RENEWABLE ENERGY INTRODUCTION

Phenomenon

Globally, the burning of fossil fuels accounts for 87% of carbon dioxide emissions by human activity. Electricity generation and heating account for 27% of carbon dioxide emissions from burning of fossil fuels. The transition to renewable energy sources from nonrenewable energy sources is a vital factor in mitigating climate change and securing a sustainable future.

Essential Question:

How can carbon dioxide emissions from human activity, such as electricity generation and heating, be reduced in your community?

Unit Introduction

During a visit to Feldheim, you will explore how one community in Germany switched from nonrenewable energy resources to 100% renewable energy resources for heating and electricity. The transition to renewable energy is part of Germany's plan to reduce human sources of greenhouse gases with an emphasis on carbon dioxide emissions. You will explore wind energy, solar energy, and bioenergy. Then you will develop a renewable energy action plan for your community.

Overview

The Earth's atmosphere is often compared to a greenhouse because the gases in the Earth's atmosphere interact with incoming solar energy and outgoing surface energy to

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maintain temperatures and pressures necessary to drive global climate and weather systems. Greenhouse gases in the atmosphere release heat when they interact with invisible infrared light. The release of thermal energy as heat warms the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxides, and fluorinated gases. The effect of a greenhouse gas depends on the concentration of the gas in the atmosphere, the time the gas spends in the atmosphere, and the global warming potential of the gas. Global warming potential is related to the chemical structure and properties of a gas molecule.

Although life on Earth depends on the heat from atmospheric greenhouse gases, too much of a good thing can lead to temperature conditions that impact survival of living things. Ice cores, fossil records, and rock formations are evidence of Earth's past climate history. Periods of glaciation and periods of warming have impacted the survival of species throughout the Earth's history.

There are natural sources and human sources of greenhouse gases. The gases that formed the Earth's atmosphere came from the Earth's geophysical processes and living organisms. Warming and cooling of the Earth's atmosphere over millions of years varied with changes in the Earth's orbit around the sun, the tilt of the Earth relative to the sun, and changes in the Earth's surface and tectonic activity. Although global temperatures may fluctuate from year to year, 30-year averages of annual global temperatures show a warming trend since the Industrial Revolution, with a steep increase in warming since 1980. The trend of warmer global average temperatures has been linked to human activity involving the burning of fossil fuels (NASA Earth Observatory, n.d.).

Fossil fuels include oil, coal, and natural gas (methane). Oil and coal are considered nonrenewable because they form over millions of years; therefore, when consumed, they are not replenished in a sustainable human time frame of 80 to 100 years. Some deposits of natural gas are considered nonrenewable if they have an ancient origin. However, methane gas can be artificially produced using controlled decomposition of organic waste by anaerobic fermentation. A current climate concern is the release of methane from thawing permafrost in the Arctic regions. Methane has a high global warming potential.

Although atmospheric methane is an emerging concern, climate scientists have focused primarily on carbon dioxide because the gas has natural and human sources. Carbon dioxide is also produced when fossil fuels and other organic matter (e.g., wood) are burned. Globally, burning of fossil fuels accounts for 87% of carbon dioxide emissions by human activity in 2017.

The main human sources of greenhouse gases include transportation, generation of electricity, industry, waste management, and agricultural activity. Globally, 27% of greenhouse gases released into the atmosphere through human activity come from production of electrical energy.

Germany's Energy Mix

According to the United Nations Sustainable Development Knowledge Platform, Germany has pledged to transform its electricity supply to 100 percent renewable energy by 2050. The goal of using renewable energy is reduction of greenhouse gas (GHG) emissions. Germany’s targets are reduction of GHG by 40% of 1990 levels by 2020 and by 80–85% of 1990 levels by 2050 (United Nations, 2010).

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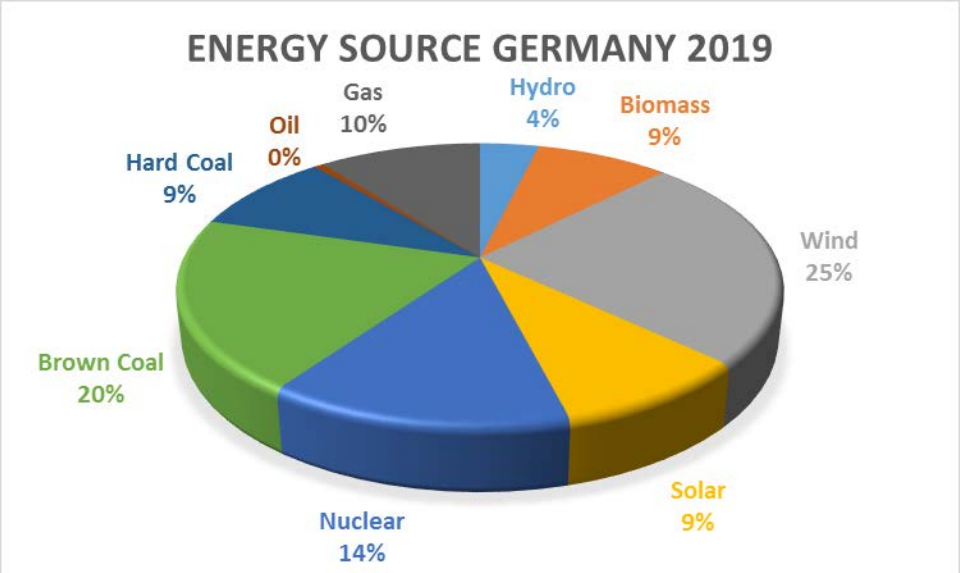
Electricity production accounts for 80% of GHG emissions in Germany. Electricity production also accounts for 40% of energy-related CO_2 (carbon dioxide) emissions. By shifting electricity production away from fossil fuels to sustainable energy, Germany could meet its GHG reduction goals. As part of sustainability planning, the transition includes consideration of economic benefit, energy security, and environmental benefit (United Nations, n.d.).

