

Step 10 Energy and environmental sustainability

Here is a review of the main concepts of this step!

1 Energy sources

Energy sources for generating power include non-renewable options like fossil fuels (oil, coal, natural gas) and uranium for nuclear fission, which have environmental impacts and finite supplies. Renewable energy sources such as solar, wind, biomass, geothermal, and hydroelectric power offer sustainable alternatives with lower environmental impact.

In the past, human energy needs were met by muscle power, domesticated animals, and firewood. Coal became widely used around 1,000 BC, followed by the steam engine in the 17th century, which fueled the Industrial Revolution. The discovery of petroleum in the 19th century led to its use in lamps and eventually as the primary fuel for vehicles.

Throughout the 20th century, electricity became essential, leading to increased exploitation of energy resources. Natural gas emerged as a more efficient fossil fuel. Concerns over fossil fuel depletion and environmental damage spurred interest in alternative energy sources like nuclear power, which remains controversial due to safety and waste disposal issues. Today, solar, wind, biomass, and hydrogen present promising alternatives for the future of global energy.

2 Nuclear energy

Nuclear energy is generated through nuclear reactions, where atoms' nuclei are altered, unlike chemical reactions involving electrons. It's harnessed in nuclear power plants for electricity, constituting about 10% of global electricity production. Two key processes are nuclear fusion, combining small atoms to produce energy without radioactive waste, and nuclear fission, splitting large atoms like uranium to release heat and radiation. Fusion holds promise for clean, abundant energy but is still in experimental stages. Fission, used in bombs and power plants, offers energy with low greenhouse gas emissions but poses risks like

nuclear waste and accidents, as seen in Hiroshima, Chernobyl, and Fukushima.

3 Renewables

Renewable energy sources are naturally replenished and include sunlight, wind, water (rain, tides, waves), geothermal heat, biomass, and ocean energy. These sources have minimal environmental impact compared to fossil fuels and nuclear energy. They are used for electricity generation, heating, cooling, transportation, and in off-grid areas, especially benefiting rural and developing regions. Globally, there is increasing adoption of renewables due to their sustainability and climate benefits. Main technologies like solar, wind, geothermal, hydropower, biomass, and emerging ocean energy play crucial roles in diversifying energy portfolios and reducing reliance on fossil fuels.

4 The debate on renewables

The debate on renewable energy highlights both advantages and challenges associated with their widespread adoption:

Pros: Renewable energy sources are virtually inexhaustible and produce minimal environmental impact, avoiding carbon dioxide emissions and other pollutants. They promote economic development, especially in rural areas, potentially reducing poverty. Given the depletion of fossil fuels and climate change concerns, renewables are seen as a promising choice for the 21st century.

Cons: Renewables face limitations due to intermittency; solar and wind power generation can fluctuate with weather conditions. Cost-effectiveness remains an issue despite the sources being abundant. Building and maintaining renewable energy infrastructure can be expensive, though individuals can benefit economically by selling excess electricity back to the grid. Solar and wind farms require significant land areas, and concerns persist over visual impact, noise, and wildlife impact, though advancements in engineering have mitigated some of these issues.

Additionally, there are supply chain concerns, particularly with solar energy infrastructure relying heavily on polysilicon production in China, which raises

human rights and environmental issues due to conditions in production areas lacking stringent standards.

5 Sources of pollution

Pollution encompasses various forms such as water, soil, thermal, radioactive, noise, and light pollution, each caused by specific contaminants introduced into the environment. Water pollution, from sources like soil erosion and improper waste disposal, degrades water quality and reduces drinkable water availability. Soil pollution, caused by toxic chemicals from industrial activities or improper waste disposal, disrupts natural ecosystems and agricultural productivity. Thermal pollution arises from temperature changes in water bodies due to industrial processes, affecting aquatic life. Radioactive pollution, often from nuclear accidents or improper disposal, poses severe health risks and environmental contamination. Noise pollution, caused by industrial activities or transportation, leads to psychological stress and hearing impairments. Light pollution results from excessive urban illumination, impacting astronomical observations and disrupting natural behaviors. Effective understanding and management of these pollutants are critical to safeguarding ecosystems and human health.

