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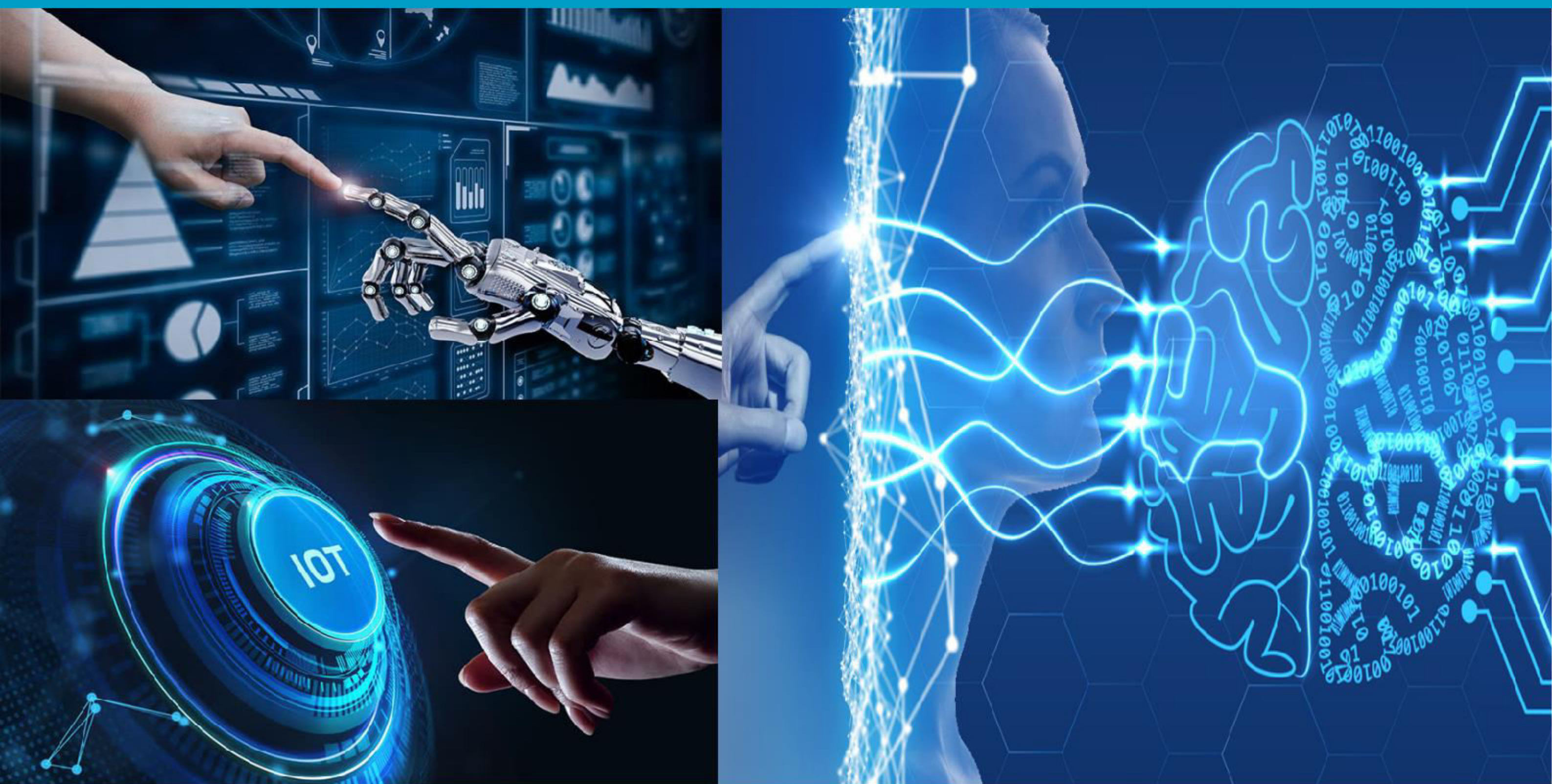

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Environmental Pollution: Suggestion for Its Mitigation Using Green Energy Concept

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ABSTRACT: As a source of energy, green energy often comes from renewable energy technologies such as solar energy, wind power, geothermal energy, biomass and hydroelectric power. Each of these technologies works in different ways, whether that is by taking power from the sun, as with solar panels, or using wind turbines or the flow of water to generate energy. In order to be deemed green energy, a resource cannot produce pollution, such as is found with fossil fuels. This means that not all sources used by the renewable energy industry are green. For example, power generation that burns organic material from sustainable forests may be renewable, but it is not necessarily green, due to the CO_2 produced by the burning process itself. Green energy sources are usually naturally replenished, as opposed to fossil fuel sources like natural gas or coal, which can take millions of years to develop. Green sources also often avoid mining or drilling operations that can be damaging to eco-systems.

