

Electrical Grid of the World



Electrical Grid

The electricity grid is understood to be the set of elements responsible for supplying electricity to consumers. The grid is made up of different structures:



Power Stations

These are facilities with the capacity to transform primary energy into electrical energy.



Transport Network

It is the set of lines and substations, with a voltage greater than or equal to 220 kV, that carry energy from power stations to transformer substations.

400 kV
30 kV

High-voltage power lines

These are lines that carry electrical energy at very high voltages – from 400,000 to 30,000 volts – in order to reduce the inevitable energy losses associated with transporting electricity over long distances.

30 kV
1.000 V

Medium voltage lines

Medium-voltage lines carry electrical current at a voltage between 30,000 and 1,000 volts.

<1.000 V

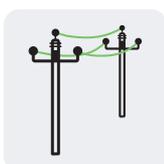
Low-voltage lines

These are the lines that carry energy to its destination so that it can be used by consumers. The voltage is less than 1,000 volts, as domestic and industrial equipment operates at a voltage of 380 or 220 V.



Transformer Substations

Transformer substations are responsible for varying the voltage to adapt it to transport (step-up substation) or distribution (step-down substation).

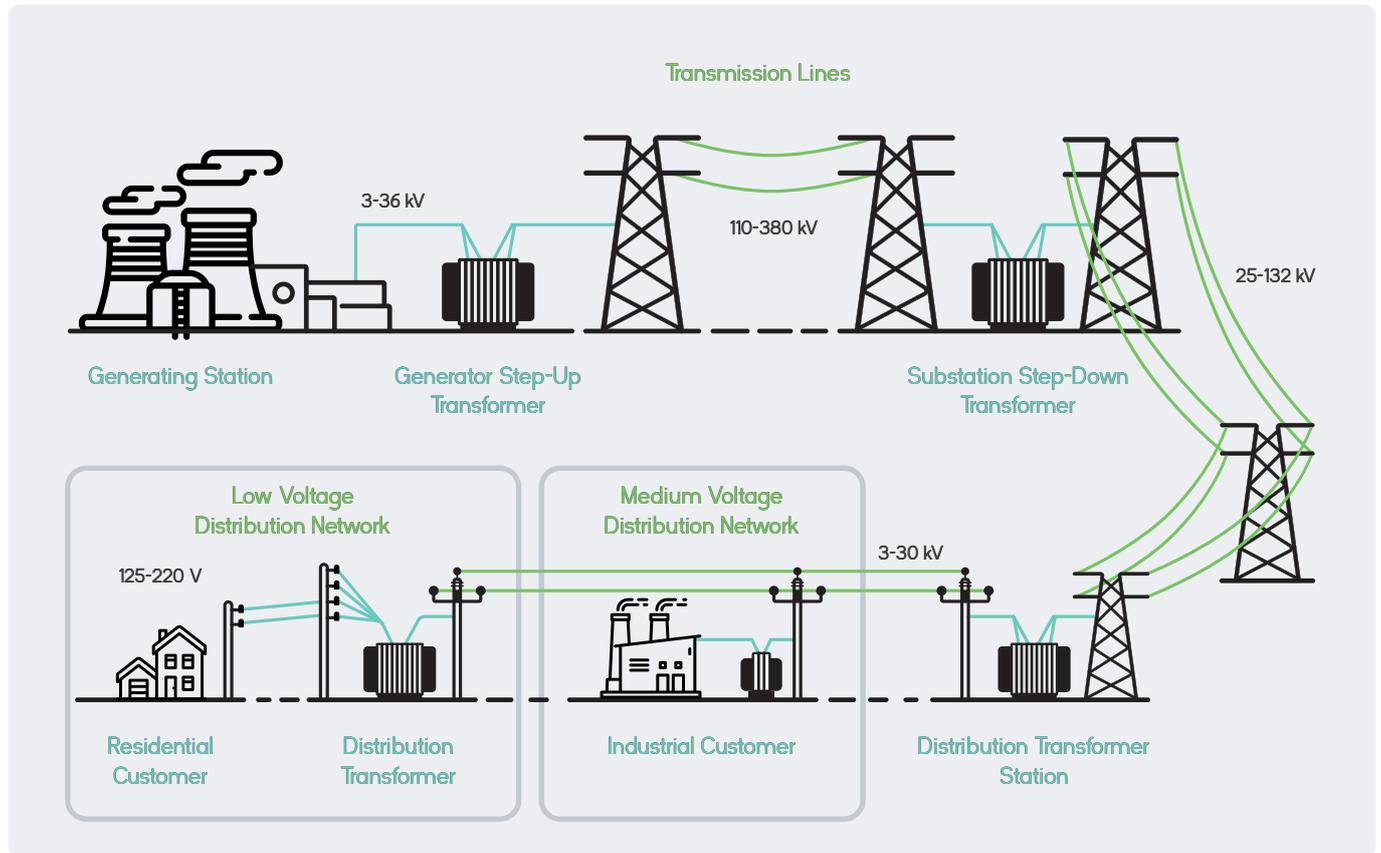


Distribution Network

The distribution network carries electrical energy from transformer substations to consumption points via medium or low voltage lines ($\leq 220\text{kV}$).



Below is a simplified diagram of the supply of AC electricity from power stations to homes.



How is the Electrical Grid around the world?

Globally, there are different ways of distributing electricity. The two main distribution network models are the North American model and the European model. Both models use very similar resources and facilities. Furthermore, both are radial systems*, with similar voltages and power transmission capacities. The main differences lie in the design, configuration and application of the distribution network.



Radial Grid

Radial-based networks use a single supply line, so that consumers have only one possible feed route. These systems have a simple, one-way path through which the current flows, starting from a substation and distributing in a 'branch' pattern throughout the distribution network.



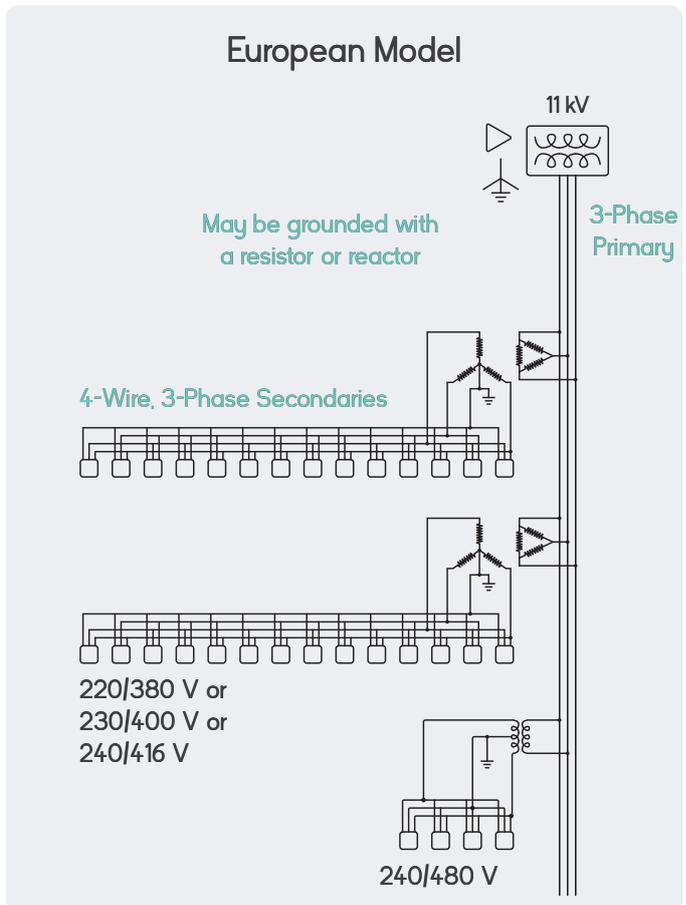
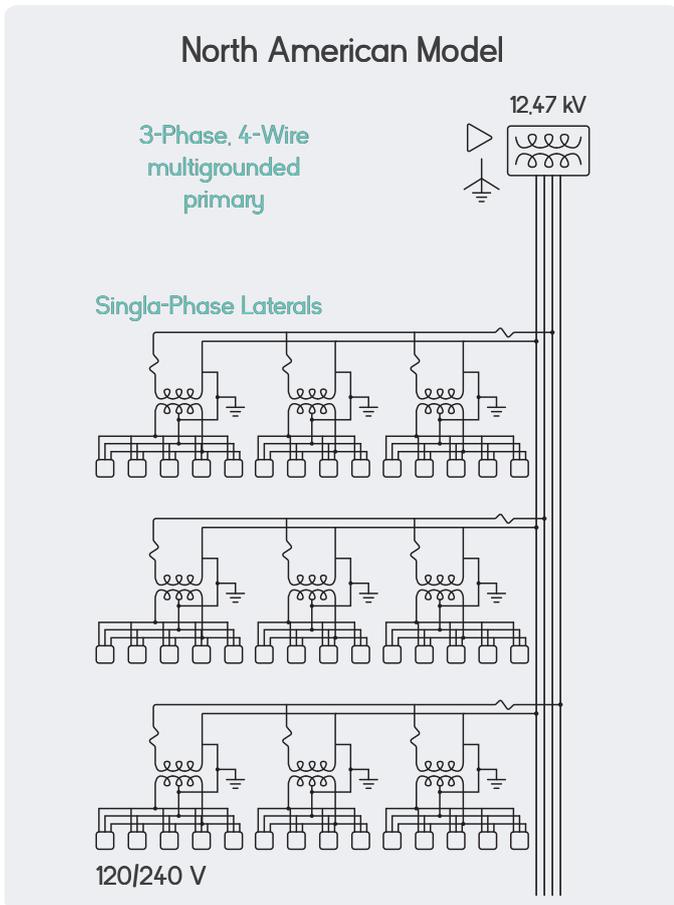
European Model vs North American Model

