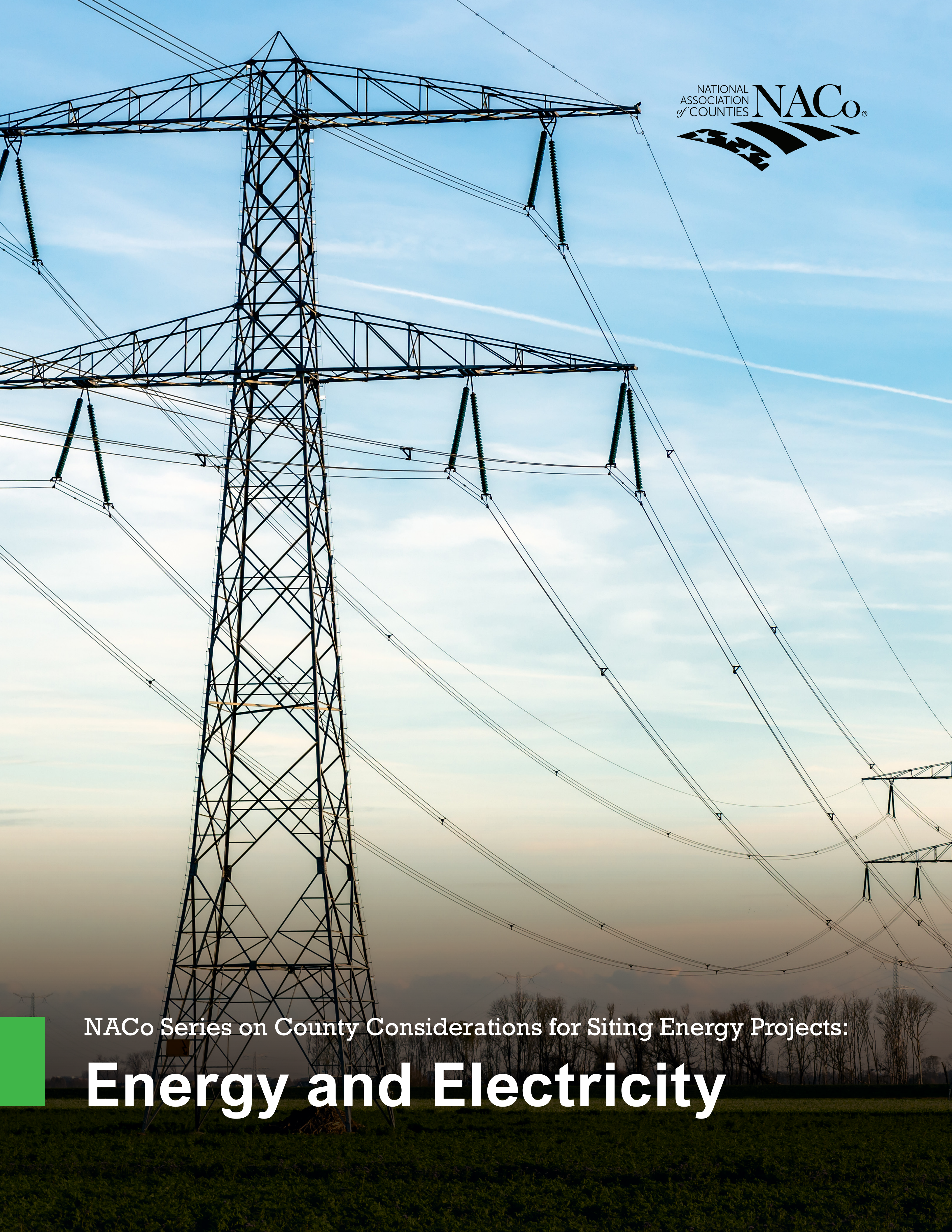


NATIONAL ASSOCIATION of COUNTIES NACo®

NACo Series on County Considerations for Siting Energy Projects:

Energy and Electricity

Introduction

America's counties are home to a wide variety of natural primary sources of energy. A diverse portfolio of electrical energy production is essential to America's leadership in every field from health care to advanced manufacturing to artificial intelligence. Counties today are supporting the build-out of electrical infrastructure that will energize the nation for generations to come. This primer presents the basics of electricity consumption, generation, transmission and storage. For more county insights on specific energy topics and technologies, visit NACo's Energizing Counties Resource Hub.

