Renewable Energy 101

A FACT-BASED GUIDE FOR CONSUMERS

SEPTEMBER 2019

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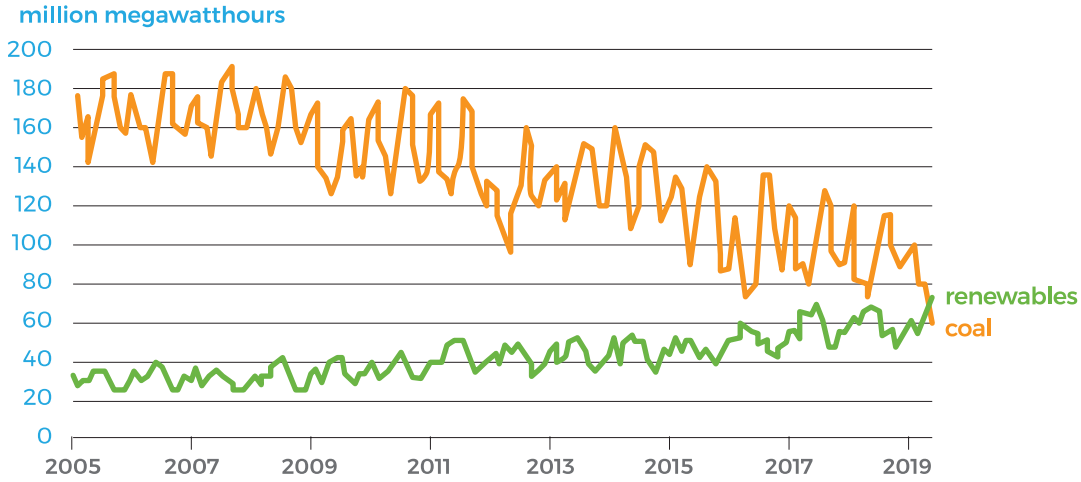
At the end of 2018, Xcel Energy, one of the largest power companies in the U.S., pledged to go 80% carbon-free by 2030 and 100% by 2050 as long as zero-carbon technologies continue to evolve. Then, in April of this year, renewable electricity generation in the U.S. overtook coal-fired electricity generation nationwide for the first time ever.

U.S. monthly electricity generation from selected sources (Jan 2005–Apr 2019)



The Source: U.S. Energy Information Administration, *Electric Power Monthly*.

Some of the largest companies in the world — including Nike, Apple, IKEA and Facebook — have recently made significant commitments to renewable energy, as have many U.S. cities and states[1]. And, across the pond, Britain generated all of its electricity for an entire week in May 2019 without using any coal. The last time they were able to do that was 1882 when Queen Victoria reigned over Great Britain!

What is behind these initiatives and how do you benefit? Keep reading to find out.

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What is renewable energy? And why is it important now?

Renewable energy comes from natural sources that are continuously replenished; increasing concerns over carbon emissions paired with decreasing costs due to innovation are two factors driving its importance today.

Renewable energy is energy collected from sources that are naturally and constantly replenished, such as sunlight, wind, tides, waves and the earth's heat. Recent innovations in technology, design and manufacturing are helping to lower costs of and increase the performance of these natural sources of electricity. For example, the U.S. Department of Energy (DOE) announced two years ago that the average cost for large-scale solar projects has dropped to the point where they are now cost competitive with or cheaper than electricity generated from coal and natural gas. In fact, the Los Angeles Department of Water and Power, the largest municipal utility in the world, recently entered a 25-year deal securing solar at $19.97 per megawatt-hour — or around half the normal cost of solar and one-fourth the normal cost of coal power[2].

The cost of electricity from new wind energy projects is similar to that of solar, especially in the central U.S. where both wind and wide-open spaces are plentiful. Newly developed, bigger and more efficient wind turbines generate a lot more electricity than older versions, especially at lower wind speeds. This lowers the cost of electricity generation, which can lead to major savings for consumers.

