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8. The Role of Renewable Energy Sources and Carbon Neutrality/Negativity in Mitigating Climate Change

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Abstract:

The environment consists of the air, water and land as well as the interactions between them with human and other living beings. Globally, the environment affects the health of people, animals, and plants. Because of our superior intelligence, it is our responsibility to safeguard the environment from harmful pollution. The issues of global warming, climate change, health risks, and depletion of natural resources. This book chapter offers a thorough understanding of the fundamentals of climate change and biodiversity changes. This book chapter also explains how to achieve a low-carbon economy, including mitigation and adaptation strategies. As a result, it offers a comprehensive range of solutions to address a variety of environmental and climate change related problems.

Keywords:

Climate change, environment, pollution, global warming, energy, economy.

8.1 Introduction:

The importance of energy in today’s world cannot be overstated. It powers everything from the lights in our homes to the vehicles that transport our goods across the globe. Without abundant and reliable energy[1-9] supplies, the world as we know it would come to a halt. It is a critical for nearly every sector of the economy - manufacturing, agriculture, transportation, information technology, etc. Access to Affordable energy can be directly associated with strong economic development and higher standards of living. personally, we humans rely on energy for many essential activities - heating and cooling our homes, cooking food, charging devices, commuting to work etc. Energy quite literally makes our modern lives possible. Taking it away will make us struggle to meet even our most basic needs. Energy is also a key player for technological progress and innovation. Many emerging technologies like electric vehicles and artificial intelligence are highly energy intensive. But our global energy system is facing immense strains. Demand continues to rise rapidly, especially in developing nations seeking to industrialize and raise living standards. At the same time, we must urgently transition away from fossil fuels to mitigate climate change[10-17]risks. This dual challenge - supplying more energy while drastically cutting emissions - is arguably the greatest test we face in this century. We will need a transformation in how we produce, distribute, store, and consume energy. Renewable sources like solar, wind, geothermal, hydroelectric, biothermal and tidal energy must be massively scaled up. Energy storage solutions are critical for balancing the generated renewable energy because of their low reliability. Smart grids, energy efficiency, nuclear power, and other innovations will all be part of the new solution. developing new, cleaner, and more sustainable energy systems is the only way in which we can power human advancement and protect our ecosystems. Getting our global energy mix right, is not only important but critical to the future civilization on this planet.

depending on the type of source energy can be classified into two types:

A. Renewable sources of energy

B. Non-renewable sources of energy

Renewable sources are the sources which cannot be exhausted i.e. sources which do not run out of fuel. Wind, solar, geothermal, biothermal, tidal and hydroelectric are examples of renewable energy. In this chapter we will go through different types of renewable sources and technologies which can help us overcome the climate challenges and ways that can help us mitigate climate change.

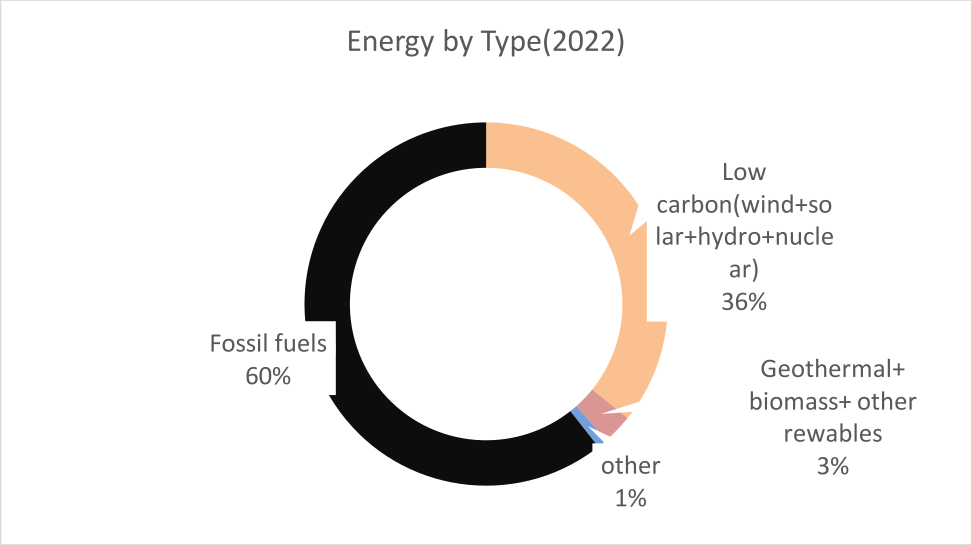


Figure 8.1: Energy by Type (2022)

