Karlsruher Institut für Technologie

SuperLink

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

SuperLink

Deployment of Superconducting Power Cables for Power Grid Enhancement

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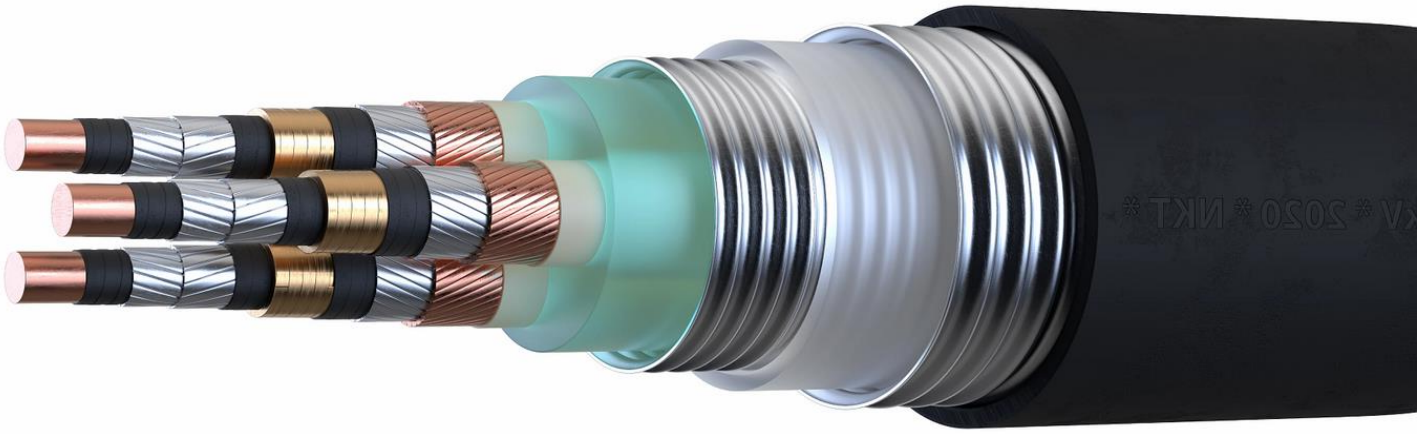
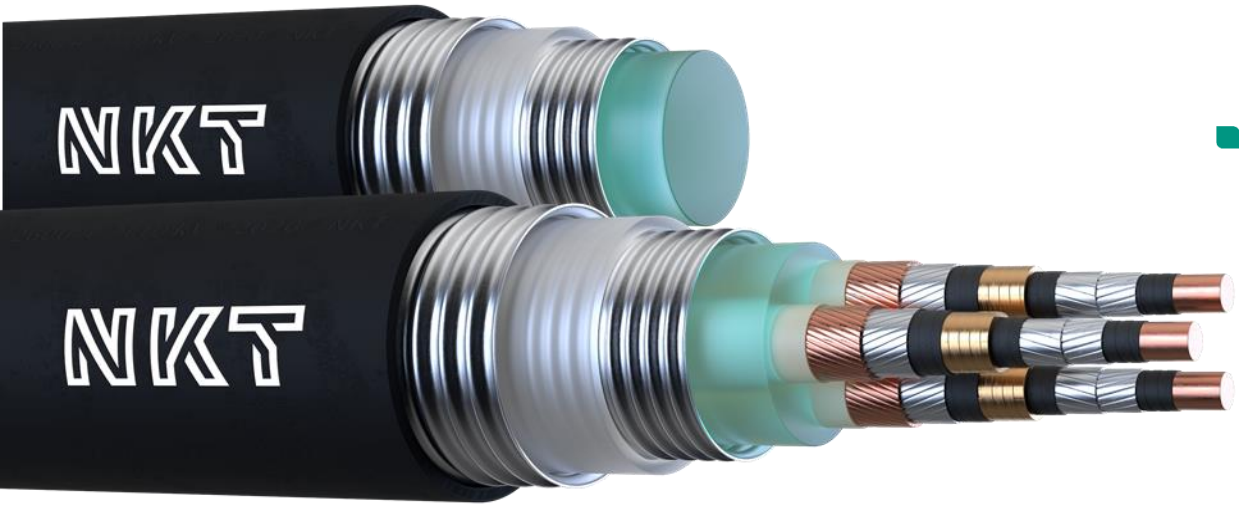
Mathias Noe
Robert Prinz
Werner Prusseit



