

**A Sectors** **B Manufacturing** **C Transportation** **D Installation/Commissioning** **F Generation** **G Distribution/Consumption**

**Renewable electricity generation emits no carbon (except for biomass production) and helps mitigate greenhouse gas emissions. Renewable energy generation accounts for 20% of the total U.S. electricity generation (4,001 gigawatts (GWs)). Renewable generation sources include wind, solar, hydro, geothermal, and biomass. Renewable electricity generation will surpass natural gas in the U.S. by 2030.**

**As demand for renewable energy increases, the manufacture of renewable energy systems has become a multi-billion dollar industry. The leading players (Vestas, GE Renewables, Siemens Gamesa, Mitsubishi, Hyundai, Tesla, and others) design, manufacture, install, and service electricity generators (including wind, hydro, and geothermal turbines and supporting components) and photovoltaic cells/solar panels.**

**Due to the size of the U.S. and often remote locations of renewable energy systems, transportation of large and heavy equipment is complex, requiring time, planning, permits, and regulatory approvals. The U.S. has a highly integrated supply chain network linking manufacturers and developers through multiple transportation modes, including air, rail, maritime, and truck transport.**

**Installation of renewable energy systems requires comprehensive coordination among manufacturers, engineering, procurement, and construction companies, and other installers. Existing equipment which may include hazardous materials, often must be removed and disposed of safely. Once a system is fully installed it must be formally tested and commissioned to ensure it is fit for purpose. Installation and commissioning require additional environmental, zoning, planning, and operating permits from federal, state, and local government authorities.**

**Renewable electricity is generated by plant owners (utilities and independent power producers) from primary energy sources, including wind, solar, hydro, geothermal, and biomass. Once generated, electricity is transmitted across high capacity grids, then stepped down to local distribution networks operated by utilities (owned by investors, municipalities, or co-operatives) for delivery to end users or storage. Megawatts (MWs) are used to measure the electric output of a power plant. One MW of capacity produces enough electricity to power approximately 650 homes for a year. A plant with capacity of 500 MWs provides power to 325,000 homes (about the size of Portland, Oregon). 1,000 MWs = 1GW.**

**Utilities distribute electricity to residential, commercial, and industrial customers, each of which consumes one-third of the electricity in the U.S. The residential sector includes single- and multi-family housing, with heat, A/C, lighting, water heaters, appliances, and electronics comprising the highest uses. The commercial sector includes government facilities, offices, and retail establishments, with heat, A/C, ventilation, and lighting comprising the highest uses. Industrial sector facilities and equipment use electricity for producing and assembling goods, including manufacturing, mining, agriculture, and construction, with more than 50% of consumption used to power production equipment. Electro-chemical processes (e.g., steel and aluminum smelting) is another high use.**

**Wind (42%)**  
A wind energy system consists of rotor blades connected to a turbine that sits in a nacelle atop a steel tower. The aerodynamic force of the wind turns the blades (due to lift and drag created by unequal air pressure) which in turn drive a shaft connected to a generator that produces electricity. Since 2000, wind energy has been the largest source of new renewable power generation, driven by federal tax credits that make wind power cost effective (1 to 2 cents per kw hour). The U.S. generates 338 GWs of wind power across 41 states with more than 200 new projects in development.



**1 SUPPLIERS OF RAW MATERIALS**  
Steel for Towers  
Fiberglass for Blades  
Turbine and Generator Components

**2 MANUFACTURERS OF WIND TURBINES, BLADES, TOWERS, NACELLES, HUBS AND PLATFORMS**  
Vestas Wind Systems  
General Electric Renewables  
Siemens Gamesa Renewable Energy  
Goldwind  
Nordex Acciona  
Sinovel Wind Group  
Mitsubishi Heavy Industries, Ltd.