KEYWORDS: renewable, sun, water, green sources, ecosystem, mitigation, environmental pollution

I. INTRODUCTION

Green energy is important for the environment as it replaces the negative effects of fossil fuels with more environmentally-friendly alternatives.[1] Derived from natural resources, green energy is also often renewable and clean, meaning that they emit no or few greenhouse gases and are often readily available.Even when the full life cycle of a green energy source is taken into consideration, they release far less greenhouse gases than fossil fuels, as well as few or low levels of air pollutants. This is not just good for the planet but is also better for the health of people and animals that have to breathe the air.Green energy can also lead to stable energy prices as these sources are often produced locally and are not as affected by geopolitical crisis, price spikes or supply chain disruptions.[2] The economic benefits also include job creation in building the facilities that often serve the communities where the workers are employed. Renewable energy saw the creation of 11 million jobs worldwide in 2018, with this number set to grow as we strive to meet targets such as net zero.Due to the local nature of energy production through sources like solar and wind power, the energy infrastructure is more flexible and less dependent on centralised sources that can lead to disruption as well as being less resilient to weather related climate change.Green energy also represents a low cost solution for the energy needs of many parts of the world. This will only improve as costs continue to fall, further increasing the accessibility of green energy, especially in the developing world.[3]

Examples

There are plenty of examples of green energy in use today, from energy production through to thermal heating for buildings, off-highway and transport. Many industries are investigating green solutions and here are a few examples:

1. Heating and Cooling in Buildings

Green energy solutions are being used for buildings ranging from large office blocks to people's homes. These include solar water heaters, biomass fuelled boilers and direct heat from geothermal, as well as cooling systems powered by renewable sources.

2. Industrial Processes

Renewable heat for industrial processes can be run using biomass or renewable electricity. Hydrogen is now a large provider of renewable energy for the cement, iron, steel and chemical industries.[4]

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3. Transport

Sustainable biofuels and renewable electricity are growing in use for transportation across multiple industry sectors. Automotive is an obvious example as electrification advances to replace fossil fuels, but aerospace and construction are other areas that are actively investigating electrification.

Can It Replace Fossil Fuels

Green energy has the capacity to replace fossil fuels in the future, however it may require varied production from different means to achieve this. Geothermal, for example, is particularly effective in places where this resource is easy to tap into, while wind energy or solar power may be better suited to other geographic locations.However, by bringing together multiple green energy sources to meet our needs, and with the advancements that are being made with regards to production and development of these resources, there is every reason to believe that fossil fuels could be phased out.We are still some years away from this happening, but the fact remains that this is necessary to reduce climate change, improve the environment and move to a more sustainable future.[5]

Can It Be Economically Viable

Understanding the economic viability of green energy requires a comparison with fossil fuels. The fact is that as easily-reached fossil resources begin to run out, the cost of this type of energy will only increase with scarcity.At the same time as fossil fuels become more expensive, the cost of greener energy sources is falling. Other factors also work in favour of green energy, such as the ability to produce relatively inexpensive localised energy solutions, such as solar farms. The interest, investment and development of green energy solutions is bringing costs down as we continue to build up our knowledge and are able to build on past breakthroughs.

As a result, green energy can not only become economically viable but also the preferred option.

Which Type Is The Most Efficient

Efficiency in green energy is slightly dependent on location as, if you have the right conditions, such as frequent and strong sunlight, it is easy to create a fast and efficient energy solution.However, to truly compare different energy types it is necessary to analyse the full life cycle of an energy source. This includes assessing the energy used to create the green energy resource, working out how much energy can be translated into electricity and any environmental clearing that was required to create the energy solution. Of course, environmental damage would prevent a source truly being 'green,' but when all of these factors are combined it creates what is known as a 'Levelised Energy Cost'[6] (LEC).Currently, wind farms are seen as the most efficient source of green energy as it requires less refining and processing than the production of, for example, solar panels. Advances in composites technology and testing has helped improve the life-span and therefore the LEC of wind turbines. However, the same can be said of solar panels, which are also seeing a great deal of development.Green energy solutions also have the benefit of not needing much additional energy expenditure after they have been built, since they tend to use a readily renewable source of power, such as the wind. In fact, the total efficiency of usable energy for coal is just 29% of its original energy value, while wind power offers a 1164% return on its original energy input.Renewable energy sources are currently ranked as follows in efficiency (although this may change as developments continue):[7]

