**Definition of electrical distribution**

Electric power distribution is **the final stage in the delivery of electric power**; it carries electricity from the transmission system to individual consumers. ... Often several customers are supplied from one transformer through secondary distribution lines.

**Electric power distribution** is the final stage in the [delivery](https://en.wikipedia.org/wiki/Power_delivery) of [electric power](https://en.wikipedia.org/wiki/Electric_power); it carries electricity from the [transmission system](https://en.wikipedia.org/wiki/Electric_power_transmission) to individual consumers. Distribution [substations](https://en.wikipedia.org/wiki/Electrical_substation) connect to the transmission system and lower the transmission voltage to medium [voltage](https://en.wikipedia.org/wiki/Voltage) ranging between 2 [kV](https://en.wikipedia.org/wiki/Volt) and 35 kV with the use of [transformers](https://en.wikipedia.org/wiki/Transformer). *Primary* distribution lines carry this medium voltage power to [distribution transformers](https://en.wikipedia.org/wiki/Distribution_transformer) located near the customer's premises. Distribution transformers again lower the voltage to the [utilization voltage](https://en.wikipedia.org/wiki/Utilization_voltage) used by lighting, industrial equipment and household appliances. Often several customers are supplied from one transformer through *secondary* distribution lines. Commercial and residential customers are connected to the secondary distribution lines through [service drops](https://en.wikipedia.org/wiki/Service_drop). Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the [subtransmission](https://en.wikipedia.org/wiki/Subtransmission) level.

**The transition from transmission to distribution happens in a power**[**substation**](https://en.wikipedia.org/wiki/Electrical_substation)**, which has the following functions:**[**[2]**](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-HSW-2)

* [Circuit breakers](https://en.wikipedia.org/wiki/Circuit_breaker) and switches enable the substation to be disconnected from the [transmission grid](https://en.wikipedia.org/wiki/Electrical_grid) or for distribution lines to be disconnected.
* Transformers step down transmission voltages, 35 kV or more, down to primary distribution voltages. These are medium voltage circuits, usually 600–35000 V.[[1]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-:0-1)
* From the transformer, power goes to the [busbar](https://en.wikipedia.org/wiki/Busbar) that can split the distribution power off in multiple directions. The bus distributes power to distribution lines, which fan out to customers.

Urban distribution is mainly underground, sometimes in [common utility ducts](https://en.wikipedia.org/wiki/Common_utility_duct). Rural distribution is mostly above ground with [utility poles](https://en.wikipedia.org/wiki/Utility_pole), and suburban distribution is a mix.[[1]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-:0-1) Closer to the customer, a distribution transformer steps the primary distribution power down to a low-voltage secondary circuit, usually 120/240 V in the US for residential customers. The power comes to the customer via a [service drop](https://en.wikipedia.org/wiki/Service_drop) and an [electricity meter](https://en.wikipedia.org/wiki/Electricity_meter). The final circuit in an urban system may be less than 15 metres (50 ft), but may be over 91 metres (300 ft) for a rural customer.[[1]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-:0-1)



Electric power distribution became necessary only in the 1880s when electricity started being generated at [power stations](https://en.wikipedia.org/wiki/Power_stations). Before that electricity was usually generated where it was used. The first power distribution systems installed in European and US cities were used to supply lighting: [arc lighting](https://en.wikipedia.org/wiki/Arc_lamp) running on very high voltage (around 3000 volts) [alternating current](https://en.wikipedia.org/wiki/Alternating_current) (AC) or [direct current](https://en.wikipedia.org/wiki/Direct_current) (DC), and [incandescent lighting](https://en.wikipedia.org/wiki/Incandescent_lamp) running on low voltage (100 volt) direct current.[[3]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-3) Both were supplanting [gas lighting](https://en.wikipedia.org/wiki/Gas_lighting) systems, with arc lighting taking over large area and street lighting, and incandescent lighting replacing gas for business and residential lighting.