6 Solid waste management

Solid waste management encompasses various methods like landfills, controlled dumps, and incineration, each with distinct environmental implications. Landfills, widely used in developing nations, involve burying waste under layers of soil to mitigate health risks from decomposing materials. However, they can leak harmful substances like heavy metals and pesticides into groundwater and emit methane gas, contributing to air pollution.

Controlled dumps, similar to landfills but less regulated, also pose health and environmental risks due to inadequate containment and management practices. Incineration involves burning solid waste at high temperatures to reduce volume, alleviating pressure on landfills. Yet, it releases toxic gases and particulates like heavy metals and dioxins into the air, which can disperse over wide areas.

To counteract these impacts, waste reduction strategies are crucial. This includes recycling materials like paper, metals, glass, and plastics to create new products, composting organic waste to produce fertilizers, and minimizing the use of disposable items. Such measures not only decrease waste volumes but also conserve resources, reduce pollution, and promote sustainability in waste management practices globally.

7 Air pollution

Air pollution refers to the contamination of the atmosphere by harmful physical, biological, or chemical substances that disrupt natural cycles like the carbon and nitrogen cycles. This pollution results from sources such as fossil fuel burning in power plants and vehicles, as well as emissions from industrial chemicals and household activities like paint and solvent use. Particulate matter, liquid droplets, and noxious gases like sulphur dioxide and carbon monoxide are among the pollutants released into the air, causing visible effects like smog and invisible harm like acid rain.

Both outdoor and indoor environments can suffer from air pollution, impacting human health and the environment at large. Short-term effects include irritation of the eyes, nose, and throat, as well as respiratory infections. Long-term exposure can lead to chronic respiratory diseases, lung cancer, heart disease, and damage to vital organs. Moreover, pollutants like volatile organic compounds (VOCs) and radon pose additional health risks indoors. Overall, air pollution remains a critical environmental and public health concern due to its widespread impacts on ecosystems and human well-being.

8 Climate change

Climate change refers to significant and long-term shifts in global temperatures and weather patterns, primarily driven by human-induced global warming. Over the last century, Earth's average temperatures have risen by approximately 1.5 °F, with a notable acceleration since 1975, largely attributed to the emission of greenhouse gases. This warming trend has profound implications across various aspects of the environment and human life.

The impacts of climate change are increasingly visible and severe. Melting icebergs and glaciers are contributing to rising sea levels, which threaten coastal regions with increased flooding and erosion. Extreme weather events such as hurricanes,

floods, and droughts are becoming more frequent and intense, disrupting ecosystems, agriculture, and human settlements worldwide. These changes are particularly challenging for vulnerable communities in low-lying areas and regions prone to extreme weather.

Biodiversity faces significant threats as species struggle to adapt to rapid environmental changes. Polar bears, for instance, are losing habitat due to diminishing Arctic ice, affecting their ability to hunt for food. Meanwhile, insects are expanding their ranges, leading to outbreaks that damage crops and forests. Changes in climate are also disrupting the timing of natural events such as flowering and migration, potentially disrupting crucial ecological relationships.

The consequences of climate change extend beyond the natural world to human health and well-being. The spread of diseases like malaria may increase as warmer temperatures expand the geographic range of disease vectors. Additionally, economic sectors dependent on stable climate conditions, such as agriculture, forestry, and tourism, face uncertainty and potential losses.

Addressing climate change requires concerted global efforts to reduce greenhouse gas emissions and adapt to the changing climate. Strategies include transitioning to renewable energy sources, enhancing energy efficiency, conserving natural habitats, and implementing policies to promote sustainability and resilience. Effective mitigation and adaptation measures are essential to safeguarding ecosystems, biodiversity, and human societies from the escalating impacts of climate change.