Background

- The conversion to electrical energy use, especially in the commercial, building and transport sector leads to a significant increase in the demand for electrical energy
  - Huge impact on distribution network
  - On its majority, old and no longer suitable for the upcoming load flow

SuperLink - The longest HTS Cable in the World

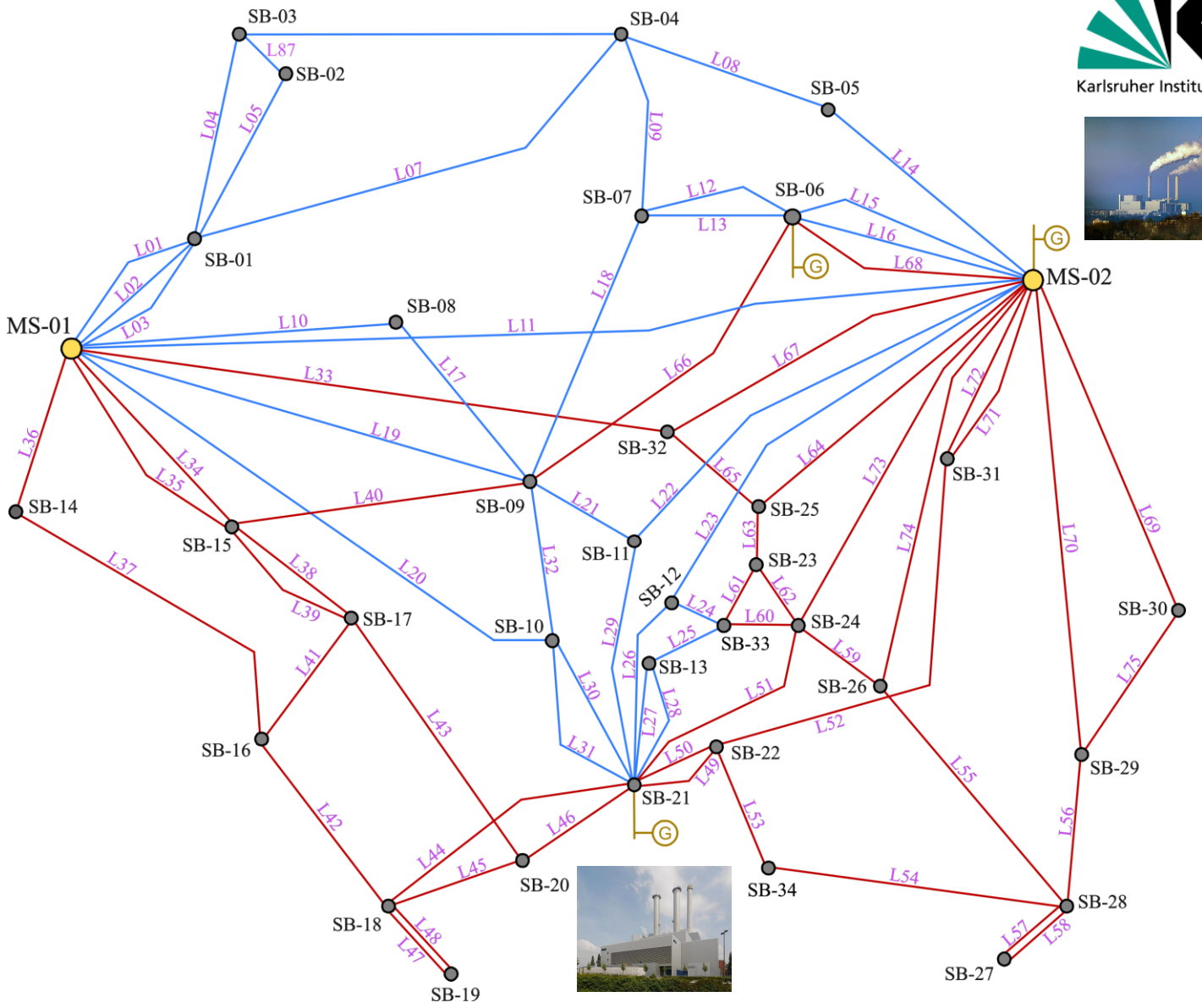


- **Cable Design**
  - **15 km long high-power HTS cable**
  - 3 Phases in one Cryostat
  - Superconducting phases and screens
  - 110 kV, 500 MVA, 2.6 kA
  - Low AC- Losses (lower than 0.5 W/m per phase)