Due to the high voltages used in arc lighting, a single generating station could supply a long string of lights, up to 7-mile (11 km) long circuits.[[4]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-4) Each doubling of the voltage would allow the same size cable to transmit the same amount of power four times the distance for a given power loss. Direct current indoor incandescent lighting systems, for example the first Edison [Pearl Street Station](https://en.wikipedia.org/wiki/Pearl_Street_Station) installed in 1882, had difficulty supplying customers more than a mile away. This was due to the low 110 volt system being used throughout the system, from the generators to the final use. The Edison DC system needed thick copper conductor cables, and the generating plants needed to be within about 1.5 miles (2.4 km) of the farthest customer to avoid excessively large and expensive conductors.

**Introduction of the transformer**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=2)]

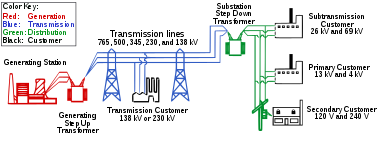
Transmitting electricity a long distance at high voltage and then reducing it to a lower voltage for lighting became a recognized engineering roadblock to electric power distribution with many, not very satisfactory, solutions tested by lighting companies. The mid-1880s saw a breakthrough with the development of functional transformers that allowed the AC voltage to be "stepped up" to much higher transmission voltages and then dropped down to a lower end user voltage. With much cheaper transmission costs and the greater [economies of scale](https://en.wikipedia.org/wiki/Economies_of_scale) of having large generating plants supply whole cities and regions, the use of AC spread rapidly.

In the US the competition between direct current and alternating current took a personal turn in the late 1880s in the form of a "[war of currents](https://en.wikipedia.org/wiki/War_of_currents)" when [Thomas Edison](https://en.wikipedia.org/wiki/Thomas_Edison) started attacking [George Westinghouse](https://en.wikipedia.org/wiki/George_Westinghouse) and his development of the first US AC transformer systems, pointing out all the deaths caused by high voltage AC systems over the years and claiming any AC system was inherently dangerous.[[5]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-5) Edison's propaganda campaign was short lived with his company switching over to AC in 1892.

AC became the dominant form of transmission of power with innovations in Europe and the US in [electric motor](https://en.wikipedia.org/wiki/Electric_motor) designs and the development of engineered *universal systems* allowing the large number of legacy systems to be connected to large AC grids.[[6]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-Thomas_Parke_Hughes_1930,_pages_120-121-6)[[7]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-Raghu_Garud_2009,_page_249-7)

In the first half of the 20th century, in many places the [electric power industry](https://en.wikipedia.org/wiki/Electric_power_industry) was [vertically integrated](https://en.wikipedia.org/wiki/Vertical_integration), meaning that one company did generation, transmission, distribution, metering and billing. Starting in the 1970s and 1980s, nations began the process of [deregulation](https://en.wikipedia.org/wiki/Deregulation) and [privatisation](https://en.wikipedia.org/wiki/Privatisation" \o "Privatisation), leading to [electricity markets](https://en.wikipedia.org/wiki/Electricity_market). The distribution system would remain regulated, but generation, retail, and sometimes transmission systems were transformed into competitive markets.

Generation and transmission[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=3)]



Simplified diagram of AC [electricity delivery](https://en.wikipedia.org/wiki/Electricity_delivery) from generation stations to consumers' [service drop](https://en.wikipedia.org/wiki/Service_drop).

