New York State Energy Generation

Offshore Wind Turbines. Source: BOEM

New York's Electricity Portfolio Overview and the Role of Offshore Wind Energy in Ongoing Renewable Energy Changes

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New York's Electricity Overview

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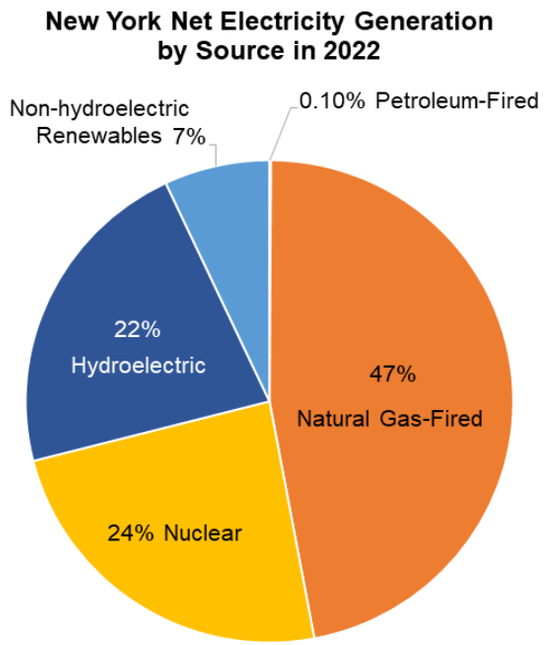
How and why is electricty generation in New York State changing?

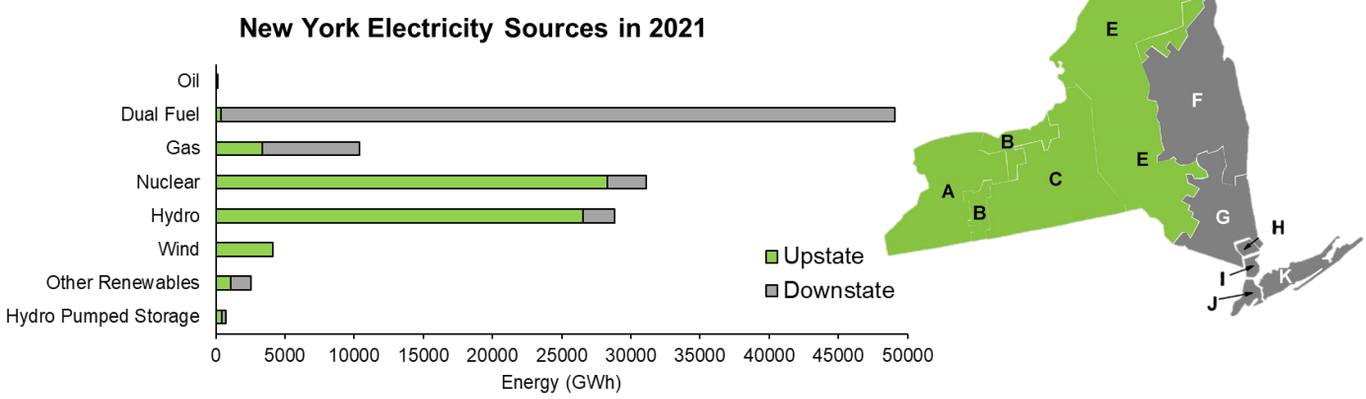
In 2019, the Climate Leadership and Community Protection Act (Climate Act or CLCPA) was signed into New York law. In the short term, 70% of New York's electricity must come from renewable sources by 2030, known to many as "70 by 30"[1]. The Climate Act also requires 9,000 MW of the electricity we use to come from offshore wind energy sources by 2035[1] . In the long term, it mandates that the state achieves 100% carbon-free electricity system by 2040. Additionally, New York must reduce greenhouse gas emission by at least 85% below 1990 levels by 2050[1].

Where does electricity in New York State come from?