8.2 Solar Energy:

Solar power is a transformative energy source that could play a pivotal role in addressing two of humanity's greatest challenges this century - meeting rising global energy demand while radically reducing carbon emissions to mitigate climate change risks. At its core, solar power simply harnesses the incredible power of the sun's rays and converts that light into electricity using photovoltaic (PV) cells. These PV cells are made from semiconducting materials like silicon which generate an electrical current when exposed to sunlight. The stronger the sunlight, the more electricity is produced. While still a relatively small part of the global energy mix today, solar power is experiencing explosive growth and rapidly falling costs. Over the past decade, the average price of solar PV panels has dropped by 90%. This has opened solar as a viable, cost-competitive energy source for homes, businesses, utilities, and nations around the world. The key advantages of solar are its renewable nature, versatility in installations, zero emissions during operation, and long-term price stability and predictability. Solar farms can be built relatively quickly compared to other power plants.

Panels can also be installed on residential and commercial rooftops, dramatically increasing consumer energy self-reliance and resilience. With no fuel cost after installation, solar protects consumers and economies from volatility in fossil fuel markets. With costs falling so rapidly, solar is already allowing some of the sunniest nations to meet a large portion of electricity demand from this clean source. Australia and Germany are notable examples where solar provides over 10% of total power generation. US solar capacity has tripled over the past 5 years. However, for solar to become a pillar of the future global energy system, significant challenges remain. While panel prices have plummeted, there are still high logistics, permitting, and costs in solar installations. Energy storage will be essential to allow solar energy to be dispatchable on demand. Further breakthroughs in efficiency, materials, and storage technologies are still needed. Most importantly, solar will need to be built at an unprecedented, massive scale over the next few decades to meet projected energy growth and supplement retiring fossil fuel plants. Leading energy models suggest deployments will need to reach terawatt scales globally by midcentury. This highlights the need for continued policy support, investment, and innovation in solar and related technologies like batteries and transmission infrastructure. With the right coordinated global push, the long-term potential of solar power is staggeringly immense. Fundamentally, harnessing the practical unlimited power of the sun in sustainable ways aligns with humanity's core goals for energy-affordability, reliability, security, and environmental sustainability. Making solar a cornerstone of the future energy system is an ethical and economic imperative. The path to a prosperous, decarbonized world runs directly through accelerated solar power development and deployment.

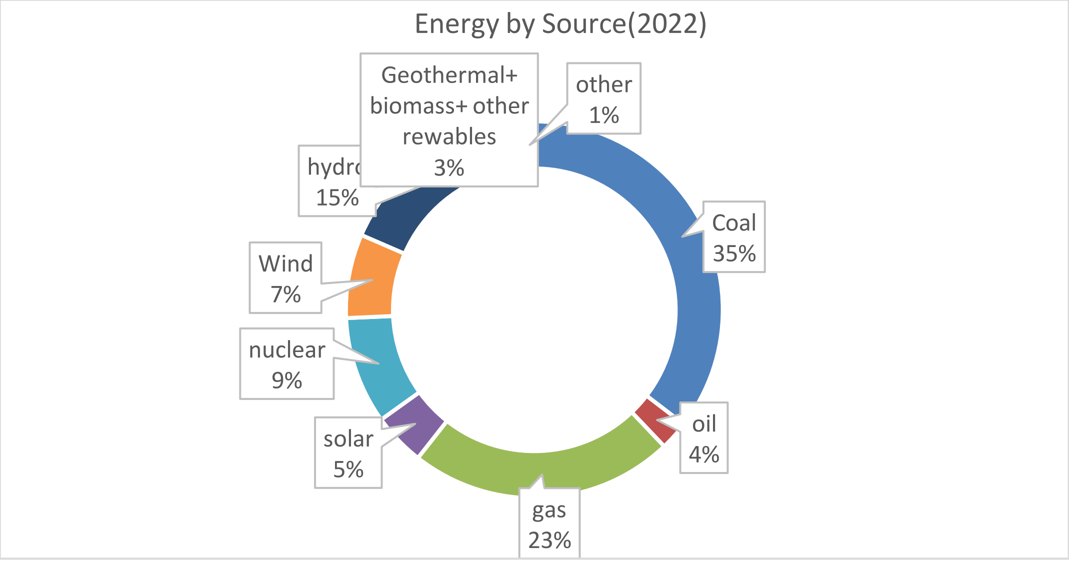
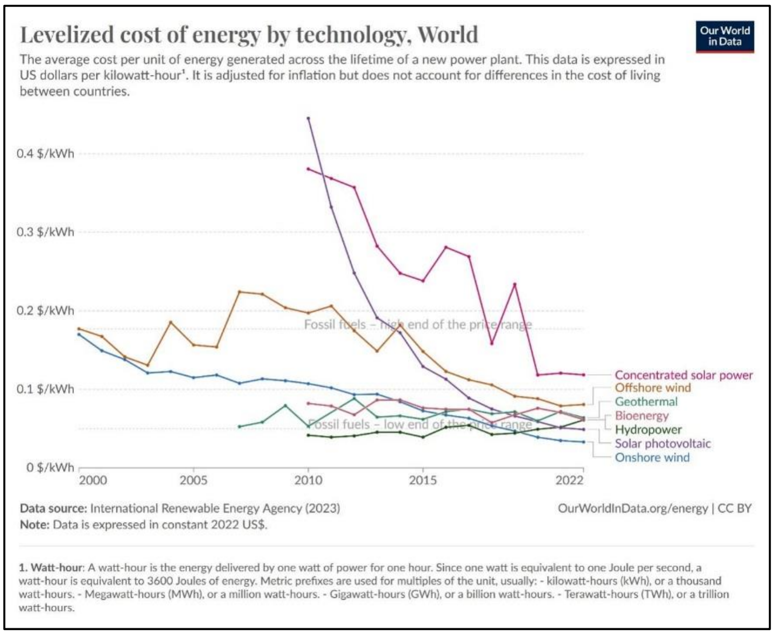