  - Fault Current Resilient (40 kA, 1 s)
- **Closed cooling system**
  - Separate LN_2 return pipe (single, one-way cable)
  - Low temperature and high pressure of LN_2 can be maintained in the main cryostat

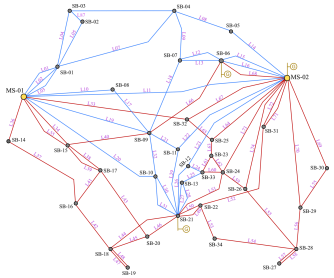
Munich 110 kV Network

SWM 110 kV-Network	
Cable Connections	87 Lines
Total Cable Length	383 km
Busbars	158

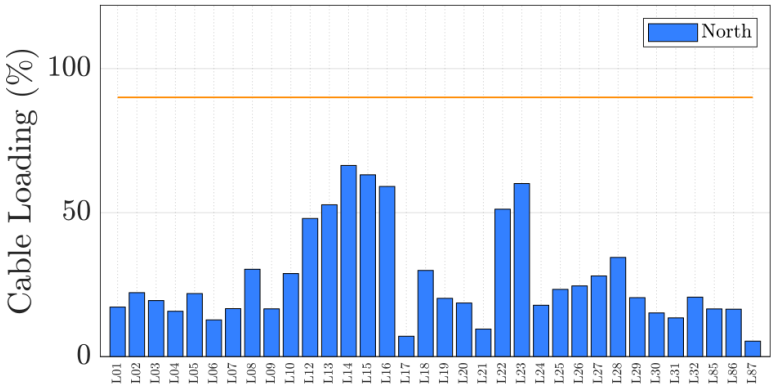
SWM 110 kV-Network Thermal Power Station	
SB-21	638 MVA
MS-02	276 MVA
SB-06	100 MVA

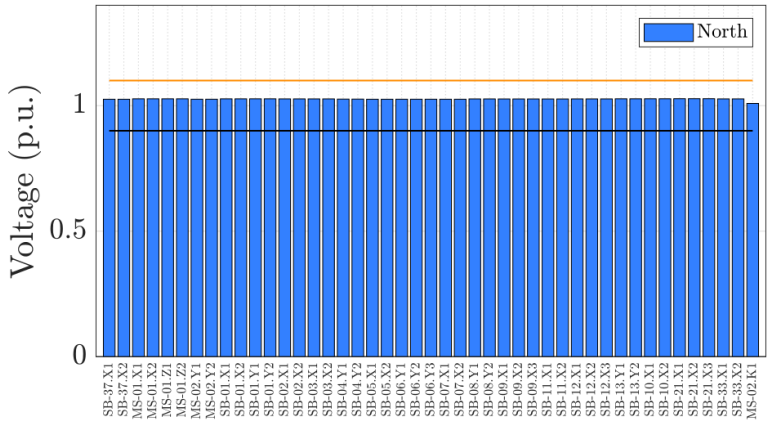


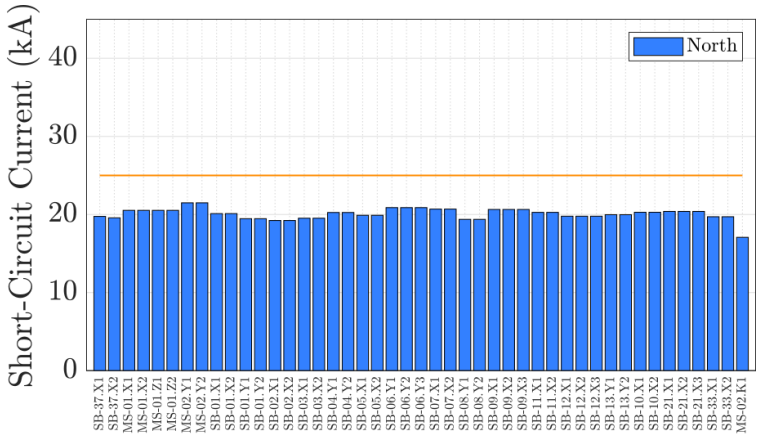
Munich 110 kV Network – Load Flow Analysis