Electric power begins at a generating station, where the potential difference can be as high as 33,000 volts. AC is usually used. Users of large amounts of DC power such as some [railway electrification systems](https://en.wikipedia.org/wiki/Railway_electrification_system), [telephone exchanges](https://en.wikipedia.org/wiki/Telephone_exchange) and industrial processes such as [aluminium](https://en.wikipedia.org/wiki/Aluminium" \o "Aluminium) smelting use [rectifiers](https://en.wikipedia.org/wiki/Rectifier) to derive DC from the public AC supply, or may have their own generation systems. [High-voltage DC](https://en.wikipedia.org/wiki/HVDC) can be advantageous for isolating alternating-current systems or controlling the quantity of electricity transmitted. For example, [Hydro-Québec](https://en.wikipedia.org/wiki/Hydro-Qu%C3%A9bec) has a direct-current line which goes from the [James Bay](https://en.wikipedia.org/wiki/James_Bay) region to [Boston](https://en.wikipedia.org/wiki/Boston).[[8]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-8)

From the generating station it goes to the generating station's switchyard where a step-up transformer increases the voltage to a level suitable for transmission, from 44 kV to 765 kV. Once in the transmission system, electricity from each generating station is combined with electricity produced elsewhere. Electricity is consumed as soon as it is produced. It is transmitted at a very high speed, close to the [speed of light](https://en.wikipedia.org/wiki/Speed_of_light).

Primary distribution[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=4)]

Primary distribution voltages range from 4 kV to 35 kV phase-to-phase (2.4 kV to 20 kV phase-to-neutral)[[9]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-eep-pdvl-9) Only large consumers are fed directly from distribution voltages; most utility customers are connected to a transformer, which reduces the distribution voltage to the low voltage "utilization voltage", "supply voltage" or "mains voltage" used by lighting and interior wiring systems.

**Network configurations**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=5)]

[](https://en.wikipedia.org/wiki/File:NCPC_Power_Plant_Yellowknife_Northwest_Territories_Canada_08.jpg)

Substation near [Yellowknife](https://en.wikipedia.org/wiki/Yellowknife), in the Northwest Territories of Canada

Distribution networks are divided into two types, radial or network.[[10]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-10) A radial system is arranged like a tree where each customer has one source of supply. A network system has multiple sources of supply operating in parallel. Spot networks are used for concentrated loads. Radial systems are commonly used in rural or suburban areas.

Radial systems usually include emergency connections where the system can be reconfigured in case of problems, such as a fault or planned maintenance. This can be done by opening and closing switches to isolate a certain section from the grid.

Long feeders experience [voltage drop](https://en.wikipedia.org/wiki/Voltage_drop) ([power factor](https://en.wikipedia.org/wiki/Power_factor) distortion) requiring [capacitors](https://en.wikipedia.org/wiki/Capacitor) or [voltage regulators](https://en.wikipedia.org/wiki/Voltage_regulator) to be installed.

Reconfiguration, by exchanging the functional links between the elements of the system, represents one of the most important measures which can improve the operational performance of a distribution system. The problem of optimization through the reconfiguration of a power distribution system, in terms of its definition, is a historical single objective problem with constraints. Since 1975, when Merlin and Back[[11]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-11) introduced the idea of distribution system reconfiguration for active power loss reduction, until nowadays, a lot of researchers have proposed diverse methods and algorithms to solve the reconfiguration problem as a single objective problem. Some authors have proposed Pareto optimality based approaches (including active power losses and reliability indices as objectives). For this purpose, different artificial intelligence based methods have been used: microgenetic,[[12]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-12) branch exchange,[[13]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-13) particle swarm optimization[[14]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-14) and non-dominated sorting [genetic algorithm](https://en.wikipedia.org/wiki/Genetic_algorithm).[[15]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-15)

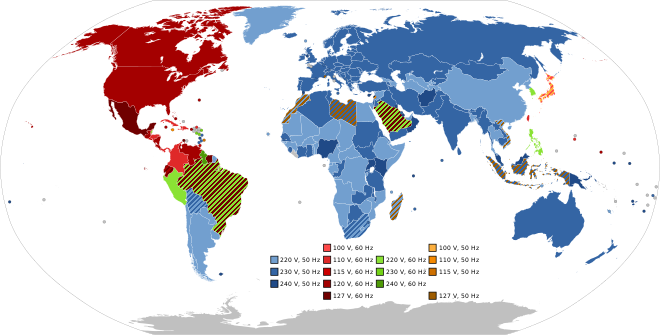
**Rural services**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=6)]