Figure 8.2: Energy by Source (2022)

8.3 Wind Energy:

Wind energy is a booming renewable power source that shows great promise for playing a major role in the future global energy mix. By harnessing the natural flow of wind, wind turbines can generate abundant electricity without producing any greenhouse gas emissions or other pollutants. The basic premise of wind power is simple - wind spins the turbine blades, which are connected to a generator that converts the kinetic energy into electricity. Wind is actually an indirect form of solar power. The differential heating of the earth's surface by the sun creates warm air which rises, causing cooler air to rush in and fill the void. These moving air currents are what we call as wind. By using wind turbines to capture a portion of this flow, we can convert the renewable energy of the wind into sustainable electricity. The key advantages of wind power include its abundant potential, low operating costs, scalability, and zero emissions. With no fuel required, wind farms involve relatively low marginal costs once constructed. And the global potential of wind is staggeringly immense - strong enough wind resources exist over land and offshore to potentially meet all of humanity's energy needs. Europe has led the way in scaling up wind power, with wind providing over 15% of electricity across the European Union. Denmark is a notable example where wind supplies nearly half of total power. China has rapidly built out massive wind installations. In the United States, wind generation has tripled over the past decade due to a combination of improved technologies and tax incentives. But still, wind still only provides around 7.5% of total global electricity demand. There is vast potential for further growth, especially in offshore wind development along coastal regions. The wind is an intermittent resource, so grid-scale battery storage is crucial for wind to provide reliable baseload power. Maintaining consistent wind speeds can be difficult across different regions and conditions. There are also concerns around the environmental impacts of massive wind farm installations on local ecosystems. Overcoming these hurdles will be critical for scaling wind power to the terawatt levels required to deeply decarbonize the global electricity system by mid-century as targeted in climate modeling scenarios. Innovations in wind turbine design, materials, and wind forecasting could further boost the efficiency and cost-effectiveness of wind farms. With its clean, sustainable profile and increasing cost-competitiveness, wind energy seems poised to be a pillar of the 21st-century power mix alongside other renewable sources like solar.



Levelized cost of energy by technology, World

The average cost per unit of energy generated across the lifetime of a new power plant. This data is expressed in US dollars per kilowatt-hour[1]. It is adjusted for inflation but does not account for differences in the cost of living between countries.

Data source: International Renewable Energy Agency (2023)

Note: Data is expressed in constant 2022 US$.

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1. **Watt-hour**: A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one Joule per second, a watt-hour is equivalent to 3600 Joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.