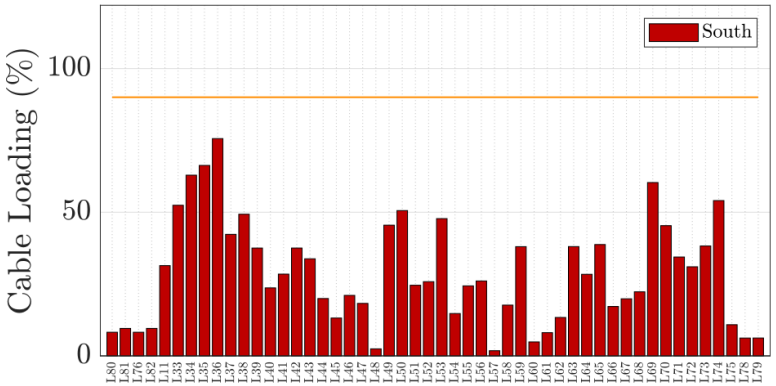


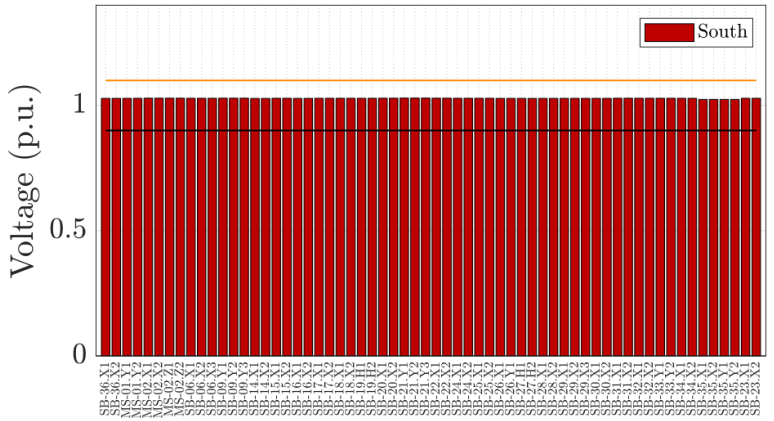
- 2019 – Peak Load = 1210 MVA
  - Network running fine