**3 TRANSPORTATION COMPANIES**  
Sea Transport Providers: Maersk, Hapag-Lloyd, DP World, Odjell, China COSCO Shipping  
Truck Transport Providers: Perkins Specialized Transportation, Lonestar Transportation, Bennett Motor Express, Anderson Trucking Service  
Rail Transport Providers: BNSF, Union Pacific, CSX, Canadian Pacific  
Air Transport Providers: Atlas Air Cargo, Cargolux, Kalitta, Polar Air Cargo, Evergreen

**4 ENGINEERING, PROCUREMENT AND CONSTRUCTION COMPANIES**  
Mortenson Construction, Quanta Power Generation, Blattner Energy, EDF Renewables, RES Americas, First Solar, Sentry Group, White Construction, Rosendin Electric, Fagen, IEA Renewable Energy, Wanzek Construction

**5 Renewable Energy Tax Credit Equity Investors/Dealers**  
JPMorgan, CIT Group, Bank of America, US Bank, GE Financial, Wells Fargo

**6 DEVELOPERS/GENERATORS**  
Utilities (as Generators and Retail Electricity Distributors): MidAmerican, EDP (Meadow Lake Wind Farm), TerraForm Power, NRG, RWE (Roscoe Wind), EDF, Alta Wind Energy Center, Duke Energy (Los Ventos Wind Farm)  
Non-Utility Independent Power Producers: Berkshire Hathaway/BHE Renewables, Brookfield Renewable Energy Group, NextEra Energy, Avangrid, Lincoln Clean Energy, Caithness Energy (Shepherds Flat Wind Farm), Invenry

**7 Wind Energy**

**8 Government**  
Tax and Renewable Energy Credits and Incentives: Production Tax Credits, Investment Tax Credits, Renewable Energy Certificates, Residential Energy Credits  
Operating Approvals and Regulation: Wildlife Protection and Monitoring (Eagle Take Permits, Migratory Bird Law Compliance), Permits and Zoning, Siting, and Construction Approvals (Local Agencies and Federal Government Agencies: Environmental Protection Agency, U.S. Dept. of Defense, U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Forest Service, Bureau of Ocean Energy Management), State Public Utility Commissions (Mandatory Purchases; Feed-In-Tariffs)

**9 END-USE CUSTOMERS**  
Residential Consumers, Industrial Companies, Commercial Establishments, Government Agencies

**10 UTILITIES AS RETAIL POWER DISTRIBUTORS**  
Investor-Owned Utilities, Electric Cooperatives, Not-for-Profit Municipalities, Retail Power Marketers

**Solar (12%)**  
Solar energy is harnessed from the radiant energy emitted by the sun using various technologies such as solar heating, photovoltaic cells/solar panels, and others. The U.S. generates more than 91 GWs of solar power per year. Solar energy market growth is driven in part by tax incentives for the installation of solar panels, as well as a decrease in the water footprint of solar energy systems. The demand for solar cells has surged with rooftop installations and novel applications in the architectural sector. An additional 40 GWs of capacity is expected in 2021, with more than half located in Texas, Nevada, California, and North Carolina.



**11 SUPPLIERS OF RAW MATERIALS**  
Battery/Energy Storage: LG Chem, Panasonic, Various Chinese Suppliers, CATL, BYD, Northvolt, Solar Panel and Inverter Components, Various Suppliers

**12 MANUFACTURERS (AND OEMS) OF SOLAR PANELS/PHOTOVOLTAIC CELLS, INVERTERS AND STORAGE**  
Panels: General Electric, Solar Electric America, Auxin Solar, Solaria, CertainTeed Solar, SolarTech Universal, First Solar, SolSuntech, Global Solar, Storage/Other: LG Chem, Lumos Solar, SunPower, Prism Solar, SunEdge, Tesla, SolarEdge, Seraphim Solar, Tesla, SunSpark

**13 TRANSPORTATION AND LOGISTICS COMPANIES**  
Transportation Companies: Fulfillment by Amazon, AxleHire, Clutch Logistics, DHL Supply Chain Management, SF Express, ModuLink, Global Solutions, Bertschi, DSV, CEVA Contract Logistics  
Logistics Companies: GLS, DHL, dpdgroup, FedEx, TNT