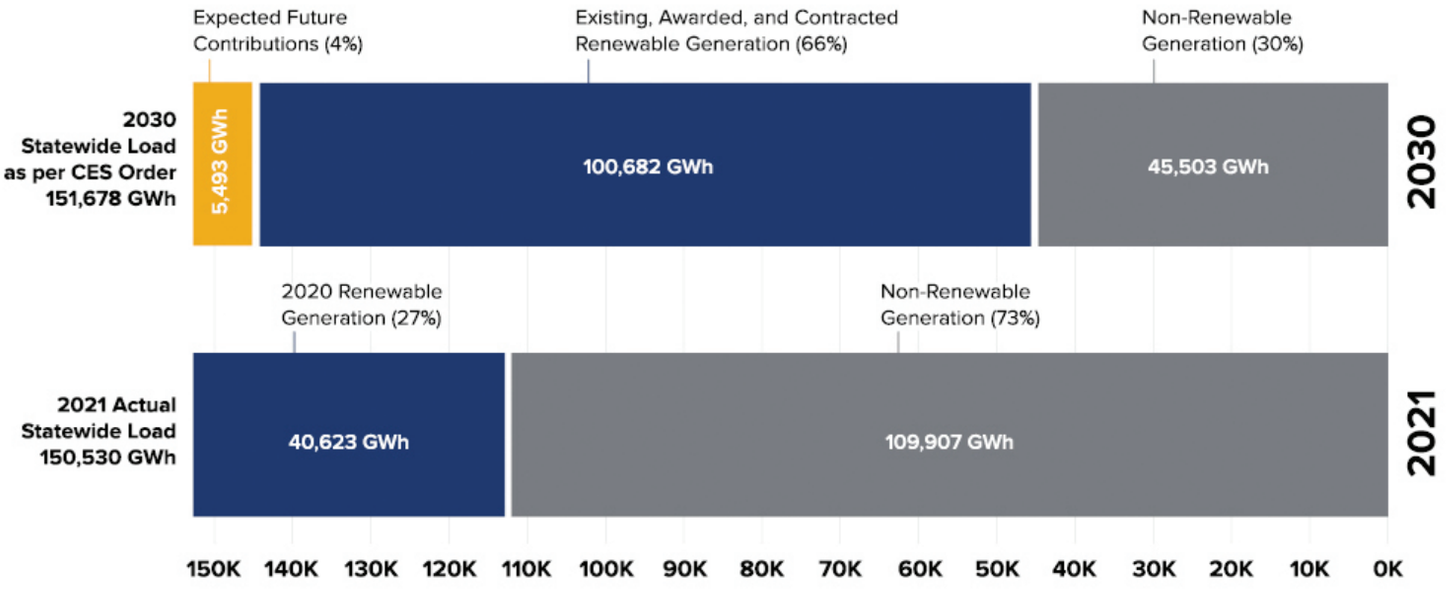
New York State is still reliant on burning fossil fuels for most of our electricity. In 2022, electricity was primarily generated four ways – natural gas-fired power plants (47%), nuclear (24%), hydroelectric (22%), and non-hydroelectric renewables such as solar and wind (7%). The energy system in New York State has been described as a "Tale of Two Grids." In downstate New York, 89% of the electricity is generated with fossil fuels[2]. Downstate's reliance on fossil fuels is a result of the much higher population density and fewer available non-fossil fuel infrastructure, from hydroelectric dams in the Great Lakes drainage system to onshore wind and solar[3]. Upstate New York's energy portfolio is 50% renewable, 44% nuclear, and only 6% fossil fuel-based[2]. In addition, some of the energy used in NY state is actually generated outside of the state. This includes major projects like the Champlain Hudson Power Express (CHPE) which aims to run high-voltage direct current cables from hydropower and wind power facilities in Quebec, Canada to power stations in Queens, NY.



Sources of electricity in New York State. 47% of electricity is from natural gas-fired power plants, 24% comes from nuclear, 22% comes from hydroelectric, 7% comes from other renewables, and less than 1% comes from petroleum-fired power plants. Data obtained from the Energy Information Administration in 2022.



New York State's Electricity sources in 2021, with upstate (in green) and downstate (in gray) electricity generation. Upstate is defined as NYISO's Zones A-E (Western and Upstate NY), and Downstate includes Zones F-K (Albany Region and South). The majority of Downstate's electricity comes from dual fuel power plants, while upstate New York has a larger proportion of nuclear, hydropower, and wind. Data obtained from the NYISO 2022 Power Trends Report, map adapted from NYISO zone map.