1. Wind Power
2. Geothermal
3. Hydropower
4. Nuclear
5. Solar Power

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How Can it Help the Environment

Green energy provides real benefits for the environment since the power comes from natural resources such as sunlight, wind and water. Constantly replenished, these energy sources are the direct opposite of the unsustainable, carbon emitting fossil fuels that have powered us for over a century.Creating energy with a zero carbon footprint is a great stride to a more environmentally friendly future. If we can use it to meet our power, industrial and transportation needs, we will be able to greatly reduce our impact on the environment.[8]

Green Energy vs Clean Energy vs Renewable Energy – What is the Difference

As we touched upon earlier, there is a difference between green, clean and renewable energy. This is slightly confused by people often using these terms interchangeably, but while a resource can be all of these things at once, it may also be, for example, renewable but not green or clean (such as with some forms of biomass energy).Green energy is that which comes from natural sources, such as the sun. Clean energy are those types which do not release pollutants into the air, and renewable energy comes from sources that are constantly being replenished, such as hydropower, wind power or solar energy.[9]

Renewable energy is often seen as being the same, but there is still some debate around this. For example, can a hydroelectric dam which may divert waterways and impact the local environment really be called 'green.However, a source such as wind power is renewable, green and clean – since it comes from an environmentally-friendly, self-replenishing and non-polluting source. Green energy looks set to be part of the future of the world, offering a cleaner alternative to many of today's energy sources. Readily replenished, these energy sources are not just good for the environment, but are also leading to job creation and look set to become economically viable as developments continue.The fact is that fossil fuels need to become a thing of the past as they do not provide a sustainable solution to our energy needs. By developing a variety of green energy solutions we can create a totally sustainable future for our energy provision, without damaging the world we all live on.TWI has been working on different green energy projects for decades and has built up expertise in these areas, finding solutions for our Industrial Members ranging from electrification for the automotive industry to the latest developments in renewable energy.[10]

II. DISCUSSION

Types of green energy

The main sources are wind energy, solar power and hydroelectric power (including tidal energy, which uses ocean energy from the tides in the sea). Solar and wind power are able to be produced on a small scale at people's homes or alternatively, they can be generated on a larger, industrial scale.

The six most common forms are as follows:

1. Solar Power

This common type of renewable energy is usually produced using photovoltaic cells that capture sunlight and turn it into electricity. Solar power is also used to heat buildings and for hot water as well as for cooking and lighting. Solar power has now become affordable enough to be used for domestic purposes including garden lighting, although it is also used on a larger scale to power entire neighbourhoods.[11]

2. Wind Power

Particularly suited to offshore and higher altitude sites, wind energy uses the power of the flow of air around the world to push turbines that then generate electricity.

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3. Hydropower

Also known as hydroelectric power, this type of green energy uses the flow of water in rivers, streams, dams or elsewhere to produce electricity. Hydropower can even work on a small scale using the flow of water through pipes in the home or can come from evaporation, rainfall or the tides in the oceans.[12]

Exactly how 'green' the following three types of green energy are is dependent on how they are created…

4. Geothermal Energy

This type of green power uses thermal energy that has been stored just under the earth's crust. While this resource requires drilling to access, thereby calling the environmental impact into question, it is a huge resource once tapped into. Geothermal energy has been used for bathing in hot springs for thousands of years and this same resource can be used for steam to turn turbines and generate electricity. The energy stored under the United States alone is enough to produce 10 times as much electricity as coal currently can. While some nations, such as Iceland, have easy-to-access geothermal resources, it is a resource that is reliant on location for ease of use, and to be fully 'green' the drilling procedures need to be closely monitored.