A typical distribution system found in American systems generally operates at 12.5 kV. The system usually operates radially. Most feeders consist of four cables (three phases and one neutral) and the branches are commonly single-phase. The transformers are connected star-to-star. The vast majority of transformers are connected single-phase from phase to neutral at 7.2 kV, and step down the voltage to 120/240 V (3-wire) for residences and most single-phase commercial loads.

The European distribution system operates at 11 or 12 kV, but does not have a neutral and therefore the feeders consist of 3-wire circuits. The transformers are connected in a three-phase delta-star configuration and are more like miniature substations.

The secondaries operate at 400/230 V, with 2 or 3 conductor sizes, and cover extensive distances.

American distribution systems tend to use small transformers ranging from 15 to 75 kVA, each serving about a dozen consumers within a radius of 30 to 80 metres from its location. In contrast, the European system, which uses a 250 V secondary, can cover an average of six times more consumers with each transformer, so the transformers used are usually 1000 kVA or more. Three-phase secondary circuits cover the distribution function performed by single-phase feeders in American systems.





The difference in voltage between the European system (250 V) and the American system (120 V) is not very great, but the following should be taken into account:

x4

European circuits can reach four times further given an equivalent load and voltage drop limitation.

x2

A balanced three-phase circuit can reach twice as far as a single-phase circuit.

x8

European three-phase secondary circuits can carry up to eight times more load, replacing the role of the primary sides of the American system.