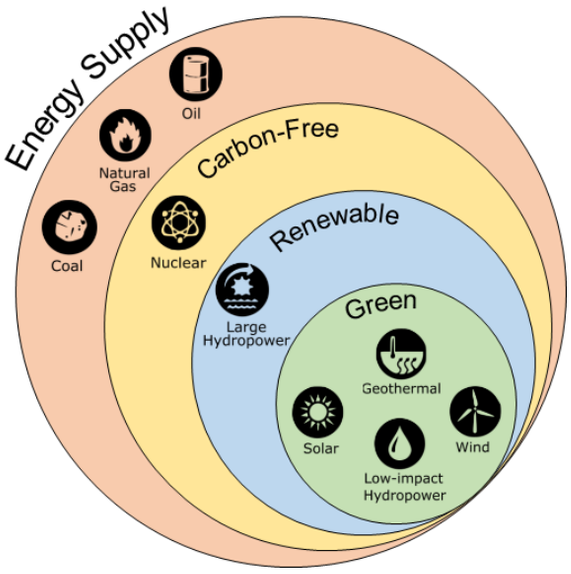
NYSERDA's progress in planning the switch to renewable energy as of March 2024. Project's already awarded or being planned will account for 66% of the electricity needed in NY state in 2030 (which is expected to increase from the amount of electricity needed today), with around 4% coming from projects that we expect to be identified in the near-future. Source: NYSERDA

The energy system in New York State has been described as a "Tale of Two Grids." In downstate New York, 89% of the electricity is generated with fossil fuels[2] . Downstate's reliance on fossil fuels is a result of the much higher population density and fewer available non-fossil fuel from hydroelectric dams in the Great Lakes drainage system to onshore wind and solar[3] . Upstate New York's energy portfolio is 50% renewable, 44% nuclear, and only 6% fossil fuel-based[2] . In addition, some of the energy used in NY state is actually generated outside of the state.

Renewable, carbon-free, clean, green – what does it mean?

The terms "renewable," "clean," "green," and "carbon-free" are commonly used but not always interchangeable. Oftentimes, there is confusion over what these different terms mean.

- Carbon-free energy is generated without emitting carbon. Adopting carbon-free energy sources reduces greenhouse gas production but may have other environmental impacts. Renewables energy like hydropower and solar power are carbon-free while nuclear power, though not renewable, is also a carbon-free energy source.
- Clean energy has zero emissions and does not pollute the air with greenhouse gases. Clean energy can also have other environmental impacts.
  - The most common examples of carbon-free or clean energy in NY include: hydroelectric, nuclear, solar, wind.
- Renewable energy comes from natural resources that can replenish themselves. They generally do not emit carbon like burning of fossil fuels or fracking does. Renewable energy is beneficial for reducing carbon emissions, but may still have environmental impacts. For example, large hydroelectric dams generate renewable energy from running water, but often times have environmental tradeoffs and lasting ecological impacts on the area.
  - Examples include: large hydroelectric, solar, wind
- Green Power is a subset of renewable electricity generation options that provides the most environmental benefits. They are zero-emissions and have a reduced carbon footprint. Green power goes "above and beyond" what is required by regulations in terms of carbon emissions and low environmental impacts.
  - Examples include: wind, solar, geothermal, low-impact hydroelectric

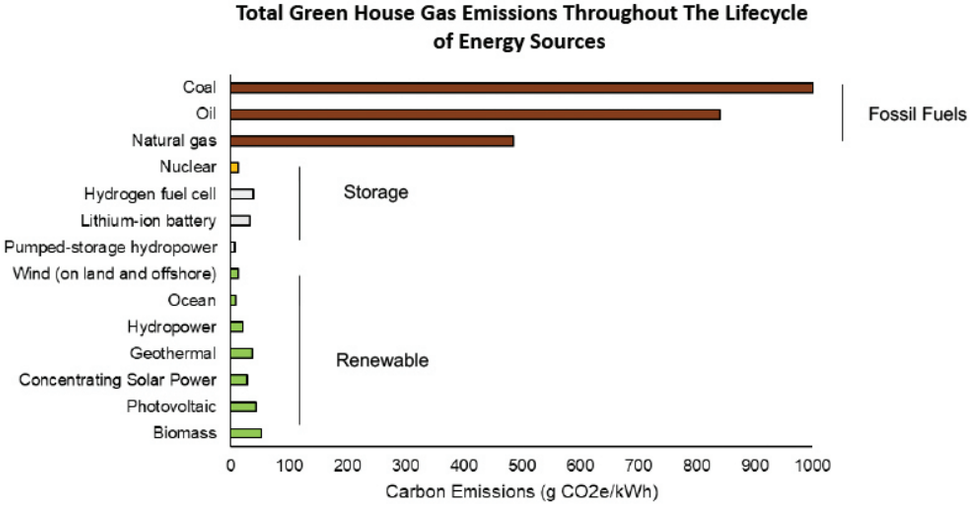


Venn diagram showing examples of fossil fuel, carbon-free, renewable, and green energy generation and their relationship to each other. For example, wind is a green, renewable, and carbon-free source of energy while nuclear energy is a carbon-free energy source but is not renewable or green.