[Rural electrification](https://en.wikipedia.org/wiki/Rural_electrification) systems tend to use higher distribution voltages because of the longer distances covered by distribution lines (see [Rural Electrification Administration](https://en.wikipedia.org/wiki/Rural_Electrification_Administration)). 7.2, 12.47, 25, and 34.5 kV distribution is common in the United States; 11 kV and 33 kV are common in the UK, Australia and New Zealand; 11 kV and 22 kV are common in South Africa; 10, 20 and 35 kV are common in China.[[16]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-eolss-16) Other voltages are occasionally used.

Rural services normally try to minimize the number of poles and wires. It uses higher voltages (than urban distribution), which in turn permits use of galvanized steel wire. The strong steel wire allows for less expensive wide pole spacing. In rural areas a pole-mount transformer may serve only one customer. In [New Zealand](https://en.wikipedia.org/wiki/New_Zealand), [Australia](https://en.wikipedia.org/wiki/Australia), [Saskatchewan, Canada](https://en.wikipedia.org/wiki/Saskatchewan), and [South Africa](https://en.wikipedia.org/wiki/South_Africa), [Single-wire earth return](https://en.wikipedia.org/wiki/Single-wire_earth_return) systems (SWER) are used to electrify remote rural areas.

Three phase service provides power for large agricultural facilities, petroleum pumping facilities, water plants, or other customers that have large loads (Three phase equipment). In North America, overhead distribution systems may be three phase, four wire, with a neutral conductor. Rural distribution system may have long runs of one phase conductor and a neutral.[[17]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-17) In other countries or in extreme rural areas the neutral wire is connected to the ground to use that as a return ([Single-wire earth return](https://en.wikipedia.org/wiki/Single-wire_earth_return)). This is called an ungrounded [wye](https://en.wikipedia.org/wiki/Three-phase_electric_power#Three-wire_and_four-wire_circuits) system.

Secondary distribution[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=7)]

[](https://en.wikipedia.org/wiki/File:World_Map_of_Mains_Voltages_and_Frequencies,_Detailed.svg)

World map of mains voltage and frequencies

*Main article:*[*Low-voltage network*](https://en.wikipedia.org/wiki/Low-voltage_network)

Electricity is delivered at a frequency of either 50 or 60 Hz, depending on the region. It is delivered to domestic customers as [single-phase electric power](https://en.wikipedia.org/wiki/Single-phase_electric_power). In some countries as in Europe a [three phase](https://en.wikipedia.org/wiki/Three-phase_electric_power) supply may be made available for larger properties. Seen with an [oscilloscope](https://en.wikipedia.org/wiki/Oscilloscope), the domestic power supply in North America would look like a [sine wave](https://en.wikipedia.org/wiki/Sine_wave), oscillating between −170 volts and 170 volts, giving an effective voltage of 120 volts RMS.[[18]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-18) [Three-phase electric power](https://en.wikipedia.org/wiki/Three-phase_electric_power) is more efficient in terms of power delivered per cable used, and is more suited to running large electric motors. Some large European appliances may be powered by three-phase power, such as electric stoves and clothes dryers.

A [ground](https://en.wikipedia.org/wiki/Ground_(electricity)) connection is normally provided for the customer's system as well as for the equipment owned by the utility. The purpose of connecting the customer's system to ground is to limit the voltage that may develop if high voltage conductors fall down onto lower-voltage conductors which are usually mounted lower to the ground, or if a failure occurs within a distribution transformer. [Earthing systems](https://en.wikipedia.org/wiki/Earthing_system) can be TT, TN-S, TN-C-S or TN-C.