After paying for the costs of building a renewable energy facility, the electricity is free to produce. Unlike generating electricity from coal or natural gas, which requires paying for the fuel to burn to run the facility, solar and wind power facilities have no fuel costs. As a result, the cost of electricity from renewable resources is stable over a long period of time. With coal and natural gas, costs can fluctuate based on global and regional supply and demand.

While renewable resources are earning their place due to the economics, today, most renewable energy including wind and solar are backed by fossil fuel generation like coal and natural gas in order to deliver reliable power to all consumers. Energy storage is emerging as a solution to reduce fluctuations in power produced at a given moment by renewables but further innovations in rates and technology are key to continuing adoption of renewables for consumers and energy providers.

Renewables are also gaining traction due to widespread recognition that carbon emissions need to be reduced to avoid environmental impacts. There are a number of other benefits from renewable energy. For example, these energy sources are often more resilient during after severe weather. Since they are often spread out over large areas, a severe weather event in one location is less likely to cut off electricity to an entire region. Another key benefit is that renewable energy creates jobs. Solar panels need workers to install them, and wind farms need technicians for maintenance and repairs. Today, nearly 250,000 Americans work in solar and about 114,000 in wind, and renewable energy is one of the fast-growing job sectors in the U.S.[3]

Renewable energy is an important part of our energy system today and in the future and can deliver many benefits, including 1) low cost, affordable electricity; 2) reduced global warming-related emissions; 3) more resilient electricity with stable prices; and 4) good jobs for Americans.

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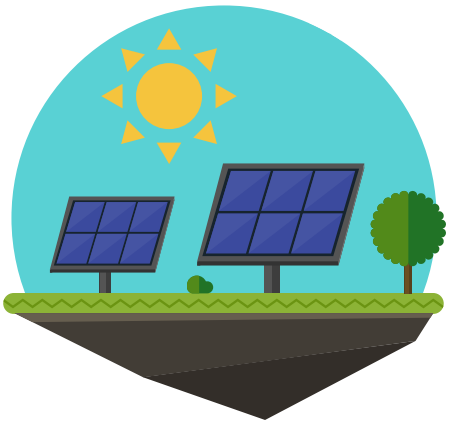
What are the types of renewable energy today?

Solar and wind energy are the two major types of renewable energy today, along with hydropower, which is the oldest and most well-established. Lesser-known types include geothermal and tidal energy.

Renewable energy currently contributes only a modest portion of the electricity generation in the U.S., but that is likely to change in the coming years. As of 2018, renewables represented about 17% of U.S. electricity generation, most of which came from hydropower, wind and other sources. However, by 2030, the share of electricity generated from renewables is forecasted to rise to 25%, with most of the increase coming from wind and solar.[4]

Let's look at the major sources of renewable energy today and some of the technologies behind them.



Solar Energy

The primary technology used today to generate solar energy is the photovoltaic cell, commonly referred to as a "solar panel". This technology generates electricity from sunlight through a natural process that occurs in certain materials, known as semiconductors. Electrons in the semiconductors are freed when the sunlight hits the solar panel and then are made to travel through an electrical circuit, creating electricity that can be used directly by a device or sent to the power grid.[5] Scientists have seen significant improvements in the efficiency of solar panels over the last few decades and continue to explore new ways of generating solar energy, including perovskite solar cells, which could provide even higher efficiencies at very low production costs.

In terms of theoretical potential, solar energy represents a significant opportunity. More energy from solar radiation reaches the Earth's surface during a single hour than the amount of energy all humans on the planet consume each year! The U.S. Energy Information Administration (EIA) estimates that solar energy will be the fastest-growing source of renewable energy for generating electricity. Currently, solar contributes about 13% of total renewable electricity generation, but by 2050, it could account for more than half of renewable generation.

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Wind Energy

Humans have relied on the wind for hundreds of years to mill grain and pump water, but the modern technology used to generate electricity is more sophisticated. The wind turbines being installed today are capable of generating nearly four times the electricity produced by turbines in 2000. In modern wind turbines, the point where the blades attach is about 80 meters off the ground, about the same height as a 25-story building and roughly twice as tall as turbines installed in 2000. Taller turbines can accommodate bigger rotors, which enables the turbine to generate more electricity, and are capable of producing electricity at lower wind speeds, meaning they are generating electricity for more hours of the day.