Does renewable energy have a carbon footprint?

It is important to understand that all energy production has an environmental impact and carbon footprint. With fossil fuels, energy generation itself emits greenhouse gases. With renewable energy, it is only the manufacturing process for the components needed to generate energy that has an environmental impact and carbon footprint. For example, clean energy technology often times relies on mining – uranium for nuclear power and rare earth elements for solar panels, wind turbines, and batteries[4] . Renewable energy also frequently needs battery storage so that the power I readily available when needed rather than when the renewable resource is generating energy, which has a carbon footprint associated with production. When considering the entire life cycle of renewable energy technologies, though the carbon footprint is not zero, it is typically much lower than non-renewable fossil fuel-based energy generation[5] . **Even though the supply chain for manufacturing renewable energy has a carbon footprint, most renewable energy generation itself is zero carbon emissions.**

Additionally, a substantial portion of emissions from the supply chain come from transportation. As more transportation begins to be powered by renewable energy, this could further reduce the greenhouse gas emissions caused by the renewable energy supply chain.



Estimated total life cycle emissions for different electricity sources. Green indicates renewable energy sources, orange is clean but not renewable, gray is storage, and brown is fossil fuel-based energy. These data were published in multiple studies and compiled by NREL in the Life Cycle Greenhouse Gas Emissions from Electricity Generation Update Report in 2021. Life cycle emissions include the emissions generated in four life phases – 1) emissions associated with constructing manufacturing plants and acquiring materials, 2) the emissions, if any, generated during electricity production or combustion, 3) the emissions generated during operations and maintenance, and 4) emissions associated with decommissioning, disposal, and recycling.

How much energy is 1 GW?

Electricity is measured and described in the unit watts. Many appliances used in your home consume this scale of electricity [6] . Some appliances, like air conditioner units, are more energy intensive. You can estimate your appliance and home electronic energy use with Energy.gov. Many renewable projects are measured in MW (1 million watts, or megawatts) and GW (1 billion watts, or gigawatts). To put this in perspective, the average American home in 2021 used 10,732 kilowatt hours (kWh) per year, or 1.21 kilowatts[7] (10,732/362.25/24). Therefore, 1 GW produced at 100% capacity all day, could power about 826,000 homes. Later we will demonstrate how no practice of energy generation can produce at 100% capacity in reality, but this gives an idea of the generation needed for the approximately 8.5 million homes in NY state.

What makes up New York State's carbon-free energy portfolio?

Hydroelectric

Until 2019, hydroelectric, also known as hydropower, was the largest source of renewable energy in the United States. In New York State, hydropower accounted for 22% of the state's energy generation in 2022[8] . Most of the hydroelectric power in New York State is generated at conventional hydroelectric facilities where water flows through turbines in rivers or dams[9] , which produces electricity. In July 2022, New York State generated 2,234 GWh[10] at conventional hydroelectric facilities. In total, the installed generating capacity from hydroelectric in NY is about 3.1 GW[8] . The largest hydropower plant in NY is the Robert Moses Niagara Hydroelectric Power Station, located near Niagara Falls, which has a capacity of 2.4 GW[11] . Most hydropower in NY is generated on significantly smaller scale compared to the Niagara Station – the median capacity is 4 MW, which is 0.1% of the power generated by the Robert Moses Niagara Hydroelectric Power Station[11] . While hydropower is considered renewable, it can still have negative environmental impacts. Dams and reservoirs are commonly constructed for conventional hydroelectric power generation and rely heavily on concrete and steel – which each have carbon footprints. Dams and reservoirs also change the ecology of a region and impacts can include: forced relocation of people and animals, changes in water chemistry, biology, ecology, and river flow, and obstructions to fish migration[12] . While no new hydroelectric dams are in the works to cause these changes, they do continue to have impacts on the ecology of our state. What new impacts that may come from existing hydroelectric facilities are associated with upgrading transmission capacity to deliver more electricity as we continue to consume more energy.