Figure 8.3: Levelized Cost of Energy by Technology, World

8.4 Biothermal and Geothermal Energy:

Biothermal and geothermal energy are two important renewable energy sources that can play valuable roles in transitioning to a cleaner, more sustainable global energy system. Bioenergy refers to energy derived from biomass - organic material from plants and waste that can be burned directly for heat or converted into liquid or gaseous fuels. Examples include wood pellets, ethanol biofuels made from corn or sugarcane, biodiesel from vegetable oils and animal fats, and methane from landfills. The advantages of bioenergy include its renewable nature, flexibility across different sectors like power generation, heating, and transportation, and potential for negative emissions when coupled with carbon capture technologies. Biofuels can also provide a sustainable substitute for fossil fuels in hard-to-electrify applications like aviation. However, some forms of bioenergy have been criticized for issues like land use change, deforestation, and localized air pollution concerns. Ensuring bioenergy is produced sustainably from waste sources or purpose-grown energy crops on marginal lands is essential.

Geothermal energy taps into the clean, virtually inexhaustible heat energy locked within the Earth's molten core. It is captured and harnessed either through geothermal power plants that use reservoirs of steam and hot water to drive turbines and produce electricity, or more simply as a direct heating and cooling source for buildings and industrial processes. Geothermal has an amazing advantage-it provides continuous baseload power uninterrupted by changes in weather conditions like wind or sunlight levels. It also has a very small environmental footprint and zero carbon emissions. Existing geothermal plants alone reduce greenhouse gas emissions by millions of metric tons annually. The main challenge is geography- viable geothermal resources are concentrated in specific regions with tectonic activity and high subsurface heat flow. Enhanced geothermal systems that artificially fracture hot dry rock could help expand geothermal reach, but costs remain high compared to other renewables. Still, in areas with strong geothermal potential, this renewable thermal energy source provides an enticing and underutilized option. Countries like Iceland and El Salvador already derive over 25% of their electricity from geothermal sources. While bioenergy and geothermal are different technologies, both offer solutions in the transition towards a 100% renewable energy future. When deployed thoughtfully and sustainably, their unique advantages could make them valuable complements to other renewable juggernauts like wind and solar power. Continuing research, innovation, and strategic investment in these areas can help accelerate decarbonization goals.

8.5 Tidal Energy:

Tidal energy is a form of hydropower that converts the natural rise and fall of ocean tides into electricity. Tidal streams are harnessed by positioning turbines in coastal areas or estuaries with strong tidal flows. As tides rise and fall, the moving currents turn the turbine blades, generating renewable power. Tidal energy has several advantages compared to other renewables like wind and solar. Tides are highly predictable decades in advance, allowing tidal plants to generate reliable, schedulable baseload electricity around the clock. Locations with high tidal ranges can also produce significant amounts of power from this renewable resource. At the same time, tidal power faces hurdles to widespread deployment. Suitable sites are limited to coastal regions with elevation differences that create strong tidal currents.

The intermittent nature of the tides requires energy storage to provide continuous power delivery. There are also potential environmental concerns around disrupting marine ecosystems and habitats. Despite these challenges, tidal stream turbines are already contributing small amounts of electricity in countries like Scotland, Canada, France, and South Korea. With further cost reductions and resolution of environmental impacts, tidal power could become a niche but valuable part of the future renewable energy mix - especially for coastal population centers seeking clean, dependable power sources.

8.6 Nuclear Fission and Fusion Energy:

Nuclear power will likely play an important role in the clean energy transition, with both fission and fusion technologies offering pathways to secure reliable, zero-emissions electricity at massive scale. Advanced nuclear fission reactors improve upon conventional light-water reactor designs with enhanced safety features, greater fuel efficiency, and reduced waste streams. These include Generation III+ reactor models like the AP1000 and EPR that are currently being deployed. But even more promising are Generation IV designs like molten salt reactors, sodium-cooled fast reactors, and high-temperature gas-cooled reactors. Generation IV fission reactors leverage innovations like passive safety systems, reduced waste production, and the ability to consume existing nuclear waste stockpiles as fuel. They are being engineered with robust containment structures and automatic cooling mechanisms to prevent meltdowns. The high operating temperatures also enable improved efficiencies in power generation as well as process heat applications.

Backed by billions in public and private funding, companies are racing to commercialize and deploy advanced reactor technologies over the next couple decades. If successful, these next-gen fission reactors could maintain nuclear's position as a vital, scalable, zero-carbon baseload power source while resolving many of the traditional concerns around safety, waste, and proliferation risks.But the ultimate prize may be unlocking nuclear fusion - a process that derives energy from fusing light atomic nuclei rather than splitting heavier elements. Fusion powers the sun and other stars through the fusion of hydrogen isotopes into helium under immense temperatures and pressures.

