufficient source of energy compare to fossil fuels (ethanol vs gasoline). It could also be a great possibility for the global warming emissions associated with growing and harvesting biomass feedstock, transporting feedstock to the power plant, and burning or gasifying the feedstock. Transportation and combustion emissions are roughly equivalent for all types of biomass. Thus, it is important to distinguish between biomass resources that are beneficial in reducing net carbon emissions, those that have an ambiguous impact, and those that increase net emissions. [11] Another environmental impact of biomass energy is associated with land erosion because of the removal of the green vegetation.

3.5 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. The Italians were the first to use geothermal energy for commercial purposes in the early 1900's. Geothermal energy is extremely kind to the environment. It offers a constant, efficient supply of clean energy with minimal impact on its surroundings. [12]

Renewable energies also meet the growing energy needs and allow the technological developments without damaging the future of our planet, the atmosphere and the environment. Geothermal energy, which is one of these energies, has great importance for some part of world. For example, Turkey has very rich geothermal energy resources and it is ranked fifth in the world after China, Japan, USA and Iceland; and the Turkish government support and promotion of the renewable energies has also been a major boost in the geothermal power. [13]

The drawbacks of geothermal energy power plants are its location because finding suitable locations for these power plants is not an easy task. The number of locations that can accommodate geothermal power plants is very limited. The location must have hot rocks so they can easily be drilled. Besides the rarity of suitable geothermal power plant locations, there is also the issue of safety. The concentration of geothermal energy can usually be found along plate boundaries, where volcanoes are concentrated and earthquakes are most frequent. Once in a while, geothermal energy locations run out of steam for a couple of months, during which the power plant is unable to produce electricity.

Geothermal energy provides relatively smaller amount of power compared to other energy sources. Power derived from geothermal energy is difficult to transport. Thus, geothermal power plants can only provide energy to the areas surrounding them. While the steam itself can be clean and safe, it can come out with hazardous materials from underground such as hydrogen sulfide, mercury, ammonia, and arsenic. Finally geothermal energy can also cause earthquakes.