**14 ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) COMPANIES; INSTALLATION COMPANIES**  
North American Board of Certified Energy Practitioners (Certification Program for Photovoltaic and Solar Heating System Installers): PV Installation Professional (PVIP), PV Technical Sales (PVTIS), PV Design Specialist (PVDS), PV System Inspector (PVSII), PV Installer Specialist (PVIS), Solar Heating System Inspector (SHSI), PV Commissioning & Maintenance Specialist (PVCMS), Solar Heating Installer (SHI)  
EPC Companies: Sun Power, Sunrun

**15 Renewable Energy Tax Credit Equity Investors/Dealers**  
JPMorgan, CIT Group, Bank of America, US Bank, GE Financial, Wells Fargo

**16 DEVELOPERS/GENERATORS**  
Utilities (as Generators and Retail Electricity Distributors): Mid American (a Berkshire Hathaway Company)  
Non-Utility Independent Power Producers: Solar Star (California, 579MW), Ivanpah Solar (California, 392MW), Topaz Solar Farm (California, 550MW), Crescent Dunes Solar Energy Project (Nevada, 110MW), Agua Caliente Solar Project (Arizona, 290MW), Tesla (Nevada, 110MW)

**17 Solar Energy**

**18 Residential, Commercial, and Industrial Customers Who Generate Solar Power**  
Homeowners: Tesla, Prologis, Costco Wholesale, General Growth Properties, Target, Amazon.com, Home Depot, Macy's, Walmart, Apple  
Other Customers: Residential Consumers, Industrial Companies, Commercial Establishments, Government Agencies

**19 UTILITIES AS RETAIL POWER DISTRIBUTORS**  
Investor-Owned Utilities, Electric Cooperatives, Retail Power Marketers, Not-for-Profit Municipalities

**Hydropower (37%)**  
Hydropower uses the force of water flowing in streams and rivers to produce mechanical energy. Hydropower was one of the first sources of energy used for electricity generation and, until 2019, was the largest source of total annual U.S. renewable electricity generation. There are 2,400 dams, many in need of repair, generating 291 GWs of hydroelectric power in the U.S. In 2019, hydroelectricity accounted for about 6.6% of total U.S. utility-scale electricity generation and 38% of total utility-scale renewable electricity generation.



**20 SUPPLIERS OF RAW MATERIALS**  
Metal Supplies  
Turbine and Generator Components

**21 MANUFACTURERS OF HYDRO TURBINES, GENERATORS, EQUIPMENT, AND DAM STRUCTURES**  
Hydropower Turbines and Equipment: General Electric, Global Hydro Energy, ABB, Toshiba, Siemens Gamesa, Gugler, Pelamis Wave Power, Hyundai, Orengine International, Hongya, Mitsubishi, Fuji Electric  
Dam Structures (Concrete, Sealant, Flooring, Roofing, Concrete Repair): R.J. Potteiger Construction Services, Sika Group, LafargeHolcim, CRH Cement

**22 TRANSPORTATION AND LOGISTICS COMPANIES**  
Sea Transport Providers: Maersk, Hapag-Lloyd, DP World, Odjell, China COSCO Shipping  
Truck Transport Providers: Perkins Specialized Transportation, Anderson Trucking Service, Bennett Motor Express, Lonestar Transport  
Rail Transport Providers: BNSF, Union Pacific, CSX, Canadian Pacific  
Air Transport Providers: Atlas Air Cargo, Cargolux, Kalitta, Evergreen, Polar Air Cargo

**23 ENGINEERING, PROCUREMENT AND CONSTRUCTION COMPANIES**  
General Electric, Global Hydro Energy, ABB, Toshiba, Siemens, Flatron, Aecom

**24 DEVELOPERS/GENERATORS**  
Utilities (as Generators and Retail Electricity Distributors): Minnesota Power, Duke Energy, PG&E Corporation, Georgia Power, Tenn. Valley Authority  
Non-Utility Independent Power Producers: US Army Corps of Engineers (Bonneville Power Administration, Southeastern Power Administration, Southwestern Power Administration, and Western Area Power Administration), U.S. Bureau of Reclamation (Grand Coulee Dam), Dominion / LS Power (Bath County Power Station)