Electricity generation from wind is also growing rapidly in the U.S. But, while the amount of wind-generated electricity is presently about three times larger than that from solar, wind generation is not growing quite as fast as solar. Wind is expected to be the second-largest renewable energy source by 2050, accounting for about a quarter of all renewable generation. Today, 40 states have large-scale wind projects, and Texas, the top wind state, has enough installed wind generation capacity to power over six million homes.[6]

One of the most exciting technological developments in the renewable industry is the development of offshore wind projects. Currently, the U.S. has only one offshore wind turbine farm in operation, located 3.8 miles off the coast of Rhode Island. Installed in 2016, the Block Island wind project provides power for roughly 10,000 homes. Following the success of this first offshore wind project, more projects are in the pipeline. For example, there is a project located 15 miles south of Martha's Vineyard in Massachusetts that is expected to produce 800 megawatts of power, enough to power more than 400,000 homes. Importantly, these projects only scratch the surface of what offshore wind can provide: according to the DOE, offshore wind in the U.S. has the potential to generate enough electricity to nearly double the nation's current electricity use. Many countries in Northern Europe are already harnessing the potential of offshore wind to provide clean energy at low costs to their residents.

Hydropower

The oldest and most well-established source of renewable energy is hydropower — water flowing through turbines that generate electricity. Hydropower is presently the world's largest source of renewable energy. In the U.S., it accounted for more than half of all renewable electricity generation in 2018 (or seven percent of total, nationwide electricity generation). Building a hydropower facility, though, is time consuming and expensive, and comes with environmental concerns. For example, dams can significantly impede fish migration pathways, which is a major issue in the Northwest. For those reasons, hydropower is expected to take a back seat to solar and wind over the coming decades.

Much of the focus for hydropower will be using existing dam infrastructure to install newer, more efficient turbine systems capable of generating more electricity without having to dam more rivers. In addition, hydropower facilities will play an important role in balancing the production of electricity from wind and solar sources through a process called pumped hydroelectric storage, or pumped hydro. When there's an excess of renewable energy production (for example, during the sunniest hours of the day), that energy can be used to pump water back into the upper reservoir. It can then be released through the turbines to generate electricity at night or when the sun's not shining.