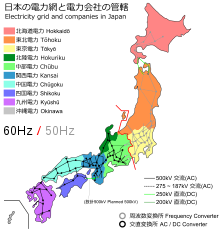
**Regional variations**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=8)]

**220–240 volt systems**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=9)]

Most of the world uses 50 Hz 220 or 230 V single phase, or 400 V 3 phase for residential and light industrial services. In this system, the primary distribution network supplies a few substations per area, and the 230 V / 400 V power from each substation is directly distributed to end users over a region of normally less than 1 km radius. Three live (hot) wires and the neutral are connected to the building for a three phase service. Single-phase distribution, with one live wire and the neutral is used domestically where total loads are light. In Europe, electricity is normally distributed for industry and domestic use by the three-phase, four wire system. This gives a phase-to-phase voltage of 400 volts [wye](https://en.wikipedia.org/wiki/Three-phase_electric_power#Three-wire_and_four-wire_circuits) service and a single-phase voltage of 230 volts between any one phase and neutral. In the UK a typical urban or suburban low-voltage substation would normally be rated between 150 kVA and 1 MVA and supply a whole neighbourhood of a few hundred houses. Transformers are typically sized on an average load of 1 to 2 kW per household, and the service fuses and cable is sized to allow any one property to draw a peak load of perhaps ten times this. For industrial customers, 3-phase 690 / 400 volt is also available, or may be generated locally.[[19]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-19) Large industrial customers have their own transformer(s) with an input from 11 kV to 220 kV.

**100–120 volt systems**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=10)]

Most of the Americas use 60 Hz AC, the 120/240 volt [split-phase](https://en.wikipedia.org/wiki/Split-phase_electric_power) system domestically and three phase for larger installations. North American transformers usually power homes at 240 volts, similar to Europe's 230 volts. It is the split-phase that allows use of 120 volts in the home.

[](https://en.wikipedia.org/wiki/File:Power_Grid_of_Japan.svg)

Japan's utility frequencies are 50 Hz and 60 Hz.

In the [electricity sector in Japan](https://en.wikipedia.org/wiki/Electricity_sector_in_Japan), the standard voltage is 100 V, with both 50 and 60 Hz AC frequencies being used. Parts of the country use 50 Hz, while other parts use 60 Hz.[[20]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-:1-20) This is a relic from the 1890s. Some local providers in [Tokyo](https://en.wikipedia.org/wiki/Tokyo) imported 50 Hz German equipment, while the local power providers in [Osaka](https://en.wikipedia.org/wiki/Osaka) brought in 60 Hz generators from the United States. The grids grew until eventually the entire country was wired. Today the frequency is 50 Hz in Eastern Japan (including Tokyo, [Yokohama](https://en.wikipedia.org/wiki/Yokohama), [Tohoku](https://en.wikipedia.org/wiki/T%C5%8Dhoku_region), and [Hokkaido](https://en.wikipedia.org/wiki/Hokkaido)) and 60 Hz in Western Japan (including [Nagoya](https://en.wikipedia.org/wiki/Nagoya), [Osaka](https://en.wikipedia.org/wiki/Osaka), [Kyoto](https://en.wikipedia.org/wiki/Kyoto), [Hiroshima](https://en.wikipedia.org/wiki/Hiroshima), [Shikoku](https://en.wikipedia.org/wiki/Shikokuch%C5%AB%C5%8D), and [Kyushu](https://en.wikipedia.org/wiki/Kyushu)).[[21]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-21)

Most household appliances are made to work on either frequency. The problem of incompatibility came into the public eye when the [2011 Tōhoku earthquake and tsunami](https://en.wikipedia.org/wiki/2011_T%C5%8Dhoku_earthquake_and_tsunami) knocked out about a third of the east's capacity, and power in the west could not be fully shared with the east, since the country does not have a common frequency.[[20]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-:1-20)

