Exploring the components and trade-offs within power systems

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Agenda

1. Components of a power system (3mins)
2. Key considerations (5mins)
3. Voltage level considerations (3mins)
4. Context dependent (2mins)
5. Cable v overhead line case study (5 mins)
6. Key points (2mins)
7. Questions (10mins)

The core components of a power system

- **Generators –** produce electrical energy (include storage systems)
- **Transformers** - A device that either increases (stepping up) or reduces (stepping down) the voltage electrical energy is transmitted at.
- **Electrical Cables** - An assembly of one or more electrical conductors surrounded by an insulating cover, usually held together with an overall sheath.
- **Overhead Lines** – Conductor wires are suspended from / supported by towers or poles where air is the main insulator.
- **Circuit breakers / Switches** - Are designed to interrupt or control the flow of electric current.
- **Substations** - A high-voltage electric system facility. It is used to switch generators, equipment, and circuits or lines in and out of a system. It is 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 Enviromental issues – flooding, proximity of trees Proximity to public and other infrastructure

Voltage Level Considerations

Low Voltage 400/230V

- Local Distribution to homes and businesses, domestic generation
- High Current - Larger conductors
- Higher losses
- Historically very simple using fuses to switch and isolate
- Easily disturbed by larger loads
- Shallowest depth for cables – least clearances for lines

High Voltage Distribution – 6.6kV-11kV in GB

- Larger scale – circuits supply multiple LV substations and industrial sites
- Small generation
- Safety more of an issue – bury deeper / more clearance
- More complex switching components, protection and control

Bulk Distribution Voltage eg 33kV

- Bulk Distribution – supplies small towns 20-40MW and large industrial sites
- Medium sized generation
- Used over longer distances than 11kV – rural areas
- Technology more similar to lower voltages

High Voltage – 132kV Up

- Larger connections and supply capacities – take supplies from National Grid – 100MW per circuit
- Highly technical - electrical stresses are now significant
- Overhead lines more likely to be on towers

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 v 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 Enviromental 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 / installaton 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 Jointing 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 straightforwards.
Environment	**Medium** Impacts during installation / access for repair	**Medium** Visual impact – large birds

There are pros and cons to all decisions- Cable v 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?	

<u>Other factors to consider</u>

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

Key Points

It is 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

Questions?

References

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