

A background image showing several wind turbines silhouetted against a sunset sky with orange and purple hues. The turbines are positioned at various heights and angles, creating a sense of depth and scale.

Exploring the components and trade-offs within power systems

The Institution of Engineering and
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Key:



Components of a power system



Key considerations



Voltage level considerations



It's context dependent



Cable vs overhead line case study



Key points



References

The core components of a power system



Generators

Produce electrical energy (including storage systems).



Transformers

A device that either increases (stepping up) or reduces (stepping down) the voltage electrical energy is transmitted at.



Overhead lines

Conductor wires are suspended from / supported by towers or poles where air is the main insulator.



Electrical cables

An assembly of one or more electrical conductors surrounded by an insulating cover, usually held together with an overall sheath.



Circuit breakers / Switches

Designed to interrupt or control the flow of electric current.



Substations

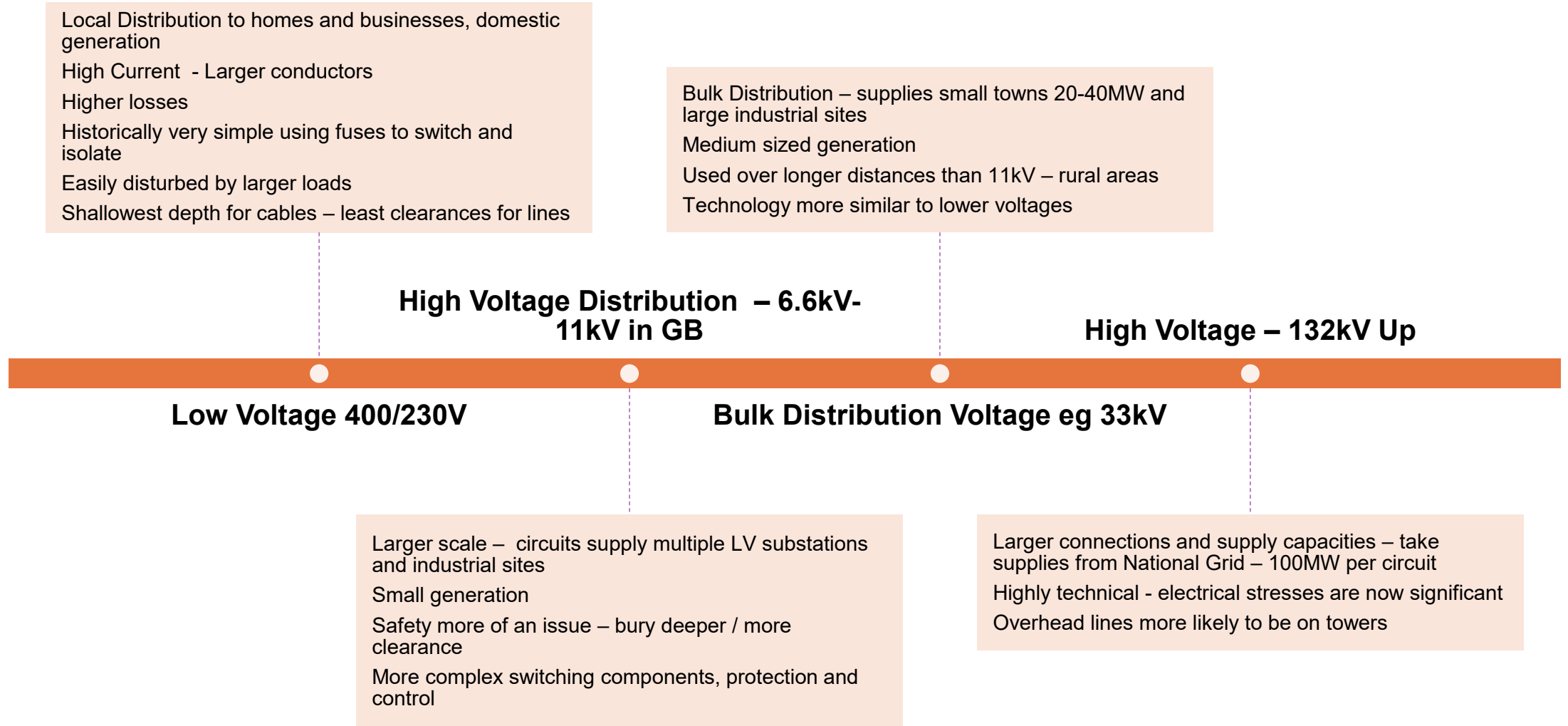
A high-voltage electric system facility, used to switch generators, equipment, and circuits or lines in and out of a system. Also used to change AC voltages from one level to another, and/or change alternating current to direct current or direct current to alternating current.