There are four [high-voltage direct current](https://en.wikipedia.org/wiki/High-voltage_direct_current) (HVDC) converter stations that move power across Japan's AC frequency border. [Shin Shinano](https://en.wikipedia.org/wiki/Shin_Shinano) is a [back-to-back](https://en.wikipedia.org/wiki/Back-to-back_connection#Power_transmission) HVDC facility in [Japan](https://en.wikipedia.org/wiki/Japan) which forms one of four [frequency changer](https://en.wikipedia.org/wiki/Frequency_changer) stations that link Japan's western and eastern power grids. The other three are at [Higashi-Shimizu](https://en.wikipedia.org/wiki/Higashi-Shimizu_Frequency_Converter), [Minami-Fukumitsu](https://en.wikipedia.org/wiki/Minami-Fukumitsu) and [Sakuma Dam](https://en.wikipedia.org/wiki/Sakuma_Dam#HVDC_frequency_converter). Together they can move up to 1.2 GW of power east or west.[[22]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-22)

**240 volt systems and 120 volt outlets**[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=11)]

Most modern North American homes are wired to receive 240 volts from the transformer, and through the use of [split-phase electrical power](https://en.wikipedia.org/wiki/Split-phase_electric_power), can have both 120 volt receptacles and 240 volt receptacles. The 120 volts is typically used for lighting and most [wall outlets](https://en.wikipedia.org/wiki/AC_power_plugs_and_sockets). The 240 volt circuits are typically used for appliances requiring high watt heat output such as ovens and heaters. They may also be use to supply an [electric car](https://en.wikipedia.org/wiki/Electric_car) charger.

Modern Distribution Systems[[edit](https://en.wikipedia.org/w/index.php?title=Electric_power_distribution&action=edit&section=12)]

Traditionally, the distribution systems would only operate as simple distribution lines where the electricity from the [transmission networks](https://en.wikipedia.org/wiki/Electric_power_transmission) would be shared among the customers. Today's distribution systems are heavily integrated with [renewable energy](https://en.wikipedia.org/wiki/Renewable_energy) generations at the distribution level of the power systems by the means of [distributed generation](https://en.wikipedia.org/wiki/Distributed_generation) resources, such as [solar energy](https://en.wikipedia.org/wiki/Solar_energy) and [wind energy](https://en.wikipedia.org/wiki/Wind_power).[[23]](https://en.wikipedia.org/wiki/Electric_power_distribution#cite_note-23) As a result, distribution systems are becoming more independent from the transmission networks day-by-day. Balancing the supply-demand relationship at these modern distribution networks (sometimes referred to as [microgrids](https://en.wikipedia.org/wiki/Microgrid)) is extremely challenging, and it requires the use of various technological and operational means to operate. Such tools include [battery storage power station](https://en.wikipedia.org/wiki/Battery_storage_power_station), [data analytics](https://en.wikipedia.org/wiki/Data_analytics), optimization tools, etc.

WHY IS ELECTRICAL DISTRIBUTION SYSTEM IMPORTANT

The primary purpose of an electricity distribution system is **to meet the customer's demands for energy after receiving the bulk electrical energy from transmission or subtransmission substation**. There are basically two major types of distribution substations: primary substation and customer substation.

#### Distribution System

|  |
| --- |
| The purpose of the distribution system is to distribute the electricity to each customer's residence, business, or industrial plant. It is primarily composed of the distribution substation and distribution feeders, but also contains many other pieces of equipment including reclosers, sectionalizers, fuses and capacitors.  Step-Down Transformer PictureElectricity is "stepped down" from a high to low voltage by transformers located at the distribution substation. These transformers are just the reverse of those which increased the voltage at the generating station. Electricity enters the primary side coil with the larger number of windings and leaves from the secondary coil with the smaller number of windings. The electricity is reduced to a lower distribution level voltage, usually less than 39,000 volts, and distributed on three phase lines. There are a wide variety of three phase distribution line types and voltages supplied by electric utilities across the country. A very common three phase distribution line voltage is 12,000 volts or 12 kV.  Distribution Transformers PictureThe distribution line supplies the final step down transformer at the customer location where the voltage is stepped down or lowered to the service voltage for the customer's electrical system. Then the electricity flows through the service drop to the electrical meter at the service to be measured for billing purposes. |