Robert Moses Niagara Hydroelectric Power Station in New York. From Wikimedia Commons

In 2021, New York State finalized contracts for the Champlain Hudson Power Express (CHPE), a Canadian hydroelectric project[13] . With CHPE, hydropower-generated electricity from Canada will travel 339 miles through Lake Champlain and down the Hudson River to Queens[13]. The amount of power planned for CHPE is 1,250 MW. This is roughly half the power generated by the Niagara hydropower facility, but is similar in scale to a nuclear power plant or large offshore wind farm.

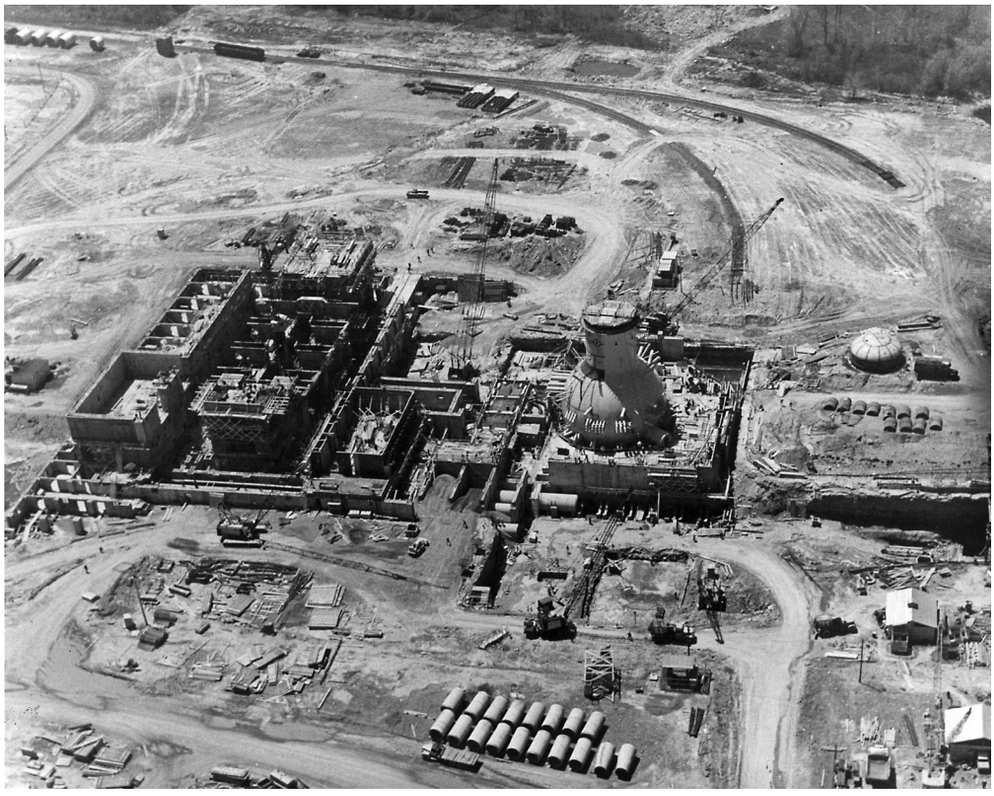
Nuclear

Nuclear energy is carbon-free in its generation, but it is not a renewable energy source. To generate electricity through the existing technology, atoms of uranium are split and the energy that held the nucleus together is released. This process is called nuclear fission and it creates a substantial amount heat, which is converted to electricity in a nuclear reactor[14] . New York State has three active nuclear power plants – Nine Mile Point Nuclear Generating Station and Fitzpatrick Nuclear Power Plant, both in Oswego County, and Ginna Nuclear Power Plant in Wayne County[15] . The

total installed capacity for these three plants is a little over 3.3 GW[15] . Nuclear reactors can generate a lot of electricity consistently over a long period of time, but also produce hazardous radioactive material that takes thousands of years to decompose and is challenging to store safely. There are some risks to nuclear power – when the heat generated from nuclear fission exceeds the cooling capacity, a nuclear "meltdown" accident occurs and uncontained radioactive material can harm people and the environment. Three infamous nuclear meltdown accidents have happened: at Fukushima in Japan, Chernobyl in Ukraine, and Three Mile Island in Pennsylvania, though safety measures continue to improve following these events. New fission technologies currently being researched, namely small modular reactors, are likely safer and more cost-effective than what is currently in use, though the technology is not yet scalable. Additionally, some of the byproducts of nuclear power production can be used as inputs to the manufacturing of nuclear weapons[16] .