5. Biomass

This renewable resource also needs to be carefully managed in order to be truly labelled as a 'green energy' source. Biomass power plants use wood waste, sawdust and combustible organic agricultural waste to create energy. While the burning of these materials releases greenhouse gas these emissions are still far lower than those from petroleum-based fuels.[13]

6. Biofuels

Rather than burning biomass as mentioned above, these organic materials can be transformed into fuel such as ethanol and biodiesel. Having supplied just 2.7% of the world's fuel for transport in 2010, the biofuels are estimated to have the capacity to meet over 25% of global transportation fuel demand by 2050.

Pollution is the introduction of contaminants into the natural environment that cause adverse change.[1] Pollution can take the form of any substance (solid, liquid, or gas) or energy (such as radioactivity, heat, sound, or light). Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants.

Although environmental pollution can be caused by natural events, the word pollution generally implies that the contaminants have an anthropogenic source – that is, a source created by human activities, such as manufacturing, extractive industries, poor waste management, transportation or agriculture. Pollution is often classed as point source (coming from a highly concentrated specific site, such as a factory or mine) or nonpoint source pollution (coming from a widespread distributed sources, such as microplastics or agricultural runoff).[14]

Many sources of pollution were unregulated parts of industrialization during the 19th and 20th centuries until the emergence of environmental regulation and pollution policy in the later half of the 20th century. Sites where historically polluting industries released persistent pollutants may have legacy pollution long after the source of the pollution is stopped. Major forms of pollution include air pollution, light pollution, litter, noise pollution, plastic pollution, soil contamination, radioactive contamination, thermal pollution, visual pollution, and water pollution.

Pollution has widespread consequence on human and environmental health, having systematic impact on social and economic systems. In 2015, pollution killed nine million people worldwide (one in six deaths).[2][3] Air pollution accounted for ¾ of these earlier deaths.[4][5] A 2022 literature survey found that levels of anthropogenic chemical pollution have exceeded planetary boundaries and now threaten entire ecosystems around the world.[6][7] Pollutants frequently have outsized impacts on vulnerable populations, such as children and the elderly, and marginalized communities, because polluting industries and toxic waste sites tend to be collocated with populations with less economic and political power.[8] This outsized impact is a core reason for the formation of the environmental justice movement,[9][10] and continues to be a core element of environmental conflicts, particularly in the Global South.[15]

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Because of the impacts of these chemicals, local, country and international policy have increasingly sought to regulate pollutants, resulting in increasing air and water quality standards, alongside regulation of specific waste streams. Regional and national policy is typically supervised by environmental agencies or ministries, while international efforts are coordinated by the UN Environmental Program and other treaty bodies. Pollution mitigation is an important part of all of the Sustainable Development Goals.[11]

Various definitions of pollution exist, which may or may not recognize certain types, such as noise pollution or greenhouse gases. The United States Environmental Protection Administration defines pollution as "Any substances in water, soil, or air that degrade the natural quality of the environment, offend the senses of sight, taste, or smell, or cause a health hazard. The usefulness of the natural resource is usually impaired by the presence of pollutants and contaminants."[12] In contrast, the United Nations considers pollution to be the "presence of substances and heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects."[13]

The major forms of pollution are listed below along with the particular contaminants relevant to each of them:

- Air pollution: the release of chemicals and particulates into the atmosphere. Common gaseous pollutants include carbon monoxide, sulfur dioxide, chlorofluorocarbons (CFCs) and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and smog are created as nitrogen oxides and hydrocarbons react to sunlight. Particulate matter, or fine dust is characterized by their micrometre size PM_{10} to $PM_{2.5}$.
- Electromagnetic pollution: the overabundance of electromagnetic radiation in their non-ionizing form, such as radio and television transmissions, Wi-fi etc. Although there is no demonstrable effect on humans there can be interference with radio-astronomy and effects on safety systems of aircraft and cars.[16]
- Light pollution: includes light trespass, over-illumination and astronomical interference.
- Littering: the criminal throwing of inappropriate man-made objects, unremoved, onto public and private properties.
- Noise pollution: which encompasses roadway noise, aircraft noise, industrial noise as well as high-intensity sonar.
- Plastic pollution: involves the accumulation of plastic products and microplastics in the environment that adversely affects wildlife, wildlife habitat, or humans.[17]
- Soil contamination occurs when chemicals are released by spill or underground leakage. Among the most significant soil contaminants are hydrocarbons, heavy metals, MTBE,[14] herbicides, pesticides and chlorinated hydrocarbons.
- Radioactive contamination, resulting from 20th century activities in atomic physics, such as nuclear power generation and nuclear weapons research, manufacture and deployment. (See alpha emitters and actinides in the environment.)
- Thermal pollution, is a temperature change in natural water bodies caused by human influence, such as use of water as coolant in a power plant.[18]
- Visual pollution, which can refer to the presence of overhead power lines, motorway billboards, scarred landforms (as from strip mining), open storage of trash, municipal solid waste or space debris.
- Water pollution, caused by the discharge of industrial wastewater from commercial and industrial waste (intentionally or through spills) into surface waters; discharges of untreated sewage and chemical contaminants, such as chlorine, from treated sewage; and releases of waste and contaminants into surface runoff flowing to surface waters (including urban runoff and agricultural runoff, which may contain chemical fertilizers and pesticides, as well as human feces from open defecation).[15][16][17]

