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Master's Thesis for xy: Literature-based Analysis of Communication Requirements and Benefits for the Operation and Reconstruction of Inverter-Based Island Networks

With the increasing replacement of synchronous generators in power systems new technologies are required to maintain stable voltage and frequency. Grid-forming inverters can provide these functions and offer new possibilities for the operation of islanded power systems and power system restoration. Primary control mechanisms, such as droop control, enable inverters to share loads without continuous communication. Secondary control can restore nominal frequency and voltage, while tertiary control coordinates power flows and the use of available energy resources. Given suitable black-start capabilities and sufficient energy reserves, inverter-based islands can also support bottom-up power system restoration following a blackout. The aim of this thesis is to investigate where and to what extent communication is required or beneficial for the restoration and operation of inverter-based islanded power systems.

The work shall begin with a fundamental literature review of grid-forming inverters, islanded operation and black-start procedures, as well as primary, secondary and tertiary control approaches. Based on this review, approaches with different communication requirements shall be identified and compared. A comparative assessment framework shall then be developed to evaluate their communication requirements and the resulting benefits for system operation and restoration. The assessment shall critically examine the trade-offs between improved control performance, communication infrastructure requirements and dependencies on communication availability.

The following structure is proposed for the thesis:

- Familiarisation with primary, secondary and tertiary control, as well as black-start procedures in inverter-based islanded power systems.
- Literature review on the use of communication in control and restoration approaches for islanded operation and black start.
- Development of a framework for the systematic assessment of communication needs considering benefits, costs and implementation effort.
- Application of the framework to selected control and restoration approaches to identify where communication is necessary, beneficial or introduces additional limitations.

Following the completion of this thesis, a presentation must be given to report on the results.

The theses can be written in English or German.

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