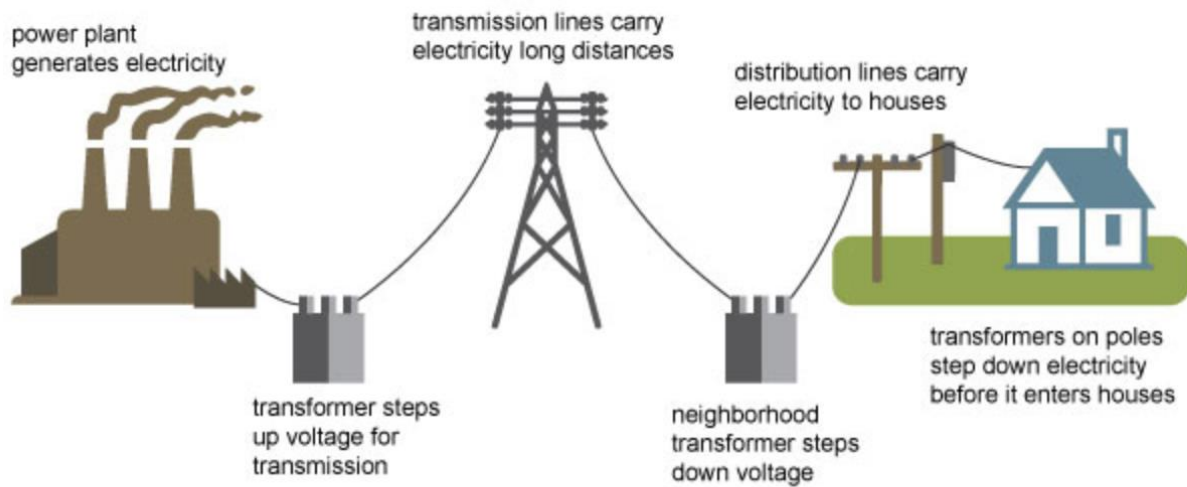

Electricity generation, transmission, and distribution



Source: Adapted from National Energy Education Development Project (public domain)

OUTLINE OF ELECTRIC POWER GRID: SAFETY ISSUES

AGENDA:

- Basics of electric power delivery
- Policy principles
- Safety risks to grid
- Safety risks to equipment and facilities powered by grid
- Safety risks for people

Basics of Electric Power Delivery:

- In the absence of electricity storage, electric power generated must match power needed at all times.
- Because of mismatch between where electric power is most effectively generated and where it is needed, long-distance transmission is required.
 - Alternating current is the most effective way of transmitting power over long distances, although direct current is used to power many devices, such as (i) laptops, (ii) Smart phones, and (iii) Electric motors. Power must be adapted from A/C to DC for these devices.

- Power is transmitted at high voltage over long distance wires, but transformed to lower voltage for distribution to organizations and residences. Most safety issues and grid vulnerabilities occur in the distribution part of the grid.
- Transmission system operators are regulated by the Federal Energy Regulatory Commission (FERC); state utility commissions regulate power distribution in states.
- Wholesale power is purchased by electric utility on a spot market. Utilities are called “distribution system operators.”
- Distributed energy resources exist at the customer level (“behind the meter”)

Policy Principles

- Electricity should be universally and affordably available
- Traditional integrated utility should give way to more diverse sources of power generation (Energy Policy Act of 1992)
- Big push to renewables, such as wind, solar, hydropower and to waste-to-energy and away from fossil fuels to generate power.
- Even where fossil fuels remain as generation sources, natural gas is becoming the preferred fuel. In 2018, natural gas fueled [more than 60 percent](#) of newly installed electric-generating capacity and [accounted for 35 percent](#) of total U.S. electricity generation. World Resource Institute
- No US appetite to grow nuclear power, despite absence of safety risks in France, even though it is clean and produces no carbon emissions.

- Increasing interest in microgrids to reduce overall power grid vulnerability. E.g. hospitals, military bases, police stations
- Two major sets of safety standards: North America: NEMA; Europe and most of the rest of the world: IEC.

Safety Risks to Grid

- **Highest source of outages: Trees and other vegetation knock out above-ground power lines; conversion to underground too expensive and adds other risks.**
- Experts are divided on electromagnetic pulse risk. Three types: geomagnetically induced current (GIC) (natural, from storm), high altitude electromagnetic pulse (HEMP) and intentional electromagnetic interference (IEMI) (intentional); Electric Power Research Institute 2019 study concludes that threat is manageable.
- Cybersecurity risks are increasing because of increasing dependence on software-controlled power distribution processes.
- Multiple paths for power transmission and distribution have reduced impact of disruption in single location, but widespread extreme weather or other natural disaster can still knock out big areas.
- Unevenness of renewables can overload grid, especially wind power. E.g. in 2013, 555 gigawatt-hours of wind power went unused because of overload risk.

Safety Risks to Facilities and Equipment Attached to Grid

- Sensitive electronic equipment can be damaged by sags or surges or voltage variations. E.g. UPS (uninterrupted power supply solutions are needed); wind and solar create risks of sags and wind creates surge risks.

- Electrical or arc faults contribute to over 760,000 fires each year worldwide because of overloaded circuits. Need for “arc flash” and “arc fault” circuit interrupters. An arc flash is the light and heat produced from an [electric arc](#) supplied with sufficient electrical energy to cause substantial damage, harm, fire, or injury.

Safety Risks for People

- Electrical fires damage facilities, but also risk human lives, including residential fires.
- Seven major workplace risks: (i) overhead power lines; (ii) damaged tools and equipment; (iii) Inadequate wiring and overloaded circuits; (iv) Exposed electrical parts; (v) Improper grounding; (vi) Damaged insulation; and (vii) Wet conditions

Best reference source: ***THE GRID. By Gretchen Bakke***

Article: <https://www.vox.com/energy-and-environment/2018/11/30/17868620/renewable-energy-power-grid-architecture>