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LEMCKO
Energy & Power Quality

The DC backbone as an answer on the increased self sufficiency in the future low voltage

In recent decades, the low-voltage grid has seen a significant increase in distributed energy resources such as PV and, to a lesser extent, small and mid-scale wind turbines. This leads to an increasing degree of grid congestion, resulting in power quality-related problems such as overvoltage and unbalance. In addition, this AC architecture, with many small-scale inverters, leads to lower system efficiency due to the many conversions. In addition, this AC architecture, with many small-scale inverters, leads to lower system efficiency due to the many conversions. As PV installations generate a direct current by nature and wind energy is converted to direct current via an intermediate step, a low voltage operated DC backbone could save on conversion losses.

The developments in power electronics during last decades enabled DC distribution systems. Energy savings due to reduced conversion and cable losses and the inexistence of reactive power flows and power quality issues are advantages that made DC grids having a high potential. A DC backbone at community level for the interconnection of distributed energy resources and storage units, and where the conversion to AC is made by one single interlinking grid inverter, offers many advantages. For example, the efficiency of inverters is higher due to the scale effect and aggregation of the energy sources and storage units can increase self-sufficiency. In the research EELAB / Lemcko carried out, the following aspects are studied for this purpose:

- Loss models of the converters and inverters are developed as well as a power flow model for the calculation of the cable losses.
- Comparative studies are conducted between an AC architecture and a DC backbone architecture, initially investigating the occurring losses. Subsequently, the impact of aggregation of energy sources and storage units on self-sufficiency and self-consumption is studied.
- The operating voltage of the DC backbone determines to a large extent the cable losses and the conversion losses. In addition, depending on the topology of the DC backbone, one (unipolar) or two (bipolar) different voltages could be made available. Voltage imbalances can occur in the case of bipolar grids, but can be mitigated using power electronics. All these aspects are investigated through a holistic approach in order to determine the most suitable operating voltage and topology.
- Sizing a DC cable requires a different approach than sizing AC cables for which standards already exist. In addition, the cables of a DC backbone will only operate in their maximum load condition in certain cases. Using a probabilistic approach, the thermal load capacity of the cable will be investigated in order to determine the techno-economically optimal cable section.

Based on these analysis the benefits of a DC backbone at community level are compared to the traditional AC grid with individual prosumers. Secondly these analysis will clarify how to operate and design such a DC backbone. However, this does not yet determine how the renewable energy resources and storage facilities for a community should be sized. This will be done in a second part in which a heuristic optimization algorithm will be developed. Generic solutions will be proposed depending on the degree of aggregation of the community and the type of consumers within the community..