Achieving controlled fusion reactions on Earth could provide humanity with virtually unlimited clean baseload energy for millions of years. The primary challenges have been containing and heating fusion fuel to temperatures hotter than the core of the sun, and developing materials capable of withstanding the intense conditions. After decades of public research, major milestones could finally be in reach within the next couple decades at projects like ITER in France and private fusion startups like Commonwealth Fusion Systems and TAE Technologies. If commercialized, fusion power plants would have a relatively small physical footprint with no risk of meltdowns and produce minimal long-lived radioactive waste. Challenges remain around developing the specialized materials, high operating costs, and achieving a sustained net energy gain. But the payoff could be a revolutionary energy source. From advanced fission reactors to the tantalizing promise of commercial fusion, innovative nuclear technologies could be pivotal in providing abundant clean electricity to complement deployments of renewable sources like wind, solar, geothermal and others. Securing ample investment, talent, and public-private collaboration in this high-stakes arena will be crucial for bringing next-generation nuclear into the mainstream. The rewards of getting it right are potentially astronomical.

8.7 Role of Renewable Energy:

The energy production industry is responsible for almost 1/3rd of the global greenhouse gas emissions. Therefore, transitioning from fossil fuels to renewable energy sources is imperative for mitigating the worst impacts of climate change. The combustion of coal, oil, and natural gas for electricity, heating, and transportation is the primary driver of global greenhouse gas emissions and the resulting climate disruption. Rapidly decarbonizing the world's energy system through the deployment of clean, renewable alternatives is crucial for reducing emissions trajectories in line with the Paris climate accord. Renewable energy sources like solar, wind, hydroelectric, geothermal, and bioenergy produce little to no global warming emissions from operations. Accelerating their deployment can directly substitute for and displace carbon-intensive fossil fuels used for power generation and other applications.

This reduces the flow of new emissions into the atmosphere from human activities. In the electricity sector, renewable sources like utility-scale solar photovoltaics and wind farms are among the most promising and scalable solutions. As technologies have improved and costs have plummeted over the past decade, renewables have become competitive with or cheaper than fossil fuels for generating electricity in most regions. Further innovation and supportive policies can supercharge the installation of these zero-emission generation sources. Renewables are also making headway in other difficult-to-abate sectors. Biofuels and renewable hydrogen can substitute for fossil fuels in applications like transportation and industrial processes. Geothermal, bioenergy, and renewable electricity can provide low-carbon heating and cooling solutions. Scaling these applications will be vital for decarbonizing harder-to-address emissions sources. Renewable energy can also play an enabling role in other climate solutions. Carbon capture methods may be powered by renewable sources. Green hydrogen produced from renewable electricity can help fossil-heavy industries like steel transition to cleaner fuels. Renewables and storage provide grid flexibility to integrate variable generation sources. renewable energy alone is insufficient for reaching net zero emissions targets. While renewable capacity has grown substantially in recent years, it still only accounts for around 35% of total global energy supply. Fossil fuels still comprise nearly 60% of the overall mix, driven largely by rising energy demand in developing economies like India and China.

Figure 8.4: Role of Renewable Energy

8.8 Role of Transportation Sector:

The transportation sector is one of the largest contributors to global greenhouse gas emissions and a major driver of climate change. In 2021, emissions from the transportation of people and goods accounted for around 27% of total energy-related CO2 emissions worldwide. Road vehicles like cars, trucks, and buses made up nearly three-quarters of that transportation footprint.

The heavy reliance on fossil fuels like gasoline, diesel, and jet fuel for powering vehicles and aircraft is the primary source of these emissions. The combustion of these petroleum-based fuels releases CO2 and other greenhouse gases that trap heat in the atmosphere, causing global temperatures to rise. As transportation demands continue growing, particularly in developing nations, emissions from this sector pose an escalating climate risk. Reducing emissions from transportation is therefore critical for mitigating climate change risks and transitioning to a low-carbon future across the globe. A variety of solutions and strategies can help drive down the carbon footprint of how we move people and goods. Improving vehicle efficiency and fuel economy standards for all modes of transport is a key lever.