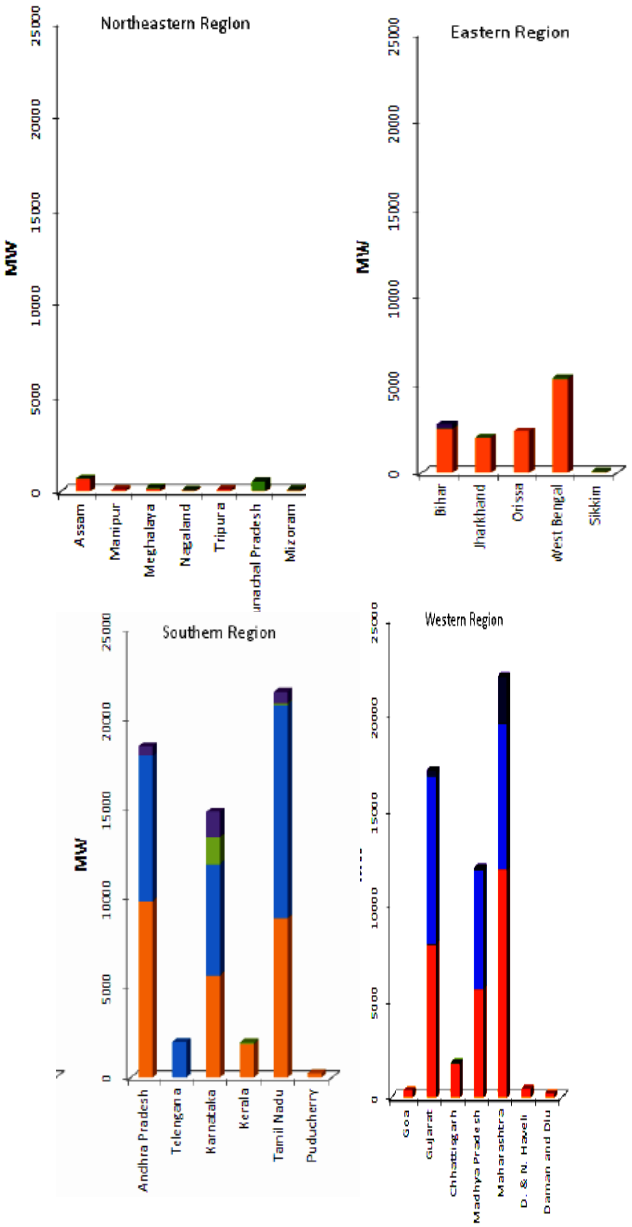
4. RENEWABLE ENERGY SOURCES WITH ADVANTAGES & ITS LIMITATIONS

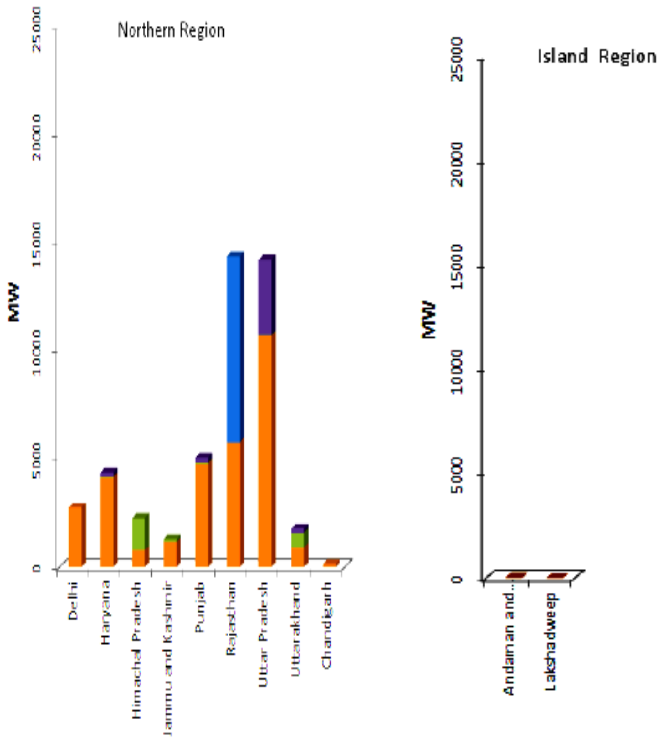
The main renewable energy forms, advantages, disadvantage & their uses are presented in Table: 4.

Power	Output type	Advantage	Disadvantage	Power Generation
Biomass Generation	AC	1. Reduces land fill disposal as it utilizes garbage, animal waste, vegetables and agriculture left-over, etc. as primary source of energy.	1. Primary fuel for biomass plant is not absolutely free like solar and wind. 2.Further research required to reduce cost of fuel required for biomass production	Heat and power generation, pyrolysis, gasification, digestion
Geothermal	AC	1. Geothermal energy is not dependent on weather conditions. 2. Low running cost	1. Geothermal energy is site specific. 2. High installation cost	Urban heating, power generation, hydrothermal, hot dry rock
Solar (PV)	DC	1. Maintenance cost is low. 2. May be used for diversified.	Installation cost is very high	Solar home systems, solar dryers, solar cookers
CSP	AC	1. CSP is predictable RE technology unlike solar PV and wind 2. Efficiency of CSP is very high 3. Operational cost is low	1. Relatively large space and water requirement 2. Installation cost is even higher than solar	Photovoltaic, thermal power generation, water heaters
Wind Power generation	AC	1.Wind turbines are available ranging from a few kW up to 10MW, so that wind power may be used for small house hold to a small town	Noise pollution due to large wind turbines	wind generators, windmills, water pump
Hydro power	AC	1. High efficiency. 2.very low operating and maintenance costs	1.high initial costs 2.Dependence on precipitation	

5. FUTURE POTENTIALS

By 2022, India is targeting the installation of 175GW of renewable energy capacity, an ambitious target that will require a four-fold growth in the sector. The country has installed capacity over 50GW of renewable capacity as of December 2016, 57% of which is wind. The 2022 target includes 60GW of large and medium-scale grid-connected solar power projects, 60GW of wind, 40GW of solar rooftop projects, 10GW of bio-power and 5GW of small hydro. This has notably resulted in a 157% increase in solar power capacity addition during FY2015 and FY2016, and the highest ever wind power capacity addition in FY2.016, which totaled 3,300MW taking India to the fourth position in overall wind installation in the world. India has now achieved 28.6% of its 2022 renewable energy installation target of 175GW [9].





CONCLUSION

Renewable Energy Sources are about sustainability, they are a clean, inexhaustible and locally available energy source that maintains a balance between the energy being consumed and the new potential energy sources being created allowing for local energy independence.

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