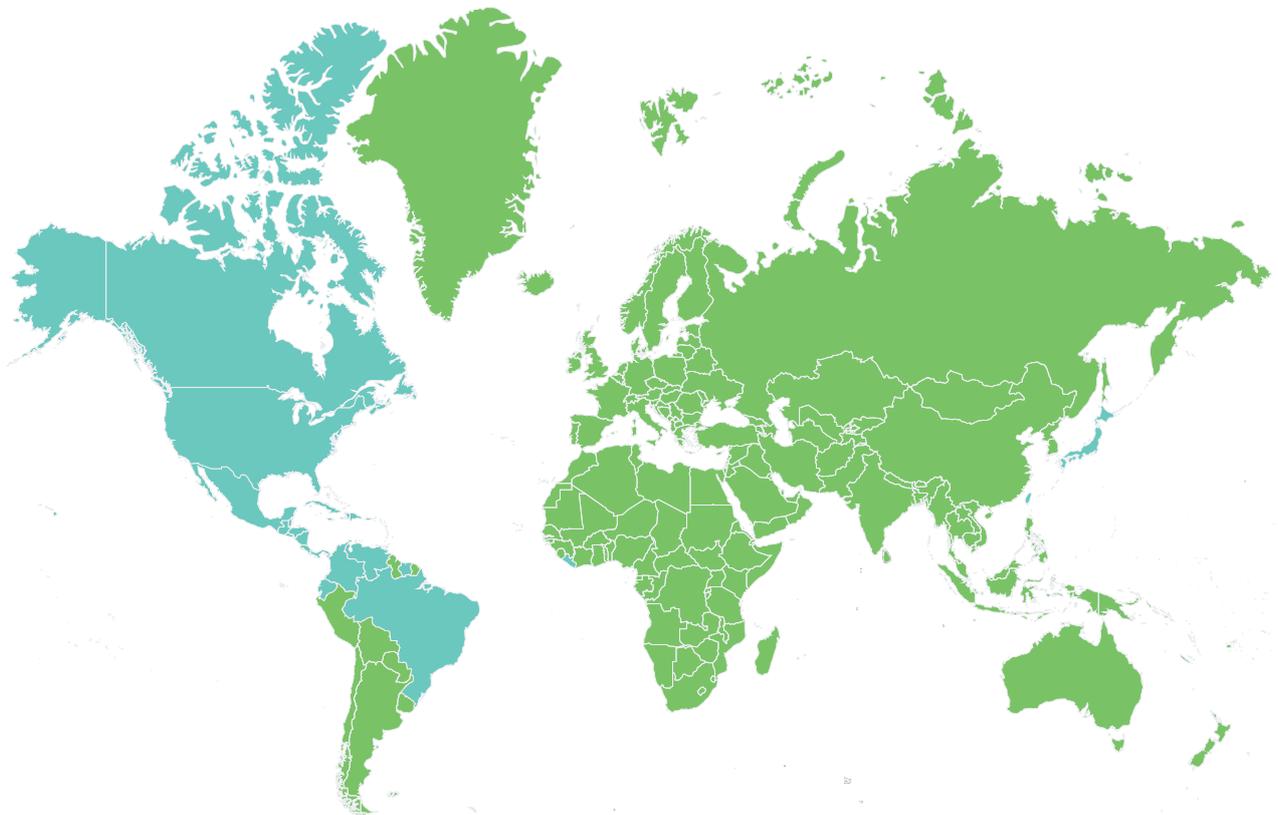
Mains voltage by country



100 / 127 V



220 / 240 V





Flexibility

The North American system has a more flexible primary design, and the European system has a more flexible secondary design. For urban systems, the European system can take advantage of the flexible secondary; for example, transformers can be located more conveniently. For rural systems and areas where the load is distributed, the North American primary system is more flexible.

The North American primary is slightly more suitable for picking up new load and for circuit upgrades and extensions.

Safety

The multiple-grounded neutral of the North American primary system provides many safety benefits. Protection can eliminate faults more reliably, and the neutral acts as a physical barrier, as well as helping to prevent dangerous touch voltages during faults.

In contrast, the European system has the advantage that high-impedance faults are easier to detect.

Reliability

Generally, North American designs result in fewer interruptions by customers. Nguyen et al. (2000) simulated the performance of the two designs for a hypothetical area and found that the average frequency of interruptions was more than 35% higher in the European system.

Energy Quality

Generally, European systems have fewer voltage dips and momentary interruptions. In a European system, lower primary exposure should result in fewer momentary interruptions compared to a North American system that uses fuse saving.

The European three-wire system helps protect against line-to-ground fault drops.

A squirrel through a bushing (line-to-ground) causes a relatively high impedance fault path that does not lower the voltage much compared to a bolted fault in a well-grounded system. Even if a phase conductor fails into a low-impedance return path (such as a well-grounded secondary neutral), customer delta-star transformers provide better immunity to voltage dips, especially if the substation transformer is grounded through a resistor or reactor.