Solar

Solar energy comes from two sources in New York – residential solar panels and solar farms. A typical solar farm in New York has an installed capacity of 2 MW[11], however, most of the solar capacity in the pipeline will come from substantially larger facilities with 20 MW capacity or more. The term "installed capacity" is especially important when talking about solar. Because it is not always sunny, the power generated from solar panels varies hour-by-hour. The installed capacity is its maximum energy generation capability. Using solar panels to generate energy from the sun is a viable form of renewable energy, but the weather, seasonal shifts, and latitudes of New York State make this renewable energy less reliable. While solar can be less environmentally damaging than other sources of renewable energy, generating enough electricity would require large swaths of land, which has its own environmental impacts, though the actual acreage required as a percentage of the total acreage of the state or even as a percentage of NYS farmland is not dramatically large (maybe as small as 5%)[17] . Compared to New York, the southwestern states in the U.S. get consistently more sun and are able to generate much more energy with solar panels and this energy cannot be easily transmitted over long distances[18] .



Nine Mile Point Nuclear Power Point in 1966 when it was under construction in New York. From Wikimedia Commons.

CS Energy is one solar company that partners with NY State to build industrial solar arrays. Completed in 2021, this 27 MW solar array has enough electric capacity to power more than 4,934.

Onshore Wind

Wind can be converted to energy through wind turbines – the wind causes the blades to turn and the blades are connected to a generator that converts the wind's energy to electricity. New York State has a couple dozen wind farms that each contain between 1 and almost 200 turbines[19] . Wind turbines are sometimes confused with windmills, but they are different. A windmill uses wind to generate energy for a specific task like grinding grain or pumping water while wind turbines are electricity generators. As turbine size and blade length increases, its capacity to generate electricity increases. The larger the turbine, the more energy it produces. In New York State, turbine rated capacities vary from 0.1 MW to 4.5 MW[20].

The biggest environmental concern about onshore wind is its effects on birds and bats. When birds and bats collide with wind turbines, they often do not survive the impact. To reduce bird and bat mortality, wind farms can be properly sited (e.g. not in migratory pathways) and turbines can be equipped with technology that reduces the chance of collision such as deterrents (e.g. UV lighting, ultrasonic acoustics) and monitoring equipment (e.g. thermal imaging cameras)[21, 22, 23] . NYSERDA anticipates that the vast majority of the state's wind generating capacity will not come from land-based wind, but rather from offshore wind located closer to the NY City demand center.

The Roaring Brook Wind Farm is a 79 MW capacity in Lewis County, New York constructed by The Wesson Group.

Offshore Wind

Offshore wind is a new renewable energy source to the United States, but has been established abroad for over 30 years[24] . In 2022, there were only seven wind turbines installed offshore in the U.S. – five off Block Island in Rhode Island state waters and two off Virginia in federal waters. Together, these seven turbines generate 42 MW of energy[25, 26] . The current short term U.S. national goal for offshore wind is 1000x the current capacity of these existing seven turbines - 30 GW of offshore wind by 2030 and 15 GW of floating wind by 2035[27] . New York State has its own offshore wind goal of 9 GW by 2035[1] . This goal is legislatively mandated in the Climate Leadership and Community Protection Act. To meet this goal, the State has multiple projects to procure energy from offshore wind farms as of 1/25/2024:

One Operational Wind Farm Contract:

1. South Fork Wind Farm (130 MW) developed by Orsted US and Eversource Energy

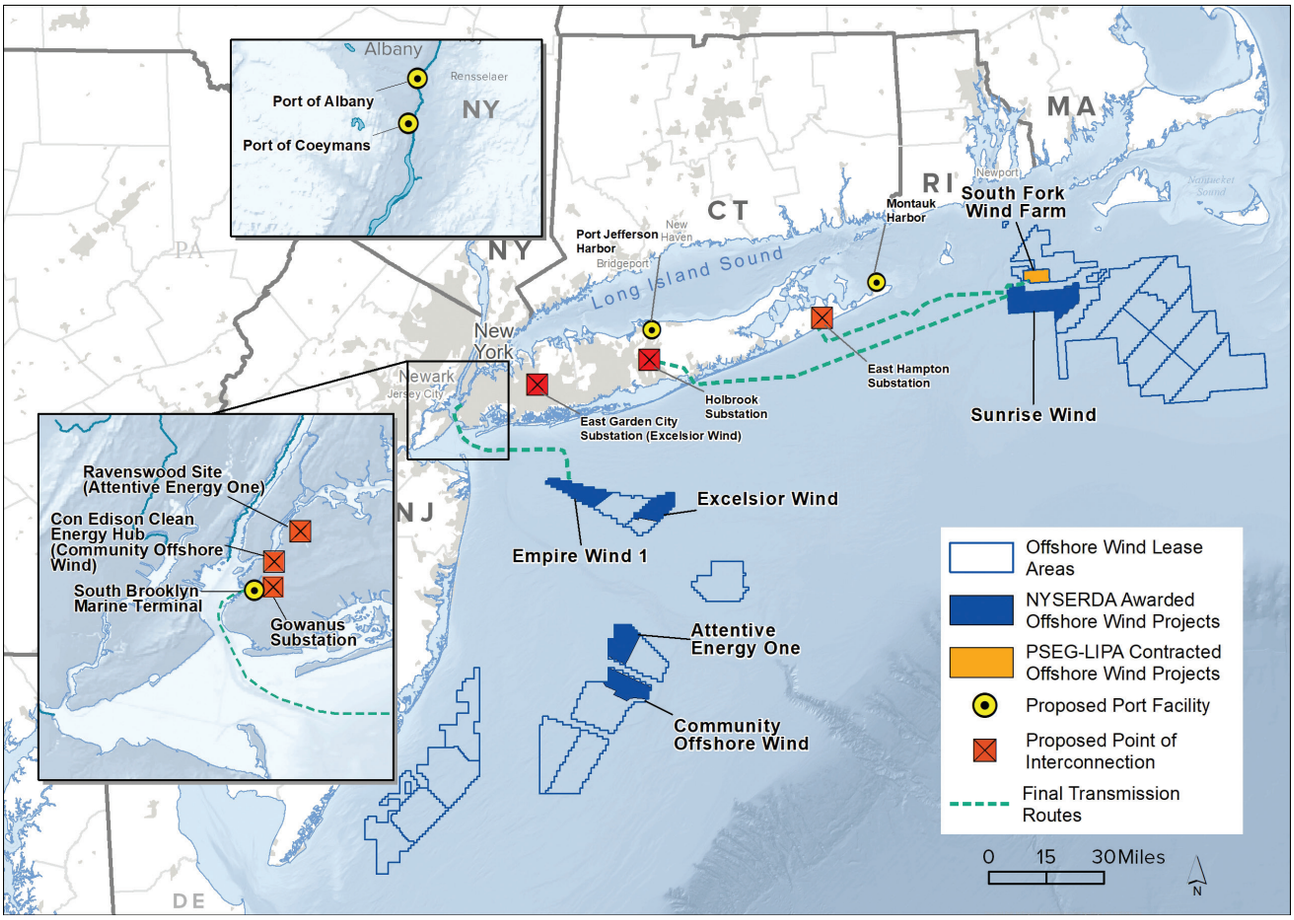
Two Contracts in Active Development:

1. Sunrise Wind (924 MW) developed by Sunrise Wind
2. Empire Wind 1 (816 MW) developed by Equinor Wind US

Three Provisional Awards:

1. Attentive Energy One (1,404 MW) developed by TotalEnergies, Rise Light & Power, and Corio Generation
2. Community Offshore Wind (1,314 MW) developed by RWE Offshore Renewables and National Grid Ventures
3. Excelsior Wind (1,314 MW) developed by Vineyard Offshore

A benefit of offshore wind is that is generates a lot of power where it is most needed near the densely-populated coast. In New York, each offshore wind farm will have the installed capacity to generate roughly as much energy as a nuclear power plant.



Picture: NYSERDA NY Offshore Wind Projects

Like all energy production, there are environmental impacts associated with offshore wind. The impacts of offshore wind on birds, bats, fish, whales, mammals, and benthic communities are still being studied, especially in the U.S. There are three phases of offshore wind development that each have their own environmental effects – construction, operation and maintenance, and decommissioning. During all three phases, there is an increase in vessel traffic, which both raises the likelihood of collisions with wildlife and could result in emissions. During construction, pile driving is used to fix turbine foundations to the seafloor. It creates a lot of noise, which can be partially mitigated by bubble curtains, but will still impact wildlife to some extent. Also during construction, long trenches are dug to bury transmission cables, which effects localized seafloor environments[28] . During operations and maintenance, electricity traveling through the cable generates an electromagnetic field (EMF). Some species in the ocean detect electric and/or magnetic fields, so researchers are determining to what extent marine life will be impacted, especially at different life stages[29] . Another active area of research is understanding how birds and bats will be affected. Monitoring for birds and bats once turbines are installed will be important to understand the impacts specific to Atlantic Coast wildlife[21] . At the end of the offshore wind turbine's operational life (typically 20-25 years), it must be decommissioned and the area will be cleared of all retired infrastructure[30] .