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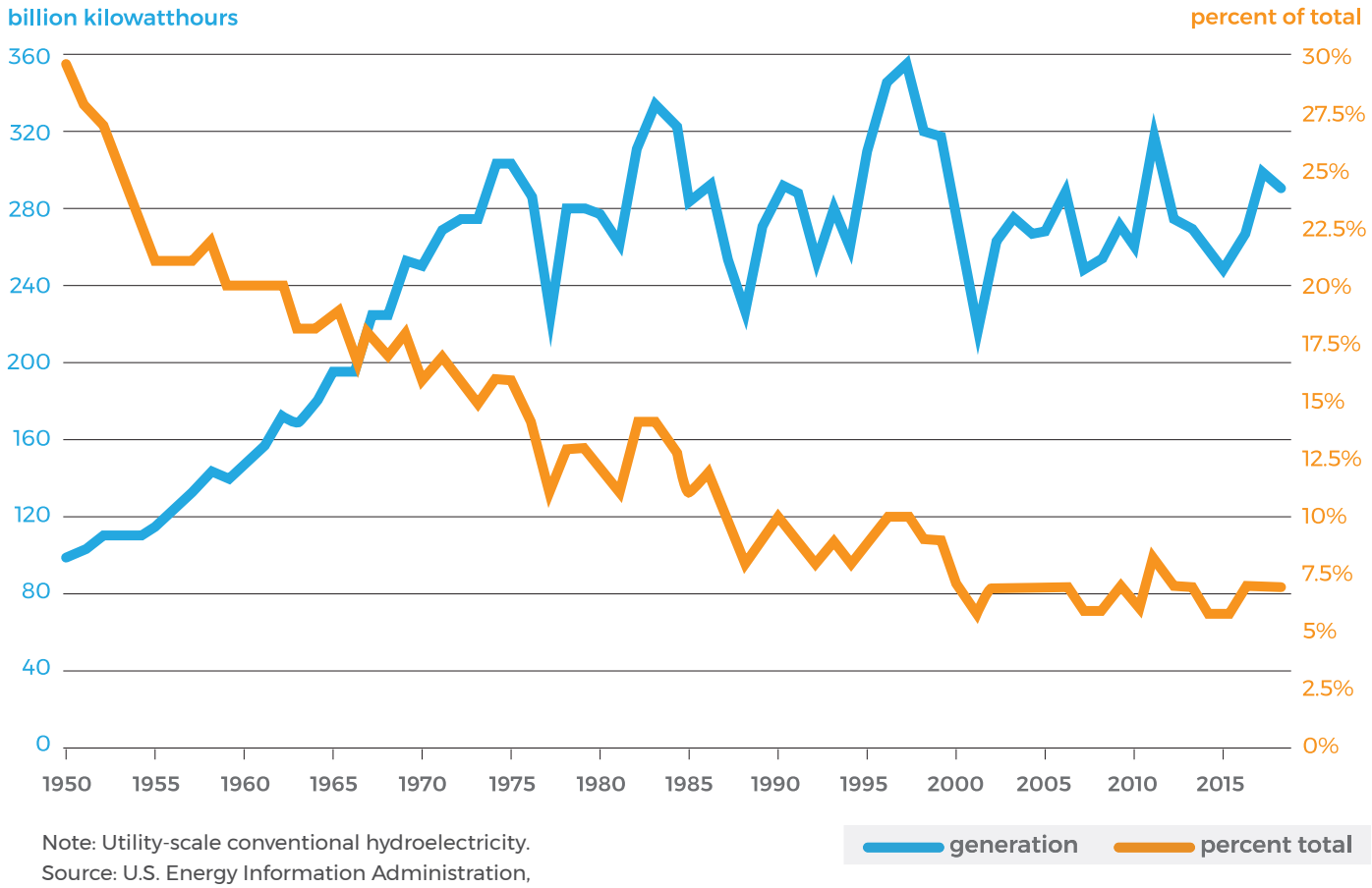
Hydroelectricity generation and share of total U.S. electricity generation, 1950 – 2018



Note: Utility-scale conventional hydroelectricity.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 7.2.a, March 2019

Although these are the three largest and most important sources of renewable energy, there are other renewable energy sources that provide electricity to homes and communities around the U.S. For example, geothermal energy taps heat from below the Earth's surface to produce steam that can drive a turbine to produce electricity. Today, seven western states are generating electricity from geothermal energy: Hawaii, Idaho, Nevada, New Mexico, Utah, Oregon and California. Tidal energy and wave energy are also being tested today as potential major sources of renewable energy. Because of the need for non-renewable fuel, like uranium and plant matter, biomass and nuclear may not considered renewable energy although many consider them to be clean and/or carbon-neutral.

Is renewable energy reliable when the sun's not shining and/or wind's not blowing?

Yes. Although weather can affect the ability of renewables to generate electricity, paired with battery storage, renewables are more reliable than ever.

One of the main concerns that people voice about renewables is the question of what happens when the sun is not shining strong enough or the wind stops blowing. The simple answer is that a solar panel's ability to generate electricity diminishes when sunlight is blocked by a cloud or when it's dark outside. Similarly, if the wind isn't blowing, then a wind turbine isn't generating electricity (although as noted above, newer turbines are able to operate at lower wind speeds and still generate electricity). However, this is only part of the story.