Energy

Energy is the capacity to do work. Energy exists in nature in various forms and is constantly converted from one form to another. Moving or spinning objects have mechanical energy. Chemical energy is stored in the chemical bonds of substances which, when broken, release thermal energy. Electrical energy powers our homes, our businesses and the demands and comforts of modern life.

Electricity and Key Terms

Electrical energy, or **electricity**, is the movement of electrons. Electrons move through conductors, or wires, similar to how water flows through a pipe.

- *Current* is the rate of flow of electrons (measured in amperes, A)
- *Voltage* is the pressure pushing it through (measured in volts, V)
- *Power* is the rate of flow of energy which increases with more voltage or more current (measured in watts, W)

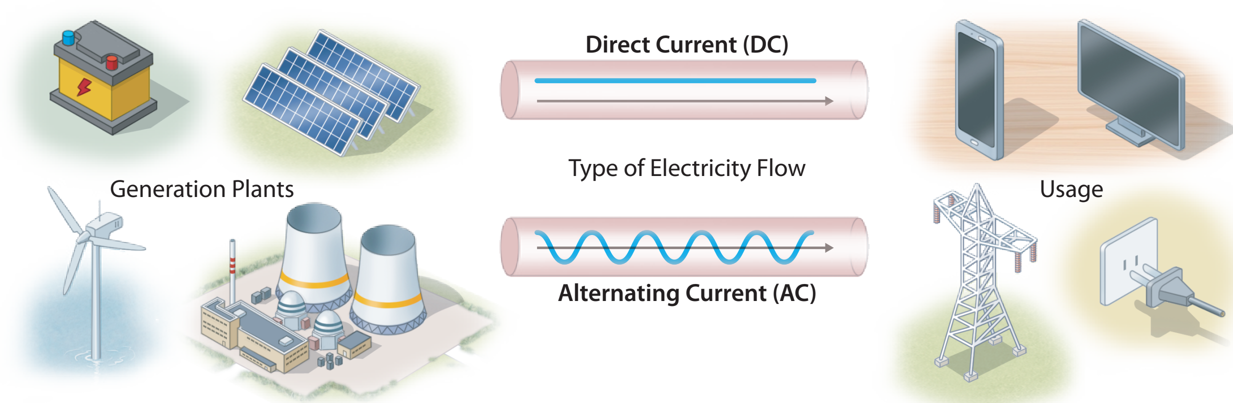
The total amount of power over time is known simply as *energy* (measured in watthours, Wh). Like leaks in a pipe, energy can be lost along the way.

Electrons flow through a wire in one of two ways: in a straight line (**direct current**, or DC) or switching directions constantly in a sine wave (**alternating current**, or AC). DC and AC power can be converted to one another depending on the end use, using an *inverter* (DC to AC) or *rectifier* (AC to DC).

DC power, generated from batteries and solar panels, is used for powering small appliances and electronics. AC power, generated from most types of power plants, can travel long distances with minimal losses and is generally used to supply power to homes and larger appliances.

DC travels in two wires while AC travels in two wires (**single-phase**) for residential use or three wires (**three-phase**), for higher efficiency in commercial or industrial applications. This is relevant for county leaders and planners in considering the infrastructure needs of projects sited within their region.

Electricity: Common Sources and Uses



Electricity Consumption

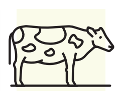
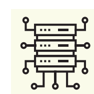
Anything that consumes electricity is called an **electric load**. Some loads like washing machines are intermittent, while others like refrigerators are continuous. Continuous load is referred to as *base load*.

Power and energy are typically measured in the thousands. One thousand watts is a kilowatt (kW); one thousand kW is a megawatt (MW); one thousand MW is a gigawatt (GW) and so on. The amount of consumption ranges from a few Wh to charge our phones at home to several MWh to operate a concrete mixing facility to several GWh for operating a data center or a modern city.