Climate change mitigation is action to limit climate change by reducing emissions of greenhouse gases or removing those gases from the atmosphere. The recent rise in global average temperature is mostly caused by emissions from fossil fuels burning (coal, oil, and natural gas). Mitigation can reduce emissions by transitioning to sustainable energy sources, conserving energy, and increasing efficiency. In addition, CO_2 can be removed from the atmosphere by enlarging forests, restoring wetlands and using other natural and technical processes, which are grouped together under the term of carbon sequestration.[19]

Solar energy and wind power have the highest climate change mitigation potential at lowest cost compared to a range of other options.[4] Variable availability of sunshine and wind is addressed by energy storage and improved electrical

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grids, including long-distance electricity transmission, demand management and diversification of renewables. [5]:1 Emissions from infrastructure that directly burns fossil fuels, such as vehicles and heating appliances, can be reduced through electrifying the infrastructure so that it is powered by electricity rather than fuels. Energy efficiency is improved using heat pumps and electric vehicles. If industrial processes must create carbon dioxide, carbon capture and storage can reduce net emissions.[6]

Greenhouse gas emissions from agriculture include methane as well as nitrous oxide. Emissions from agriculture can be mitigated by reducing food waste, switching to a more plant-based diet, by protecting ecosystems and by improving farming processes.[20]

Climate change mitigation policies include: carbon pricing by carbon taxes and carbon emission trading, easing regulations for renewable energy deployment, reductions of fossil fuel subsidies, and divestment from fossil fuels, and subsidies for clean energy.[8] Current policies are estimated to produce global warming of about 2.7 °C by 2100.[9] This warming is significantly above the 2015 Paris Agreement's goal of limiting global warming to well below 2 °C and preferably to 1.5 °C.[10][11] Globally, limiting warming to 2 °C may result in higher economic benefits than economic costs.[12]

The overall aim of climate change mitigation—to sustain ecosystems so that human civilisation can be maintained—requires that greenhouse gas emissions be cut drastically. Accordingly, the Intergovernmental Panel on Climate Change (IPCC) defines mitigation (of climate change) as "a human intervention to reduce emissions or enhance the sinks of greenhouse gases".

Some publications describe solar radiation management (SRM) as a climate mitigation technology.[14][Unrelated to greenhouse gas mitigation,[15] SRM would work by changing the way Earth receives solar radiation. Examples include reducing the amount of sunlight reaching the surface, reducing optical thickness and cloud lifetime, and changing surface reflectivity.[17] The IPCC describes SRM as a "climate risk reduction strategy" or "supplementary option" but not as a climate mitigation option.[21]

Mitigation measures can be approached in parallel, as there is no single pathway to limit global warming to 1.5 or 2°C. Such measures can be categorized as follows:

1. Sustainable energy and sustainable transport
2. Energy conservation (this includes efficient energy use)
3. For agricultural production and industrial processes: sustainable agriculture and green industrial policy
4. Enhancing carbon sinks: Carbon dioxide removal (this includes carbon sequestration)[22]

Carbon dioxide removal (CDR) is defined as "Anthropogenic activities removing carbon dioxide (CO_2) from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS), but excludes natural CO_2 uptake not directly caused by human activities."[1]

III. RESULTS

Greenhouse gas emissions from human activities strengthen the greenhouse effect, contributing to climate change. Most is carbon dioxide from burning fossil fuels: coal, oil, and natural gas. Human-caused emissions have increased atmospheric carbon dioxide by about 50% over pre-industrial levels. Emissions in the 2010s averaged 56 billion tons (Gt) a year, higher than ever before.[20] In 2016, energy (electricity, heat and transport) was responsible for 73.2% of GHG emissions, direct industrial processes for 5.2%, waste for 3.2% and agriculture, forestry and land use for 18.4%.[3]