As we have seen in China, Measures like tighter regulations, gas taxes, feebates, and incentives can accelerate adoption of more efficient internal combustion engine vehicles, hybrids, and zero-emission electric models like EVs and hydrogen fuel cell vehicles. electrification powered by clean electricity sources is the most promising path for deep decarbonization of transportation over the long-term. Rapid scale-up of electric vehicles, transit buses, bikes, rail networks, and related charging infrastructure can effectively eliminate tailpipe emissions in urban environments and beyond. Sustainable aviation fuels derived from waste biomass, produced from renewable hydrogen and captured carbon can help decarbonize harder-to-electrify aviation and shipping sectors. Green hydrogen could potentially enable zero-emission shipping as well if fuel cell and storage challenges can be overcome.

Beyond vehicle technologies, wider systemic changes around urban planning, public transportation, ride-sharing can dramatically reduce total transportation energy use and emissions. Things like high-speed rail networks, bicycle infrastructure, and smart transportation systems are important pieces too.

On a lifecycle basis, creating a more circular economy around vehicle production, operation, and recycling is also crucial for paring emissions from transportation. Sustainable sourcing of key materials like lithium, cobalt, steel, and aluminum is important. So is renewable electricity for manufacturing and recyclability for battery components. Overall, the transportation sector must be a major focus and contributor to any serious climate mitigation efforts moving forward. Decarbonizing mobility is both an immense technical challenge, given its scale and embeddedness in the current fossil-based system, but also represents a massive economic opportunity around vehicle electrification, smart infrastructure, and new transportation models. With smart policy frameworks, public-private collaboration, and investments in R&D and deployment, we can reimagine and reshape how we move across all modes of transportation.

8.9 Role of Carbon Negative Processes:

A. Trees:

Trees are often described as the lungs of this planet, and for good reason. Through the process of photosynthesis, trees absorb carbon dioxide from the atmosphere and release oxygen back into the air we breathe. As trees grow, they sequester and store significant amounts of carbon in their wood, leaves, and soil. Conserving and expanding the world's forests is therefore one of our most powerful natural solutions to removing greenhouse gases and mitigating climate change. Deforestation is a major contributor to climate change, responsible for around 10% of global greenhouse gas emissions caused by human activities. The clearing and burning of forests releases stored carbon back into the atmosphere as CO2. Protecting existing forests from further deforestation is crucial for avoiding these emissions and maintaining vital carbon sinks. Beyond avoided deforestation, allowing previously cleared lands to regenerate into new forests through reforestation and afforestation efforts can actively remove CO2 from the air.

As new tree growth occurs, more and more carbon gets pulled down and hidden from the atmosphere in vegetation and soils. Restoring cleared tropical forests is particularly impactful given their biodiversity and rapid carbon uptake. Some estimates suggest that reforestation across just 900 million unutilized hectares could remove upto two-thirds of all the CO2 emitted since the Industrial Revolution began. While large-scale reforestation alone cannot fully offset current emissions trajectories, it can make a significant dent while providing a host of other ecological co-benefits.

In urban and suburban communities, preserving green spaces and planting more trees can moderate heat islands, improve air quality and offset emissions from concentrated human activities. Integrating forestry into sustainable agriculture through techniques like agroforestry systems can also boost food production and protect rural environments. Beyond just letting trees grow, active forest management is key to maintaining and enhancing the carbon sequestration potential of existing and new forests.

Improved monitoring and measurement tools, optimized planting methods, sustainable harvesting practices, and wildfire prevention strategies all boost the climate mitigation value of forestry programs. Additionally, utilizing wood from sustainably-managed forests as a substitute material for emissions-intensive products like steel and concrete can provide further climate benefits through a concept called stored carbon. By locking in sequestered CO2 in long-lived wood products for buildings or furniture, we can phase out more fossil fuel-intensive materials. Looking ahead, next-generation technologies like genetically engineered tree varieties optimized for carbon uptake or nano-concrete materials derived from plant compounds could further revolutionize how forestry is leveraged for climate change mitigation. While transitioning energy systems away from fossil fuels is paramount, interdisciplinary natural climate solutions centered around forests, trees, and sustainable land use are also vitally important. Conserving, restoring, and managing forests proactively represents a vastly underutilized but immensely powerful carbon capture solution we already have at our disposal. Supercharging these natural climate solutions can make a major dent in reaching net-zero emissions.