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The more complete answer is that along with a transition to renewable energy sources, there's an equally important transition taking place in the overall electricity system known as the grid. For the past 100 years or so, the electric grid has been a system characterized by large, centralized generating plants, usually powered by coal, hydro or nuclear power plants, along with a complex network of wires that transmit and distribute electricity from the generating plants to residences and businesses. Historically, there hasn't really been a way to store electricity; it must be produced as it is used. Increasingly, however, the grid is becoming a more diverse, decentralized system with different electricity sources, including wind, solar and natural gas, distributed over large regions, helping energy providers supply reliable energy year-round.

By including many different renewable energy sources spread over large areas, the smart technology used for grid reliability can adjust based on weather conditions and the demand for electricity and swap one resource for another. For example, during Hurricane Sandy in 2012, the renewable energy facilities in the New York and New Jersey weathered the extremely destructive storm with minimal damage and continued providing power, leading the region to invest more in renewables and other grid upgrades.

Additionally, the modern electricity grid increasingly includes technologies, such as lithium-ion batteries or pumped hydro, that store electricity for later use. Tesla, for example, offers its large-scale Powerpack[7] for power companies to store energy.[8] And similarly, Tesla sells their Powerwall system to homeowners with solar panels to store excess energy generated from a home's panels for use when the panels are not producing electricity and to provide backup power in case of an outage. Some experts expect electric vehicles to play a similar role by sending energy stored in the batteries back to the grid when needed. In a modern power grid, energy storage will play an important part in helping energy providers balance electricity supply with demand, improving reliability and potentially avoiding spikes in costs.

In many ways, the electric grid is being transformed into a diverse and interconnected energy "ecosystem", like a natural ecosystem that has soil, water, plants and animals, which are all interconnected and interdependent. The energy ecosystem includes a diverse collection of distributed electricity sources, technologies for storing electricity and technologies and programs that encourage people to reduce their consumption of electricity. This can include energy-efficient LED lighting, smart thermostats and rebates to encourage consumers to reduce their electricity use during high electricity demand, like extremely hot summer days. The emerging energy ecosystem consists of a vast network of component parts — all working together to make a more reliable, resilient and adaptable system.

The energy ecosystem includes a diverse collection of distributed electricity sources, technologies for storing electricity and technologies and programs that encourage people to reduce their consumption of electricity.

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Are solar panels, wind turbines and batteries actually better for the environment?

Yes, these technologies are very important for reducing carbon emissions; however, there are several factors to consider to ensure a low environmental impact.

Reduced Emissions

In the United States, electricity generation accounts for about one-third of global warming-related emissions; however, renewable energy sources produce few of these emissions across their lifetimes. While the manufacturing, installation and decommissioning of renewable energy resources does result in emissions and other pollutants, the total emissions from renewable energy facilities is relatively minor.[9] For instance, one nonprofit think tank estimated that generating 25% of U.S. energy via solar could reduce CO2 emissions by the equivalent of the annual output from 70 coal plants. Further, a DOE study concluded that using solar energy to meet 27% of the nation's electricity demand by 2050 could save $259 billion in climate change-related damages, reduce enough water consumption in the electricity sector to hydrate 1.3 million households, save $167 billion in reduced health and environmental damages, and save 25,000 lives as a result of the reduced pollution.[10]

Land, Water & Wildlife

Although a solar farm or wind farm takes up space and has a footprint, they are usually located in wide-open, rural areas where there's lots of available land. In addition, wind farms and solar farms can be divided up and distributed across even larger areas, reducing the impact on any one community. The land around solar and wind farms can also be utilized for growing crops or grazing livestock, known as "dual-use farming", and a solar farm in Germany is even being used as a refuge for endangered wildlife.

Renewable energy also offers significant benefits for water conservation. Nuclear reactors, along with coal-fired and natural gas-powered electric plants, use nearly half of all freshwater extracted from U.S. lakes, rivers and aquifers to cool the plants, a figure that excludes the water used to mine coal or frack for natural gas. Renewable energy generation consumes only a fraction of the water required for traditional generation.

While there are some concerns around the impacts of wind energy specifically on wildlife, studies have shown otherwise. For example, bird deaths due to wind turbines are much lower than those for cars, airplanes, agriculture, building windows and many other causes.[11] Even so, considerations are being made to reduce the impact on birds, and the new, larger turbines are likely to help greatly in this area.