Electricity generation and transport are major emitters: the largest single source is coal-fired power stations with 20% of greenhouse gas emissions.[21] Deforestation and other changes in land use also emit carbon dioxide and methane. The largest sources of anthropogenic methane emissions are agriculture, and gas venting and fugitive emissions from the fossil-fuel industry. The largest agricultural methane source is livestock. Agricultural soils emit nitrous oxide, partly due to fertilizers.[22] The problem of fluorinated gases from refrigerants has been politically solved now so many countries have ratified the Kigali Amendment.[23]

Carbon dioxide (CO_2) is the dominant emitted greenhouse gas, while methane (CH_4) emissions almost have the same short-term impact.[24] Nitrous oxide (N_2O) and fluorinated gases (F-Gases) play a minor role. Livestock and manure

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produce 5.8% of all greenhouse gas [23] emissions,[3] although this depends on the time frame used for calculating the global warming potential of the respective gas.[25][26]

Greenhouse gas (GHG) emissions are measured in CO_2 equivalents determined by their global warming potential (GWP), which depends on their lifetime in the atmosphere. There are widely-used greenhouse gas accounting methods that convert volumes of methane, nitrous oxide and other greenhouse gases to carbon dioxide equivalents. [24] Estimations largely depend on the ability of oceans and land sinks to absorb these gases. Short-lived climate pollutants (SLCPs) including methane, hydrofluorocarbons (HFCs), tropospheric ozone and black carbon persist in the atmosphere for a period ranging from days to 15 years, whereas carbon dioxide can remain in the atmosphere for millennia.[27]

Satellites are increasingly being used for locating and measuring greenhouse gas emissions and deforestation. Earlier, scientists largely relied on or calculated estimates of greenhouse gas emissions and governments' self-reported data.[28][29]

Global primary energy demand exceeded 161,000 TWh in 2018. This refers to electricity, transport and heating including all losses. In transport and electricity production, fossil fuel usage has a low efficiency of less than 50%. Large amounts of heat in power plants and in motors of vehicles are wasted. The actual amount of energy consumed is significantly lower at 116,000 TWh. [25]

Energy conservation is the effort made to reduce the consumption of energy by using less of an energy service. This can be achieved either by using energy more efficiently (using less energy for a constant service) or by reducing the amount of service used (for example, by driving less). Energy conservation is at the top of the sustainable energy hierarchy. Energy can be conserved by reducing wastage and losses, improving efficiency through technological upgrades, and improved operations and maintenance.

Efficient energy use, sometimes simply called energy efficiency, is the process of reducing the amount of energy required to provide products and services. Improved energy efficiency in buildings ("green buildings"), industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and thus help reduce global emissions of greenhouse gases. For example, insulating a building allows it to use less heating and cooling energy to achieve and maintain thermal comfort. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process or by application of commonly accepted methods to reduce energy losses.[26]

To reduce pressures on ecosystems and enhance their carbon sequestration capabilities, changes are necessary in agriculture and forestry, such as preventing deforestation and restoring natural ecosystems by reforestation. Scenarios that limit global warming to 1.5 °C typically project the large-scale use of carbon dioxide removal methods over the 21st century. There are concerns though about over-reliance on these technologies, and environmental impacts. Nonetheless, the mitigation potential of ecosystem restoration and reduced conversion are among the mitigation tools that can yield the most emissions reductions before 2030.

Land-based mitigation options are referred to as "AFOLU mitigation options" in the 2022 IPCC report on mitigation. The abbreviation stands for "agriculture, forestry and other land use" The report described the economic mitigation potential from relevant activities around forests and ecosystems as follows: "the conservation, improved management, and restoration of forests and other ecosystems (coastal wetlands, peatlands, savannas and grasslands)". A high mitigation potential is found for reducing deforestation in tropical regions. The economic potential of these activities has been estimated to be 4.2 to 7.4 Giga tons of CO_2 equivalents per year. Some mitigation measures have co-benefits in the area of climate change adaptation. This is for example the case for many nature-based solutions. Examples in the urban context include urban green and blue infrastructure which provide mitigation as well as adaptation benefits. This can be in the form of urban forests and street trees, green roofs and walls, urban agriculture and so forth. The mitigation is achieved through the conservation and expansion of carbon sinks and reduced energy use of buildings. Adaptation benefits are provided for example through reduced heat stress and flooding risk.[27]

