

WIND, WATER & WASTE

“When a butterfly flaps it’s wings...”¹

Together Wind, Water & Waste made up almost 17% of the total U.S. electricity generation in the United States as of 2021.²

Wind – is the natural movement of air produced when the earth's irregular surfaces (mountains, valleys, water reserves, etc.) along with the planet’s revolution around the sun contribute to the uneven heating of the atmosphere.³

Wind energy is the collection and conversion of the kinetic energy that wind produces into electricity. Wind energy was the source of about 9% of total U.S. electricity generation and about 46% of electricity generation from renewable energy in 2021.⁴ The three categories of wind energy are a) land-based wind energy where wind turbine are used in stand-alone applications or built close together to form a wind farm; b) distributed wind energy systems are wind turbines that are connected at the distribution level but located throughout a network; and c) offshore wind energy.⁵

Water - is vital for all known forms of life, despite providing neither food, energy, nor organic micronutrients. The amount of precipitation that drains into rivers and streams (from the water cycle) in a geographic area determines the amount of water available for producing hydroelectric energy.⁶

Hydroelectric energy is energy in moving water and was one of the first sources of energy used for electricity generation. Most hydropower plants use flowing water to spin a turbine connected to a generator. The first industrial hydropower plant was built in 1880, today there about 1,500 hydrogen power sources operating in the U.S. that produced about 6.3% of total U.S. electricity generation and about 31.5% of electricity generation from renewable energy in 2021.⁷ Most U.S. hydroelectricity is produced at large dams on major rivers built before the mid-1970s by federal government agencies.⁸

“No time to waste...”⁹

Waste – Four major categories of waste: municipal solid waste, industrial waste, agricultural waste and hazardous waste. The world generates 2.01B tons of municipal solid waste annually, with at least a third not managed in an environmentally safe manner. Waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms.¹⁰

¹ This is a nod to the late meteorology professor Edward Lorenz from MIT and his infamous Chaos Theory, for an overview of his contribution to science read: “When the Butterfly Effect took Flight,” by Peter Dizikes, *MIT Technology Review*, February 22, 2011, Available at: <https://www.technologyreview.com/2011/02/22/196987/when-the-butterfly-effect-took-flight/>, Retrieved November 9, 2022.

² <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php>, Retrieved November 9, 2022.

³ <https://www.energy.gov/eere/wind/wind-energy-basics>, Retrieved November 9, 2022.

⁴ <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php>, Retrieved November 9, 2022.

⁵ <https://www.nrel.gov/research/re-wind.html>, Retrieved November 9, 2022.

⁶ <https://www.eia.gov/energyexplained/hydropower/>, Retrieved November 9, 2022.

⁷ <https://www.eia.gov/energyexplained/hydropower/>, Retrieved November 9, 2022.

⁸ <https://www.eia.gov/energyexplained/hydropower/>, Retrieved November 9, 2022.

⁹ Quoted from the World Bank’s Report Titled: “What a Waste: An Updated Look into the Future of Solid Waste Management” Available at: <https://www.worldbank.org/en/news/immersive-story/2018/09/20/what-a-waste-an-updated-look-into-the-future-of-solid-waste-management>

¹⁰ https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html.

According to the company's 10K, Waste Management, Inc. (NYSE: WM) provides waste management services including landfill gas-to-energy facilities throughout the United States, "to manage and reduce waste at each stage from collection to disposal, while recovering valuable resources and creating clean, renewable energy." The company owns or operates 260 landfill sites and 340 transfer stations across the U.S. and Canada.

The company uses waste to create energy, recovering the gas produced naturally as waste decomposes in landfills and using the gas in generators to make electricity and provides recycling programs for municipalities, businesses and households. The company operates a hazardous waste facility where they isolate treated hazardous waste in liquid form by injection into deep wells that have been drilled in certain "acceptable geologic formations far below the base of fresh water to a point that is safely separated by other substantial geological confining layers."

The methane component of the landfill gas is a renewable energy source that can be gathered and used beneficially as an alternative to fossil fuel. The U.S. Environmental Protection Agency ("EPA") endorses landfill gas as a renewable energy resource, in the same category as wind, solar and geothermal resources.

As of December 31, 2021, WM had 144 landfill gas beneficial use projects producing commercial quantities of methane gas at owned or operated landfills. For 102 of these projects, the processed gas is used to fuel electricity generators and sold to public utilities, municipal utilities or power cooperatives. For 16 of these projects, the landfill gas is processed to pipeline-quality natural gas and then sold to natural gas suppliers. For 26 of these projects, the gas is used at the landfill or delivered by pipeline to industrial customers as a direct substitute for fossil fuels in industrial processes.

Biofuels –The first generation of biofuels are still most commonly in use today come from plant materials that cannot be eaten by humans, such as corn stalks, grasses, and wood chips. Current next-generation biofuels made from wastes, cellulosic biomass, and algae-based resources are increasing in economic feasibility.¹¹ Most biofuels are used as transportation fuels, but they may also be used for heating and electricity generation.¹²

Four major categories of biofuels:

- **Ethanol**—is an alcohol fuel that is blended with petroleum gasoline for use in vehicles. In 2021, ethanol accounted for the largest shares of U.S. biofuel production (85%) and consumption (82%).
- **Biodiesel**—is a biofuel that is usually blended with petroleum diesel for consumption and accounts for the second-largest shares of U.S. biofuel production (11%) and consumption (12%) in 2021.
- **Renewable diesel**—a fuel chemically similar to petroleum diesel fuel for use as a drop-in fuel or a petroleum diesel blend with small but growing U.S. production and consumption. Renewable diesel's percentage shares of total U.S. biofuels production and consumption were about 3% and 5% respectively in 2021.
- **Other biofuels**—include renewable heating oil, renewable jet fuel (sustainable aviation fuel, alternative jet fuel, biojet), renewable naphtha, renewable gasoline, and other emerging biofuels that are in various stages of development and commercialization.

¹¹ <https://www.energy.gov/eere/bioenergy/biofuel-basics>, Retrieved November 7, 2022.

¹² U.S. Energy Information Administration, "Biofuels Explained," <https://www.eia.gov/energyexplained/biofuels/>