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Battery Storage

Batteries convert electrical energy to chemical energy and release it again as electrical energy, so the manufacturing of batteries requires chemicals, some of which may need to be handled with care. Lithium-ion batteries are the most common type of battery today and are better performing and less toxic than older batteries made with lead or cadmium. Nevertheless, there are still environmental and safety concerns about the mining of raw materials and the manufacturing of lithium-ion batteries. Given the importance of batteries, though, there is a tremendous amount of research taking place to develop new, more powerful and less toxic batteries. One promising technology is sand. Researchers say that sand-based lithium ion batteries have the potential to outperform traditional lithium ion batteries by threefold and are far less toxic.[12]

The net result is that even though there are environmental impacts associated with the manufacturing of renewable energy technologies, like solar panels and wind turbines, using these technologies as a means of producing electricity is a far better choice for the environment and society at large than the status quo.

How can I take advantage of renewable energy options?

There are several ways you can participate, including purchasing your electricity from renewable sources, participating in a community solar program or buying rooftop solar for your home.

Green Power Plans

There are a number of ways that consumers can get involved with renewable energy in their area. Perhaps one of the simplest ways is to contact your electricity provider and ask about programs they may already be offering. For example, Austin Energy has a residential program called GreenChoice that customers can enroll in to purchase 100%, Texas-generated wind power. Consumers pay a very small premium ($0.0075 per kWh) for participating in the program, and anyone can sign up. In the Pacific Northwest, Puget Sound Energy in Washington State offers several programs for residential customers, including a program called Solar Choice that enables any residential customer to purchase 100% solar-generated electricity.

Community Solar

Another way to get involved is through community solar. Community solar provides a way for homeowners, renters and businesses to get involved with a solar project in their community or region. It's a great way to support solar energy and take advantage of its benefits, even if you are a renter and do not own your home or if your home's roof is not suitable for installing solar panels. Consumers get involved with a community solar project by becoming a subscriber. In turn, subscribers receive a credit on their electric bills that is proportional to their share of the project. According to the Solar Energy Industries Association (SEIA),[13] as of 2018, there were at least 43 states with one or more community solar projects, providing enough electricity to power over 227,000 homes. And more projects are in the pipeline. SEIA estimates that community solar could more than double over the next couple of years. Georgia Power is an example of an energy provider who is helping their customers get involved in community solar: customers can sign up for one or more blocks (or shares) of a community solar project and receive a bill credit proportional to their share of the electricity the project generated that month.

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Rooftop Solar

If you're interested in rooftop solar, you can either purchase the solar panels or lease through a company, and fortunately, there are many tools available to help with the decision-making process. For example, multiple energy providers in the Northeastern United States — Con Edison[14] and National Grid[15] — offer their customers solar marketplaces for learning about opportunities for getting involved with solar energy and getting a rooftop solar system installed at their home. The marketplaces help consumers learn about the technology, find qualified contractors and get personalized cost estimates. They also help consumers understand how to estimate the energy and cost savings they can expect from installing a solar system. It is important to consult with your energy provider when investing in solar to ensure you have a full understanding of their rooftop solar programs.

Will rooftop solar or community solar actually save me money?

It depends — savings can be realized with a correct combination of tax credits, assessment of the type of solar to participate in and the upfront investment required.

The installed costs for rooftop solar today are less than one-third of what they were back in 2000, which is evidence of how fast the industry is progressing. Yet, even considering the dramatic cost declines, the answer to the question of "Will I save money?" is... "It depends." Everyone's situation is different, and the suitability and cost of solar depends on lots of factors, including where they live, how big their home is, how their roof is oriented, and how much they are paying currently for their electricity. If these factors add up to an ideal situation, you could save thousands of dollars from lower electricity bills and enhanced home value over the lifetime for a solar energy system.

If you're interested in rooftop solar, a good way to start is to use a solar calculator, such as the one from EnergySage,[16] a resource for learning about rooftop solar that is supported by the DOE and a number of states. The calculator asks for an address and your average monthly electricity bill and then calculates the suitability of solar and provides resources for connecting with potential installers.