History

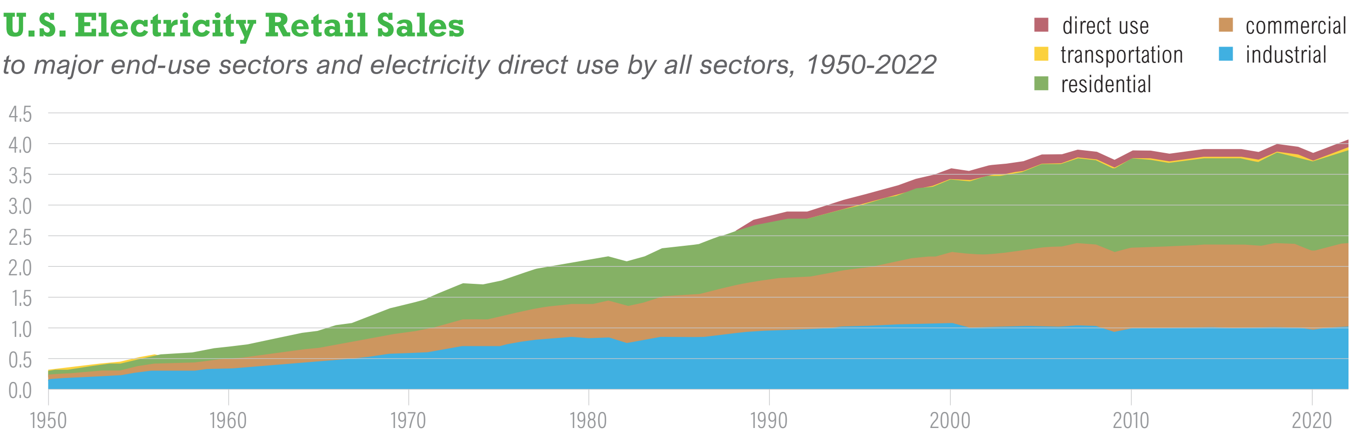
Early power systems used DC power, but because it was expensive and energy losses were higher over long distances, power plants were located near users and mostly in urban centers. In the late 1800s, AC power was discovered, making it possible to send electricity much farther and more efficiently with the help of transformers, which change the voltage as needed. While AC became the standard, DC is still useful for sending power over very long distances and in certain special cases.

Typical Daily Energy Use by Type

					
RESIDENTIAL	**SMALL FARMS/ OFFICE**	**LARGE FARMS/ DAIRY**	**SCHOOL BUILDING/ MANUFACTURING FACILITY**	**DATA CENTER**	**METROPOLITAN COUNTY** (POPULATION ~1 MILLION)
Energy Consumption: **30 kWh**	Energy Consumption: **50-150 kWh**	Energy Consumption: **1,000-3,000 kWh**	Energy Consumption: **5-15 MWh**	Energy Consumption: **3,000-15,000 MWh**	Energy Consumption: **50,000 MWh**
Peak Power Demand: **~5 kW**	Peak Power Demand: **20-50 kW**	Peak Power Demand: **100-500 kW**	Peak Power Demand: **250 kWh-5 MW**	Peak Power Demand: **20-400 MW**	Peak Power Demand: **~300 MW**

U.S. Electricity Retail Sales

to major end-use sectors and electricity direct use by all sectors, 1950-2022



Source: *U.S. Energy Information Administration, "Monthly Energy Reivew". Table 7.6, March 2023, preliminary data for 2022*

Electricity Generation

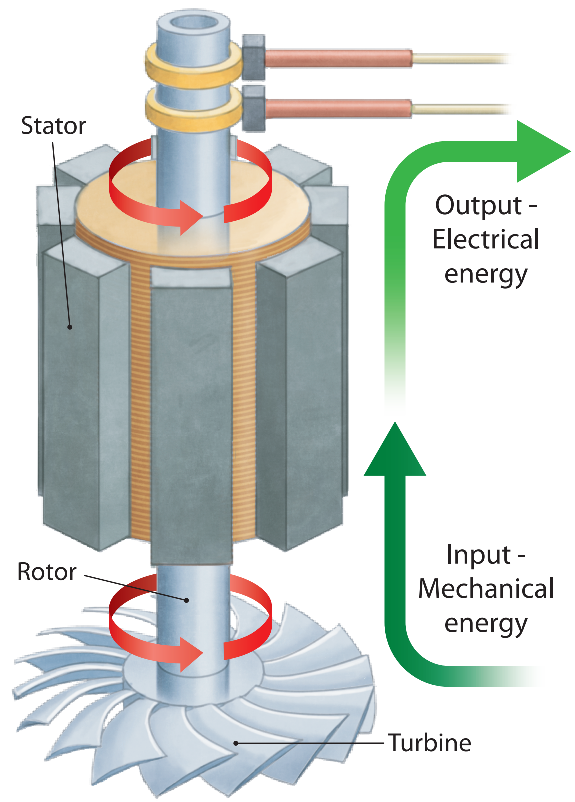
Electricity is most commonly generated by rotating a magnet or magnetic element (*rotor*) inside a coil of stationary conductors (*stator*). Rotation is accomplished by using a ***turbine***, a mechanical device that is turned by the flow of fluid like wind, water, steam or the combustion of gases.