Key considerations

Consideration	Notes
Power and energy transmission scale – size and distance of transmission	Affects voltage level choice based on the amount of current (power is a function of voltage and current) and hence the heat losses generated by the electrical resistance of the components
Voltage limits	There are upper and lower limits you have to maintain , both when under load and when there is very light or no load. Voltages can rise along cables under light/ no load
Fault current level	When there is a fault on the system very high currents can flow. This property of electrical systems is used to very quickly and safely identify and isolate faulty equipment. Equipment has limits to the amount of current that can be switched.
Installation	Can you get the equipment to site? Are there suitable routes for circuits (tower locations, space for cables etc)? Cost of installation – indoor v outdoor Environmental issues – flooding, proximity of trees Proximity to public and other infrastructure



Voltage level considerations





Decisions are unique to the context

- There is no magic bullet and there is no universal answer – a solution that may have worked in one circumstance may not work in another
- Unique environmental and ecological impacts must be considered
- Every kilometre of a circuit is different and will require assessment
- Network operators are already considering these factors when making decisions

There are pros and cons to all decisions – cable vs overhead line case study

	Cable	Overhead line
Route selection	Challenging Route is critical – ground type, slopes, width of trench Ground type affects heat dissipation (as does proximity of adjacent cables) Separation to reduce risk of failure impact Bending radius of cable affects route choice Environmental impact – size of trench etc	Easier to plan Straighter lines are easier – fewer strain towers Single v double circuit routes Tower style and foundation/footing needs Avoidance of wooded areas – clearances for safety and reliability
Installation	High impact Excavation of multiple trenches (even with ploughing) along entire route Higher voltages impact land above Can be installed in roads – route length and access / installation disruptions for higher voltage cables	Lower impact Tower footings most difficult Can be expensive if using helicopters etc Tower choice
Repair	Difficult Failures rare unless subject to third party damage Joining higher voltages requires larger excavations and dry conditions	Straightforward Failures on higher voltage OHLs relatively rare – usually trees or ice
Operation	Medium Technical issues with voltage rise over longer lengths	Medium Inspection usually done with drones / helicopters – low impact. Replacing fittings etc straightforward.
Environment	Medium Impacts during installation / access for repair	Medium Visual impact – large birds





There are pros and cons to all decisions – cable vs overhead line case study

Cable	Overhead line
How many cables need to be installed?	Tower choices – height, foundation needs
How far apart do they need to be?	Woodland/ forestry can this be avoided
How deep and what is the terrain?	Clearance from other OHL
Road routes (ease of access) – is there space at side of road ? Bridges?	

Other factors to consider

- Impacts of climate change – flooding, higher temperatures
- Land type – cabling through rock vs cabling soil/soft ground



Key points



It's complicated

Higher voltages means more power transfer, but also greater technical expertise is required for the building and upkeep process.

You can only build what is feasible, and the harder it is to build, the higher the cost.



Every project is different

Decisions made are project specific and context dependent.

Different projects have different environmental and ecological considerations – network operators evaluate what is right for every kilometre.



There is no golden ticket

Every option has trade offs. DNOs and network operators are constantly weighing these up.

Overhead lines are easier to install and maintain but have visual impacts and are more vulnerable to damage. Cables are more costly to install and repair but are more durable.



References

1. [Powering Up Britain: Net Zero Growth Plan - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/consultations/powering-up-britain-net-zero-growth-plan)
2. [CBP-9888.pdf \(parliament.uk\)](#)
3. [Net-Zero Unveiled: UK's Ambitions Analysed | Carbon Free Europe](#)
4. <https://www.theiet.org/media/9376/electricity-transmission-costing-study.pdf>
5. <https://www.nationalgrid.com/stories/energy-explained/what-is-a-substation>