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Another thing to keep in mind are available tax credits and other incentives. Currently, there is a 30% federal tax credit for solar, which decreases to 26% in 2020 and then to 22% in 2021, after which it goes away altogether unless Congress extends it. In addition, some energy providers will cut you a check based on installation of a home solar system; for example, Duke Energy in North Carolina offers residents up to $6,000 in rebates.[17] A good resource for learning more about available incentives for rooftop solar is the Database of State Incentives for Renewables and Efficiency.[18] Many power companies also support "net metering", which allows those with rooftop solar to sell the electricity they aren't using back to the power company. Consumers can either receive bill credits or their electric meter will actually run backwards, and they will eventually only pay for their total "net" energy consumption. Other energy providers may only pay an established "avoided cost" rate for electricity sold by customers with rooftop solar that reflects wholesale prices and can greatly impact the cost benefit for rooftop solar.

While the primary benefit of community solar is arguably to enable people to go solar even if they do not own property on which to put their own system, there can also be financial benefits for participants. For example, in a subscription-based community solar farm, a participant can lock in an affordable rate for electricity for the duration of the subscription. This rate could be much less than what they would pay normally through their power company. Similar to rooftop solar, some community solar projects are eligible for net metering, and participants can receive bill credits for times when the community solar farm is producing excess energy. Additionally, community solar typically optimizes the generation of electricity compared to rooftop solar because of greater control over location and sun exposure.

What does the future for renewable energy look like?

Although there has been a lot of innovation recently related to renewable energy, these innovations may have only scratched the surface of what's possible.

There has been a tremendous amount of innovation and advancement in renewable energy technologies in recent decades. In many ways, though, these innovations have only scratched the surface as researchers continue to improve the efficiency and applications of renewable energy technology.

Offshore wind turbines, for example, appear particularly promising considering that over 40% of Americans live in coastal areas on both sides of the country. Another promising technology is "floatovoltaics", or solar panels floating on the water. These floating solar panels could be deployed in the reservoirs behind dams or other large water bodies across the country, so they wouldn't compete with other uses for the surrounding land area like agriculture. In addition, the floating panels help reduce evaporation and could help inhibit the growth of algae.

For homeowners and other consumers, another technology that could catch on is solar roofs, or solar panels that are integrated directly into roof shingles, which eliminates the need to install solar panels on top of an existing roof. Also known as building-integrated photovoltaic (BIPV), one of the companies that is developing and promoting this technology is Tesla, who is developing and producing its Solar Roof[19] at its facility in Buffalo, New York.

Finally, many state and city governments have demonstrated support for renewable energy independently of any federal policy initiatives. Led by Hawaii and California, 12 states so far have pledged or signed legislation mandating either renewable or non-carbon emitting electricity generation.[20] This includes states on the east coast like New York, New Jersey and Maine, and well over 100 cities across the country have made similar commitments to embrace clean, renewable energy.[21]

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Image Credit: Duke Energy

Bottom line: a cleaner, brighter energy future for you

Renewable energy is growing quickly, and many municipalities and states are embracing a future of clean energy. But what does this ultimately mean for you?

First, it could mean access to clean electricity that is increasingly more affordable. It also could mean more jobs for Americans. These are jobs that cannot be outsourced or offshored, because they're needed locally to install and maintain the generating equipment.

Furthermore, renewable energy generation will play an important role in the emerging energy ecosystem of technologies and services that help make the electricity grid more reliable and dependable. Finally, renewable energy means a cleaner and healthier environment for all Americans and far fewer emissions that contribute to global warming.

Renewable energy is poised to provide Americans with a cleaner, safer, healthier and even more prosperous future.

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A Special Note of Thanks:

SECC would like to thank Dr. Paul Schwarz for his assistance writing this guide. Paul is a researcher and writer contributing to the transition to cleaner and more sustainable energy resources. Learn more about him at: www.linkedin.com/in/paschwarz.

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