Coal, oil, nuclear, natural gas and geothermal systems all generate steam, which turns the turbine. Wind, hydro and tidal power systems use wind, water and tides to directly turn the turbine, not requiring any conversion. Solar is the outlier and does not visibly turn anything. Solar panels use the energy intrinsic to light to move electrons through a process called photovoltaics (PV).

Conventional energy systems are powered by non-renewable fossil fuels like coal, natural gas and oil. Since the fuel can be extracted and stored, energy can be generated on demand; however, extracting, storing, transporting and burning them require large scale use and result in by-products that require responsible management. **Non-conventional energy systems** are powered by renewable sources like water, wind, solar and ground sourced heat. Because they produce negligible harmful by-products, they are referred to as "clean energy" systems. These sources are unlimited but can be intermittent and require additional planning for integration with the current electric grid.

Other fuel sources do not neatly fall into conventional or non-conventional systems. Nuclear energy uses a depletable source (Uranium), but generates a tremendous amount of power from a very small amount of fuel. Nuclear energy is very efficient with limited by-products in the energy generation process; however, the spent fuel creates waste that requires very careful mitigation measures. Renewable natural gas uses biogas instead of fossil natural gas. Biogas comes from burning waste from industries like landfills, farms, post-disaster debris and other waste products.

Typical Electric Generator



Comparing Generation Technologies

*The **capacity factor** of a generator is the ratio of the actual energy produced to the maximum possible production over time. Expressed as a percentage, this figure is used to compare different generation technologies. For conventional energy systems, this is influenced by the cost of fuel and the demand for energy. For non-conventional energy systems, it varies with time of year and location based on resource availability.*

Energy Transmission

The **electric grid** is the network of wires that connects power generation sources to electric loads. The strength of this network and proximity to users is a deciding factor in determining where new projects are located. Increasing electricity consumption creates strain on our current grid.

From the power plant, three-phase AC power is stepped up to very high voltage, using ***transformers***, for travel along transmission lines – much like high-speed travel on a highway. Think of ***transmission substations*** as offramps to slower roads; this is where power is diverted to heavy industry or routed down to ***distribution substations.*** Again using transformers, substations step down the voltage for safe distribution to local communities and consumers.

The conventional grid was designed around conventional energy systems, where generators are located close to the fuel source. Cities and industries tend to be located around the transmission system, while rural areas are serviced by secondary lines.

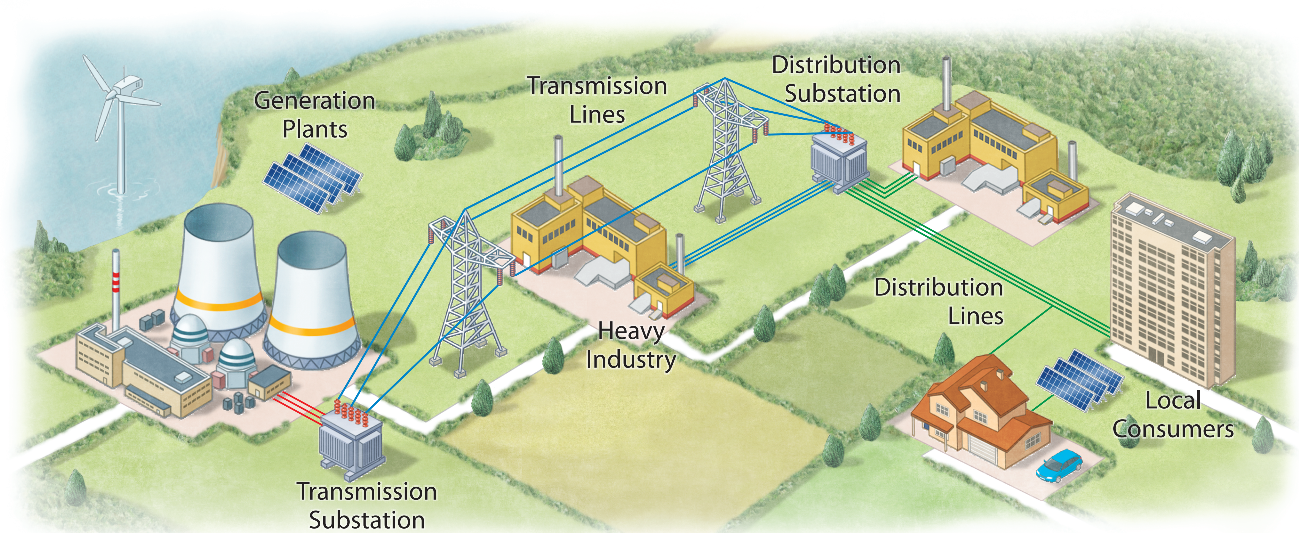
Large-scale non-conventional systems like hydro, utility scale wind and solar are designed to integrate with the transmission system the same way as conventional systems.