Types of national policies that would support climate change mitigation include:

- Regulatory standards: These set technology or performance standards, and can be effective in addressing the market failure of informational barriers. If the costs of regulation are less than the benefits of addressing the market failure, standards can result in net benefits. One example are fuel-efficiency standards for cars.
- Market-based instruments such as emission taxes and charges: an emissions tax requires domestic emitters to pay a fixed fee or tax for every tonne of CO_2-eq GHG emissions released into the atmosphere. If every emitter were to face the same level of tax, the lowest cost way of achieving emission reductions in the economy would be

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undertaken first. In the real world, however, markets are not perfect, meaning that an emissions tax may deviate from this ideal. Distributional and equity considerations usually result in differential tax rates for different sources.[28]

- Tradable permits: Emissions can be limited with a permit system. A number of permits are distributed equal to the emission limit, with each liable entity required to hold the number of permits equal to its actual emissions. A tradable permit system can be cost-effective so long as transaction costs are not excessive, and there are no significant imperfections in the permit market and markets relating to emitting activities.
- Voluntary agreements: These are agreements between government (public agencies) and industry. Agreements may relate to general issues, such as research and development, but in other cases, quantitative targets may be agreed upon. There is, however, the risk that participants in the agreement will free ride, either by not complying with the agreement or by benefitting from the agreement while bearing no cost.
- Informational instruments: Poor information is recognized as a barrier to improved energy efficiency or reduced emissions. Examples of policies in this area include increasing public awareness of energy saving with home heating and insulation or emissions from meat and dairy products. However some say that for a politician asking people to eat less meat is "politically toxic".[29]
- Research and development policies: Some areas, such as soil, may differ by country and so need national research. Technologies may need financial support to reach commercial scale, for example floating wind power.
- Low carbon power: Governments may relax planning regulations on solar power and onshore wind, and may partly finance technologies considered risky by the private sector, such as nuclear.
- Demand-side management: This aims to reduce energy demand, e.g., through energy audits, labelling, and regulation.[30]
- Adding or removing subsidies:
  - A subsidy for greenhouse gas emissions reductions pays entities a specific amount per tonne of CO_2-eq for every tonne of greenhouse gas reduced or sequestered. Although subsidies are generally less efficient than taxes, distributional and competitiveness issues sometimes result in energy/emission taxes being coupled with subsidies or tax exceptions.
  - Creating subsidies and financial incentives: for example energy subsidies to support clean generation which is not yet commercially viable such as tidal power.
  - Phasing-out of unhelpful subsidies: Many countries provide subsidies for activities that impact emissions, e.g., subsidies in the agriculture and energy sectors, and indirect subsidies for transport. Specific example agricultural subsidies for cattle or fossil fuel subsidies[31]
- A Green Marshall Plan, which calls for global central bank money creation to fund green infrastructure,
- Market liberalization: Restructuring of energy markets has occurred in several countries and regions. These policies have mainly been designed to increase competition in the market, but they can have a significant impact on emissions.[32]

Significant fossil fuel subsidies are present in many countries. Fossil fuel subsidies in 2019 for consumption totalled USD 320 billion spread over many countries. As of 2019 governments subsidise fossil fuels by about $500 billion per year: however using an unconventional definition of subsidy which includes failing to price greenhouse gas emissions, the International Monetary Fund estimated that fossil fuel subsidies were $5.2 trillion in 2017, which was 6.4% of global GDP. Some fossil fuel companies lobby governments. [33]

Phasing out fossil fuel subsidies is very important. It must however be done carefully to avoid protests and making poor people poorer. In most cases, however, low fossil fuel prices benefit wealthier households more than poorer households. So to help poor and vulnerable people, other measures than fossil fuel subsidies would be more targeted. This could in turn increase public support for subsidy reform.Almost all countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate objective of the UNFCCC is to stabilize atmospheric concentrations of greenhouse gases at a level that would prevent dangerous human interference with the climate system. The Paris Agreement has become the main current international agreement on combating climate change. Each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. Climate change mitigation measures can be written down in national environmental policy documents like the nationally determined contributions (NDC). The Paris agreement succeeds the 1997 Kyoto Protocol which expired in 2020. Countries that ratified the Kyoto protocol committed to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases.[34]