The term *energy mix* refers to the mix of sources that is used in a region or a country to meet its energy needs. In Germany, 54% of generated electrical power comes from the burning of fossil fuels. In the United States, 68% of electrical power is produced by the burning of fossil fuels, primarily coal and natural gas (Environmental Protection Agency, 2018). Shifting from nonrenewable to renewable energy resources for electricity generation is a sustainability initiative in Germany.

The following graphs show Germany's energy mix in 2019.



Data taken from Fraunhofer ISE/Bruno Burger, 2019

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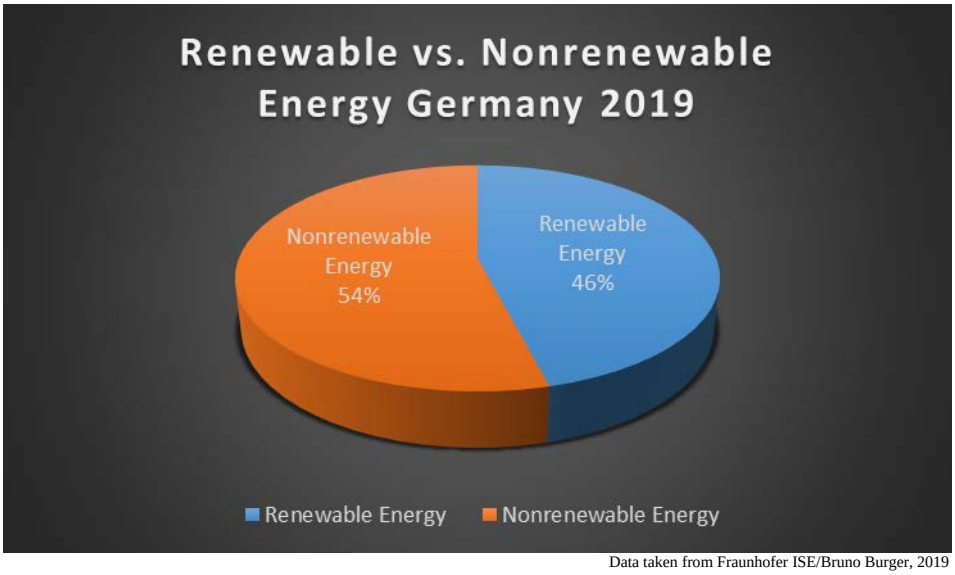

Data taken from Fraunhofer ISE/Bruno Burger, 2019

Germany's renewable energy portfolio includes wind, solar, biomass, and geothermal energies. It is expected that in the short term, sustainable energy will be supplemented by nuclear power and fossil fuel power generated using carbon capture and storage technology. The long-term plan is to phase out nuclear and fossil fuel power plants.

In 2017, the German Renewable Energy Federation, known as BEE (Bundesverband Erneuerbare Energie e.V.), reported a doubling of electricity generation from renewable energy resources since 2009. In 2016, 188 billion kilowatt hours of electricity were produced using renewable energies.

According to the "Factsheet Renewables from Germany" (2015) published by the BEE, the benefits of the renewable energy program are:

- Climate protection from reduced GHG emissions
- Independence from energy imports
- Economic stimulus for growth

Energiewende

The *Energiewende* (translates to “energy transition” in English) is Germany’s energy strategy to achieve the transition from nonrenewable energy sources to renewable energy sources and a significant reduction in GHG emissions by 2050. Some of the more concrete transition targets of the *Energiewende* are:

- Reaching a 40–45% share of renewable energy in Germany’s power consumption
- Shutting down the remaining nuclear power plants by 2022
- Reducing greenhouse emission by 55% by 2030
- 50% reduction in primary energy consumption by 2050

(Federal Ministry for Economic Affairs & Energy, 2020)

Germany has limited domestic sources of nonrenewable energy. Transitioning from nonrenewable resources to domestic renewable energy resources reduces Germany’s need for energy imports. Although the transition is considered a benefit by some, domestic coal producers are concerned about the impact on profits from mining. Coal, more specifically brown coal or lignite, is Germany’s main domestic fossil fuel reserve.

Germany has an industrial capacity for providing the technology needed for renewable energy production. German companies are already global leaders in renewable energy engineering and technology. Large corporations and entrepreneurial start-up companies are using Germany’s vocational education system to ensure a technology proficient workforce. However, complicated energy and environmental laws and tariffs often seem to reward users of electricity from fossil fuel sources and burden users of electricity from renewable sources.

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In spite of debate on how to transition, Germany is still betting on becoming a leader in the European Union renewable energy sector by focusing on natural geographic advantages. In the north, offshore wind can be harnessed to generate electricity. The north also has the advantage of a flat topography, and like the Netherlands, it has the high wind density necessary for efficient generation of electricity by wind turbines. Topography in the south is less favorable to electrical generation by wind power. The Alps are a major factor in reducing wind density in the south. However, the south may have an advantage over the north for generation of electricity by solar panels because there are more sunny days on average as the distance from the North Sea increases.