**25 Hydro Energy**

**26 Residential, Commercial, and Industrial Customers**  
Residential Consumers, Industrial Companies, Commercial Establishments, Government Agencies

**27 UTILITIES AS RETAIL POWER DISTRIBUTORS**  
Investor-Owned Utilities, Electric Cooperatives, Retail Power Marketers, Not-for-Profit Municipalities

**Geothermal (2%)**  
Geothermal energy is produced from heat generated by the magma core (hot molten rock) of the planet and retained in the rocks and fluids beneath the Earth's surface. Wells are dug deep into underground reservoirs to access steam and hot water, which are used to drive turbines connected to generators. U.S. geothermal plants (91% in California) generate 17 GWs of electricity.



**28 SUPPLIERS OF RAW MATERIALS**  
Metal Supplies  
Turbine and Generator Components

**29 MANUFACTURERS OF GEOTHERMAL TURBINES, GENERATORS, AND EQUIPMENT**  
Mitsubishi Power, Tetra Tech, First Gen Corporation, Ormat Technologies, Engie SA

**30 TRANSPORTATION AND LOGISTICS COMPANIES**  
Sea Transport Providers, Truck Transport Providers, Rail Transport Providers, Air Transport Providers

**31 ENGINEERING, PROCUREMENT AND CONSTRUCTION COMPANIES**  
Ormat Technologies, Quanta Power Generation, Marubeni, EGESIM Energy Electro-Mechanic Construction Contracting Co., The Industrial Company

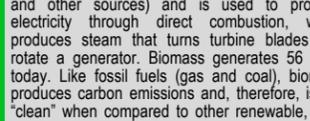
**32 DEVELOPERS/GENERATORS**  
Utilities (as Generators and Retail Electricity Distributors): Northern California Power Agency (Consortium of Local Electric Utilities That Provides Purchasing, Aggregation, Scheduling and Management of Electric Power), Berkshire Hathaway - BHE Renewables (CalEnergy, PacificCorp and NVEnergy), Calpine, Terra-Gen Power  
Non-Utility Independent Power Producers: Ormat Technologies

**33 Steam Energy**

**34 Residential, Commercial, and Industrial Customers**  
Residential Consumers, Industrial Companies, Commercial Establishments, Government Agencies

**35 UTILITIES AS RETAIL POWER DISTRIBUTORS**  
Investor-Owned Utilities, Electric Cooperatives, Retail Power Marketers, Not-for-Profit Municipalities

**Biomass and Other (7%)**  
Biomass is renewable organic material that comes from plants and animals (wood, landfill gas, waste and other sources) and is used to produce electricity through direct combustion, which produces steam that turns turbine blades that rotate a generator. Biomass generates 56 GWs today. Like fossil fuels (gas and coal), biomass produces carbon emissions and, therefore, is not "clean" when compared to other renewable, non-combustion sources of energy.



**36 SUPPLIERS OF RAW MATERIALS**  
Metal Supplies  
Turbine and Generator Components

**37 MANUFACTURERS OF BIOMASS GASIFIERS, COMBUSTION TURBINES, AND GENERATORS**  
Renewable Energy Group Inc., Green Plains, Aemetis, Green Plains Partners, Gevo, REX American Resources

**38 TRANSPORTATION AND LOGISTICS COMPANIES**  
Sea Transport Providers, Truck Transport Providers, Rail Transport Providers, Air Transport Providers

**39 ENGINEERING, PROCUREMENT AND CONSTRUCTION COMPANIES**  
Advanced Renewable Energy Ltd., StormFisher Biogas, Siemens AG

**40 Generation**  
Covanta, ReEnergy, Wheelabrator, BHE Renewables - Sierra Pacific

**41 Biomass Energy**

**42 Residential, Commercial, and Industrial Customers**  
Residential Consumers, Industrial Companies, Commercial Establishments, Government Agencies

**43 UTILITIES AS RETAIL POWER DISTRIBUTORS**  
Investor-Owned Utilities, Electric Cooperatives, Retail Power Marketers, Not-for-Profit Municipalities