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In 2015, two official UNFCCC scientific expert bodies came to the conclusion that, "in some regions and vulnerable ecosystems, high risks are projected even for warming above 1.5 °C This expert position was, together with the strong diplomatic voice of the poorest countries and the island nations in the Pacific, the driving force leading to the decision of the Paris Conference 2015, to lay down this 1.5 °C long-term target on top of the existing 2 °C goal. In addition to the main agreements, there are many additional pledges made by international coalitions, countries, cities, regions and businesses. According to a report published in September 2019 before the 2019 UN Climate Action Summit, full implementation of all pledges, including those in the Paris Agreement, will be sufficient to limit temperature rise to 2 degrees but not to 1.5 degrees. After the report was published, additional pledges were made in the September climate summit and in December of that year.[35]

In December 2020 another climate action summit was held and important commitments were made. The organizers stated that, including the commitments expected in the beginning of the following year, countries representing 70% of the global economy will be committed to reach zero emissions by 2050.

In September 2021 the US and EU launched the Global Methane Pledge to cut methane emissions by 30% by 2030. UK, Argentina, Indonesia, Italy and Mexico joined the initiative, "while Ghana and Iraq signaled interest in joining, according to a White House summary of the meeting, which noted those countries represent six of the top 15 methane emitters globally. Israel also joined the initiative

Although not designed for this purpose, the Montreal Protocol has benefited climate change mitigation efforts. The Montreal Protocol is an international treaty that has successfully reduced emissions of ozone-depleting substances (for example, CFCs), which are also greenhouse gases.[36]

IV. CONCLUSIONS

Potential Results of Short Lived Climate Pollutants (SLCP) Mitigation

Health. Action to reduce SLCPs has the potential to achieve multiple benefits. For example, each year, more than 6 million people die prematurely from indoor and outdoor air pollution. Short-lived climate pollutants are largely to blame. Fast actions on short-lived climate pollutants, such as the widespread adoption of advanced cook stoves and clean fuels, have the potential to prevent over 2 million of premature deaths each year.[2][10][11]

Agriculture. Reducing methane and black carbon could also prevent major crop losses. Present day global relative yield losses due to tropospheric ozone exposure range between 7-12 percent for wheat, 6-16 percent for soybean, 3-4 percent for rice, and 3-5 percent for maize . In addition, black carbon influences the formation of clouds that have a negative effect on the photosynthesis that impacts plant growth. Rapidly reducing short-lived climate pollutants, for instance through the collection of landfill gas or the recovery of methane from coal mines, has the potential to avoid the annual loss of more than 30 million tons of crops.[2][4][5][10]

Climate. Reducing SLCPs could slow down the warming expected by 2050 by about 0.4 to 0.5 °C,[5] almost halving projected near-term warming as compared to a baseline scenario. However, this applies to the simultaneous reduction of short and long lived climate forcers.[5] Reducing short-lived climate forcers without reducing long-lived emissions, especially CO_2, would not substantially reduce the amount of warming beyond some decades. Therefore, long-term climate change mitigation implies that reduction in emissions of long-lived forcers cannot be replaced with reduction in short-lived forcers. This is a risk in a framework of emission trading and/or objectives based on aggregated emissions, which implies that reducing a certain amount of a given forcer is equivalent to reducing another amount of another forcer.[12]

SLCP reduction is likely to have enhanced climate benefits in many vulnerable regions, such as elevated snow- and ice-covered regions, and is also likely to reduce regional disruption of traditional rainfall patterns.[37]

Though HFCs currently represent a small fraction of total greenhouse gases, their warming impact is particularly strong, and their emissions are projected to increase nearly twentyfold in the next three decades if their growth is not reduced. The most commonly used HFC is HFC-134a, which is 1,430 times more damaging to the climate system then carbon dioxide.[38]

HFC emissions could offset much of the climate benefits from the Montreal Protocol. They are projected to rise to about 3.5 to 8.8 Gt CO_2eq in 2050, comparable to total current annual emissions from transport, estimated at around 6-7 Gt annually. There are options available that could avoid or replace high-GWP HFCs in many sectors and also ways to reduce emissions.[39]

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