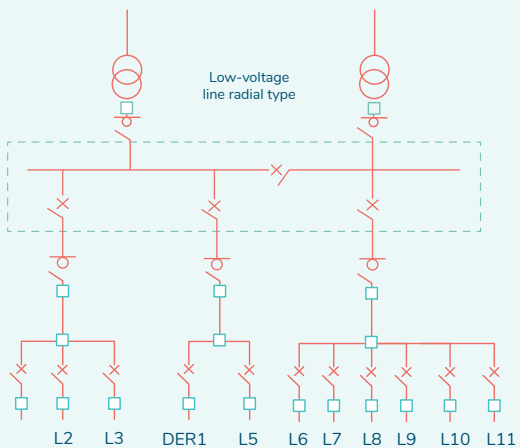


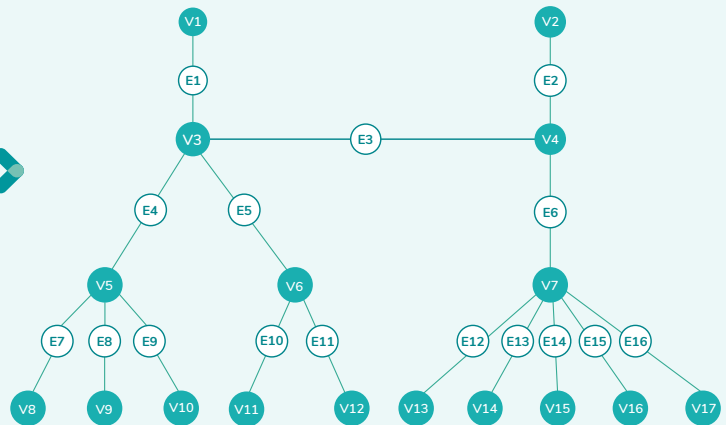
Grid topology

What is it?

In energy systems, grid topology refers to the physical and logical connections between electrical nodes and network elements. Essentially, it describes how components like transformers, lines, switches, and loads are interconnected. Grid topology can be visualized as a graph, of nodes and edges, which represent different network elements.



Low voltage radial line topology



Abstract simplified model of line topology

Topology Information

Why is it Important?

Grid topology plays a crucial role in both the planning and operational activities of a Distribution System Operator (DSO). The logical representation of relationships within the network enables a variety of analyses, such as:

1 Grid Planning: Using topology information, DSOs can perform power flow analysis to determine if parts of the network are at risk of congestion or voltage deviation. It also helps identify sections that may require reinforcement or where new renewable energy sources (RES) can be connected.

2 Grid Operation: In real-time operation, grid topology allows for better monitoring and control, ensuring that power can be effectively distributed and managed. Understanding the layout of the network is key to ensuring that loads are balanced and the grid remains within its operational limits.

In the STREAM project, grid topology models are essential components of tools like sPLAN (for grid planning) and sGRID (for grid operation). These tools rely on accurate topology information to simulate the network's behavior, forecast potential issues (such as congestion or voltage fluctuations), and identify optimal interventions to maintain grid stability.

Lessons Learned in STREAM from Building a Grid Topology Model



1 GIS is Essential for Building Larger Network Topologies:

Geographic Information Systems (GIS) provide crucial data for building, visualizing, and analyzing grid topologies. The completeness of GIS data is key—geospatial information must also include relevant attributes (such as material types for lines and transformers) for accurate analysis.

2 Connectivity is Key:

When constructing a topology model, it's important to first ensure the correct geographical positions of the elements. After that, it's essential to accurately define how internal connections within the structures are organized to form a coherent network.

3 No Model is Perfect:

This is especially true for the low-voltage (LV) side of the grid, where common issues arise:

→ Elements may be incorrectly connected or left unconnected during the spatial-to-graph processing, leading to “topological islands”—isolated segments of

the network that are not properly integrated with the rest of the system.

→ Material information for lines and transformers may be missing.

→ Metering points can be incorrectly placed.

→ Continuous connection across all voltage levels is essential for a well-functioning topology.

4 No One-Size-Fits-All Solution:

Different DSOs use GIS systems differently. As a result, each topology model implementation must be tailored to the specific needs of the DSO and the unique characteristics of their system.

5 No History Log for Topology Changes:

Many DSOs lack a record of changes in network topology. This becomes a problem when switch configurations change, as they can significantly affect power flows, which is particularly important for forecasting needs.

6 Lack of 3-Phase Topology Models:

Many DSOs do not have detailed 3-phase topology models, which are critical for performing accurate simulations on LV networks. A lack of detailed impedance information can further complicate these simulations, leading to inaccurate results in grid analysis.