Authority

Interconnections to the transmission system – whether for new generation systems or large loads – fall under the purview of the Federal Energy Regulatory Commission (FERC) and independent system operators (ISOs). Interconnections to the distribution system are handled by the electric services provider and regulated by the Public Utilities Commission (PUC). Close coordination with appropriate agencies helps counties make informed planning decisions.

The scalability of some energy systems, such as wind, solar, natural gas and nuclear, allows for locating the generators closer to where the power is consumed and either interconnect to the grid or be used in a closed system. These **Distributed Energy Resource (DER)** systems can range in size from a small residential rooftop solar PV system to a large wind turbine or combined-heat power plant powering a factory or community. DER systems can be combined with on-site energy storage to form **microgrids,** that can independently power local loads during power outages caused by natural disasters, providing resilience.

Typical U.S. Electric Grid



Electricity Storage

The ability to store electricity offers significant opportunities to optimize our current electric grid. Storage allows for power generation at any time – regardless of resource availability or demand – and consumption as needed. Recent advancements in **Battery Energy Storage Systems (BESS)** have made it realistic to deploy storage at the scale needed to support modern demand. Batteries are essentially packs of cells that store charge in the form of chemical energy and can discharge it as electrical energy when connected to a load. Systems are sized to match the load by connecting multiple cells together. System sizes range from a wall-mounted 13 kW unit that can power a house for several hours to MW systems in shipping container-sized units that can power communities for a few days during a storm.

Energized Counties

A **smart grid** that integrates all the above technologies can provide reliable, low-cost power to all consumers. These technologies are advancing at a rapid pace and counties are at the forefront of enabling responsible deployment. By staying up-to-date on new technologies, considering local needs and conditions and fostering collaboration, counties can help build a resilient, efficient and sustainable energy system that benefits all communities.

Utility Scale BESS

Frequently Asked Questions

What influences the location of generators in a county?

Resource availability is the primary factor for siting energy projects. Conventional generators like coal and natural gas are located close to mines or existing pipelines. Non-conventional generators like wind, solar and hydro are located where the resources are stronger. Additional factors like access to grid infrastructure, local, state and federal incentives also affect location of energy generation projects.

How do grid upgrades affect county decisions?

In addition to land use permits from the county, adding new generators (or large consumers) often requires upgrades to the grid for interconnection. The cost and time for such upgrades can influence whether projects move forward. Understanding the local grid capacities and constraints aid in informed county decision-making.

How can counties determine the grid capacity in their communities?

Most utilities maintain hosting or grid capacity studies for the region they serve, some of which are available publicly. Counties can work directly with the utilities to understand not only existing capacity, but also future or potential projects.

Where can I find more specific information about different energy technologies?

This primer is the first in a series to include plain language explainers on different energy technologies and county considerations for siting projects, including Solar, Wind, Data Centers, Nuclear and more. These will be available on NACo's Energizing Counties Resource Hub.

Intended Use:

This content is intended for educational purposes only. The National Association of Counties (NACo) supports policies and programs that equip county governments with the resources and flexibility needed to serve our residents. NACo does not endorse any particular strategy or approach shared in this resource over another.

For official NACo positions, please refer to the American County Platform

How can I get involved/participate in energy discussions at NACo?

Join NACo's Energy Counties Exchange to engage other county leaders, access (and contribute to) a repository of ordinances and other local resources and be the first to hear about new programming

Participate in NACo's Rural Energy Academy program events and technical assistance opportunities

Help shape NACo's federal policy priorities through the Environment, Energy & Land Use Policy Steering Committee

Elevate county innovation in resilience by joining NACo's Resilient Counties Innovation Council

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