How do these renewable energy sources compare?

Comparing renewable energy generation is not straightforward because renewable resources are not controllable. Renewable resources are dependent on variable factors such as weather patterns and time of day. We will compare here only two measures of electricity generation output: theoretical maximum generation capacity at any given point in time and the more realistic anticipated output in actual operation over time. Bear in mind there are other metrics that can be used to compare "energy generation, such as the footprint, or the acres required per MW of electricity generated, or the dollars per MW of electricity generated, etc.

The first method is to directly compare the energy capacity of the powerplants. Energy capacity, also referred to as nameplate capacity or installed capacity, is the amount of energy the facility could generate if it is working at its full capacity and the renewable resource is also present 100% of the time. The below table averages the capacity of facilities existing as of January 2024. Note, solar capacity is set to increase significantly in NY state with infrastructure currently in development.

Comparing Energy Capacity of Renewables*

1 Offshore Wind farm =	1 Nuclear power plant =	14 Onshore Wind farms =	335 Hydroelectric power plants =	337 Solar Power farms
Each offshore wind farm produces 872 MW, the mean planned offshore wind project procurement in NY.	Each nuclear power plant produces 849 MW, the mean installed capacity for nuclear in NY.	Each onshore wind farm produces 63 MW, the mean installed capacity in NY.	2.6 MW is the mean installed capacity of hydroelectric generators in NY. **	1 solar farm in NY produces 2.6 MW, the mean installed capacity.

*Information gathered from EIA Electricity Data based on 2021 data.
**The major outlier in NY is Robert Moses Niagara Hydroelectric Power Station, which has a capacity of 2,429 MW. This generator produces much more power than the average hydroelectric dam.

Construction of the first offshore wind turbines off Montauk, Long Island. South Fork Wind, by Orsted and Eversource, generates approximately 130 MW to power approximately 70,000 Long Island homes. Source: Orsted.

The second way to compare energy generation is a bit more accurate; it takes into account the capacity factor. A capacity factor is a measure of the reliability of the power plant – it is the percentage of how often the power plant runs and is calculated by dividing actual power generated by installed capacity. Renewable source is not always present for energy generation (the sun is not always out, it is not always windy, sometimes there are droughts, etc.). Therefore, capacity factors are useful to compare the efficiency of energy generation between renewables.

In NY state, renewable energy structures vary in efficiency and the amount of energy they generate. Finding the most appropriate renewable energy sources based on the amount of space, renewable resource availability, location, electricity needs, etc. Is ongoing and essential for reaching New York's energy goals.

Comparing Energy Capacity of Renewables Considering Their Capacity Factor

1 Nuclear power plant =	**2 Offshore Wind farms =**	**50 Onshore Wind farms =**	**547 Hydroelectric power plants =**	**2400 Solar Power farms**
Capacity factor of 0.95[33]	Capacity factor of 0.52[34]	Capacity factor of 0.26[31]	Capacity factor of 0.54[32]	Capacity factor of 0.13[31]

Footnotes

1. NYSERDA Climate Act Description
2. NYISO 2022 Report
3. NY Profile Analysis EIA
4. USGS Critical Mineral Commodities
5. NREL Life Cycle GHG Emissions from Electricity Generation
6. https://hr.umich.edu/sites/default/files/appliance-energy-2015.pdf
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8. EIA NYS Overview
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10. Utility Scale Facility Net Generation from Hydroelectric (Conventional) Power
11. EIA, Interactive GIS Data Viewer
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13. NYSERDA Newsroom
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15. New York's Upstate Nuclear Power Plants' Contribution to the State Economy Report
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17. NYSERDA Solar Installations On Agricultural Lands
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20. USWTDB data
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29. BOEM EMF Fact Sheet
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31. NY ISO
32. NY Large Scale Renewable Projects
33. NEI Nuclear Operating Plant Basic information
34. Dept of Public Service CASE 15-E-03021 Appendix A – Cost Analysis

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