Load flow calculations of a municipal electrical energy distribution grid

Simulation-based analysis of necessity and costs of conventional and alternative grid reinforcements for future loads

Graduate

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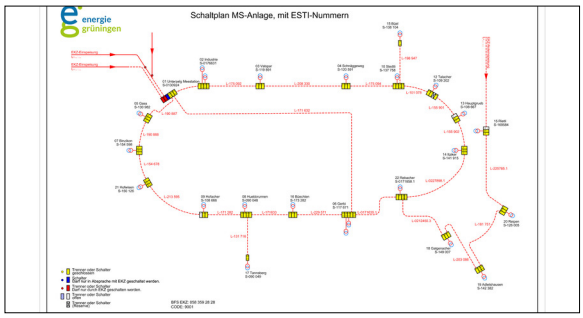
Introduction: This bachelor's thesis focuses on analysing the municipal electrical energy distribution grid of Grünigen, specifically addressing the anticipated changes in load demand. Grünigen, situated in the Zürcher Oberland region, features dispersed consumers of electric energy, typical of rural areas with integrated industry. Notably, the municipality is home to a bus operating company (VZO) that will electrify its entire fleet until 2038, necessitating daily charging at their site. To comprehend and study the impact of increased energy demand, a load forecast incorporating diverse load profiles, funded on measurements and studies on the change of energy demand, was developed. These profiles, which were generated for general loads, the bus charging station of VZO, and the generation of PV power, were subsequently simulated using Neplan, a specialised software for electrical load flow analysis. The objective was to identify grid vulnerabilities by assessing that may face overloading in the future.
Furthermore, the thesis compares conventional grid reinforcement measures, such as additional parallel cable lines, with alternative approaches such as the integration of energy storage units (batteries and PtX). Additionally, a (n-1) redundancy simulation was conducted to evaluate grid reliability and resilience. The cost-effectiveness of these reinforcement measures was also examined.

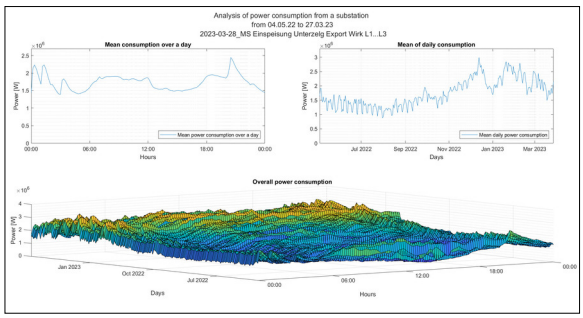
Result: The findings demonstrate that conventional grid reinforcement measures which target specific lines, are considerably more cost-effective than incorporating energy storage units. However, the redundancy simulation revealed that such measures alone might not suffice to guarantee grid stability and reliability, as the loading of some lines still reaches critical levels. Therefore, further investigations and alternative solutions are required to address the redundancy security of the grid.

Conclusion: This thesis contributes to the understanding of grid management and the challenges presented by rising electricity demand in the context of municipal energy distribution systems. It underscores the necessity for comprehensive analysis and alternative approaches to ensure the grid's long-term sustainability and dependability. Additionally, it provides valuable insights to the grid operator regarding the precise load distribution within the grid, which is challenging to comprehend without simulation.

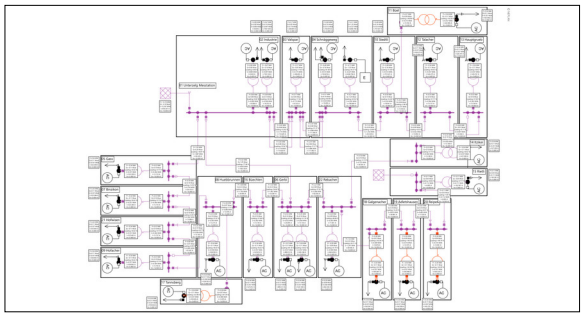
Schematic of the medium voltage grid of Grünigen
Energie Grünigen



Load analysis in the grid of Grünigen
Own presentment



Simulation of a future scenario in Neplan
Own presentment



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