8.10 Carbon Capture Technologies:

As the world works to transition away from fossil fuels and toward renewable energy sources, carbon capture technologies will likely play an important role in mitigating climate change. Carbon capture involves separating carbon dioxide (CO2) from industrial processes or directly from the air and then storing or utilizing it to prevent its release into the atmosphere. There are three main approaches to carbon capture: pre-combustion capture, post-combustion capture, and direct air capture. Pre-combustion involves processing fossil fuels into hydrogen and CO2 before combustion, then capturing the CO2 stream. Post-combustion captures CO2 from the flue gases after fossil fuels have been burned. Direct air capture uses chemical processes to selectively remove CO2 directly from the atmosphere. out of the three, direct air capture is highly carbon negative in nature. Once captured, the concentrated CO2 can either be stored permanently underground in geological formations like depleted oil/gas reservoirs or deep saline aquifers, a process known as carbon capture and storage (CCS). Alternatively, it can be repurposed into products or services through carbon capture and utilization (CCU), such as enhanced oil recovery, creation of synthetic fuels or chemical feedstocks, manufacturing of carbon-cured concrete, or production of carbonated beverages. CCS is widely viewed as a crucial technology for achieving deep decarbonization across major industrial sectors like power generation, cement, iron and steel making, and petrochemicals - which collectively account for over 20% of global CO2 emissions. Deploying carbon capture at these large point sources can enable continued utilization of fossil fuels while mitigating a significant fraction of the associated emissions. However, CCS faces economic hurdles due to the high capital costs of capture equipment and storage site characterization. Substantial policy incentives like tax credits, low-cost financing, emissions pricing, and supportive regulations will likely be needed to make CCS widely cost-competitive versus unabated emissions at current technology levels. Currently for DAC technologies, there is an industry target of 100$ for metric ton of CO2 removal from atmosphere but right now it cost above 200$ on average for every metric ton of carbon pulled from the atmosphere. Direct air capture (DAC) is even more challenging given the dilute concentration of CO2 in ambient air. But as a complement to emissions reductions, DAC could play a vital role in achieving net negative emissions by actively removing legacy CO2 already accumulated in the atmosphere. With sufficient low-cost, zero-carbon electricity and storage sites, DAC may be one of few viable routes for counteracting difficult-to-mitigate emissions from agriculture, aviation, and legacy sources. Significant research efforts are underway to improve the efficiency, scalability, and costs of carbon capture systems through advanced materials, processes, and integration with emission sources. Utilizing low-cost energy from renewables, developing CO2 transport and storage hubs, and incentivizing carbon utilization pathways will further boost economic viability. Ultimately, carbon capture, removal, and storage should be viewed as a portfolio of transitional and potentially permanent solutions for managing CO2 waste streams as we decarbonize major economic sectors over coming decades. While not eliminating the need for dramatic emissions cuts, these technologies can help conventional industries defray hard-to-avoid emissions while negative emissions capacities are built in parallel. When combined with rapid deployment of renewable power, next-gen nuclear, green hydrogen, and other innovations, carbon capture and utilization or storage provide additional mitigation tools for bending the emissions curve toward climate stabilization targets. Advanced approaches will be needed at massive scales to make a significant dent in the climate crisis.

8.11 Conclusion:

Renewable sources of energy, carbon neutral transportation and carbon negative technologies will be the pillars of a net-zero carbon goal. To seriously bend the curve on emissions, deployment rates of wind, solar, and other renewables will need to be accelerated at an unprecedented scale and pace over the coming decades, according to most energy transition models. This will require policy reforms, financial commitments in trillions of dollars, new infrastructure buildouts, and overcoming intermittency challenges through storage and transmission advances. Additionally, renewables need to be complemented by strategies in other sectors like transportation, industry, agriculture, and forestry where phasing out fossil fuels is not an easy task. Technologies like carbon capture, next-generation renewables, and negative emissions solutions will also likely be needed to fully neutralize emissions from hard-to-decarbonize activities and remove legacy concentrations of CO2 from the atmosphere. Still, ramping up renewable energy deployment remains a foundational climate solution and key to supplying a greater share of global energy needs with zero-carbon sources.

Realizing renewables' full potential through aggressive innovation and installation is both an environmental necessity and an immense economic opportunity as the world transitions to sustainable energy systems. Getting renewables policy and deployment right is critical for preserving a livable climate. Also, it is important to keep in mind that trees play a crucial role in decarbonizing the already carbon heavy planet. With the potential to remove almost 2/3rd of the carbon in atmosphere, trees are the most natural and effective weapon we have against climate change.

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