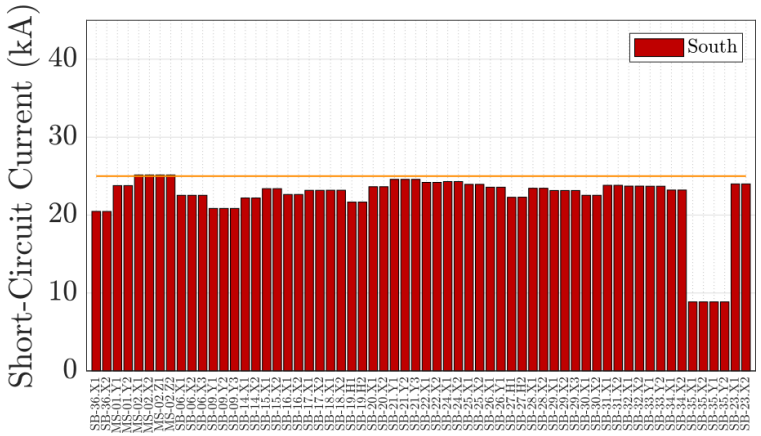




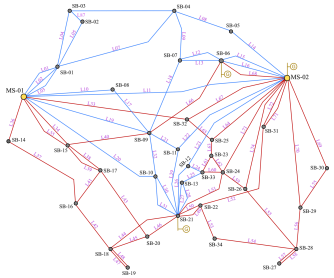




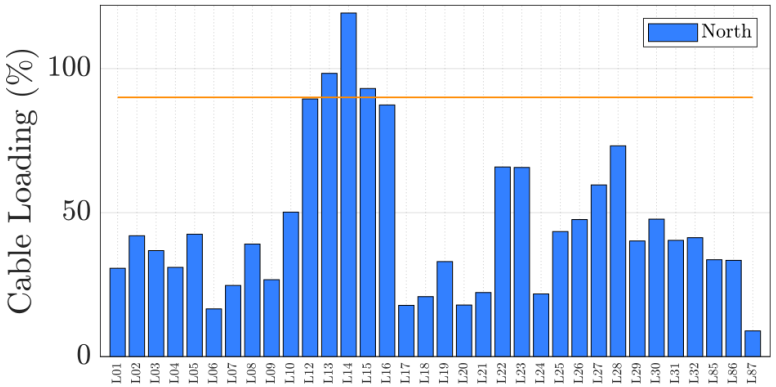


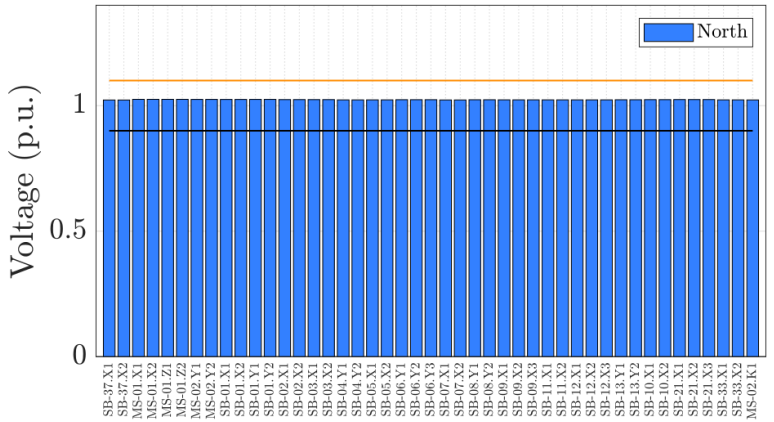


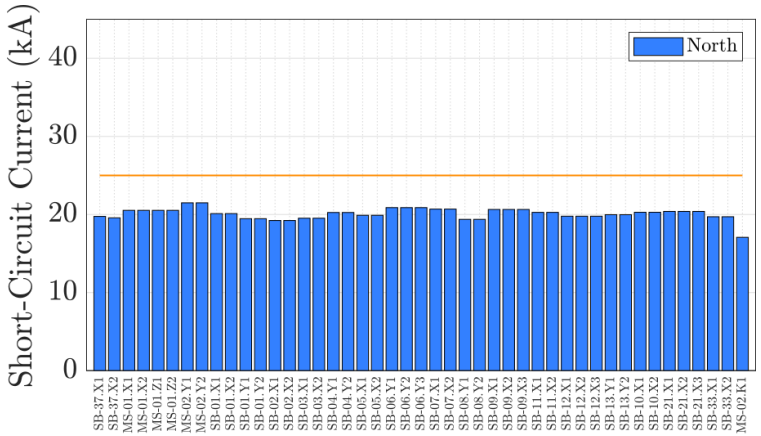
Munich 110 kV Network – Load Flow Analysis

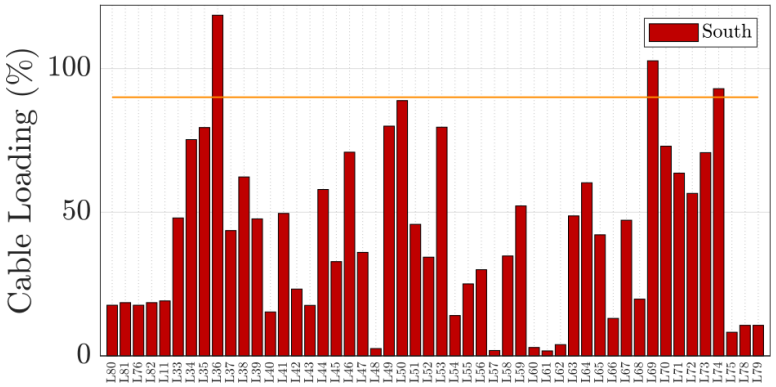


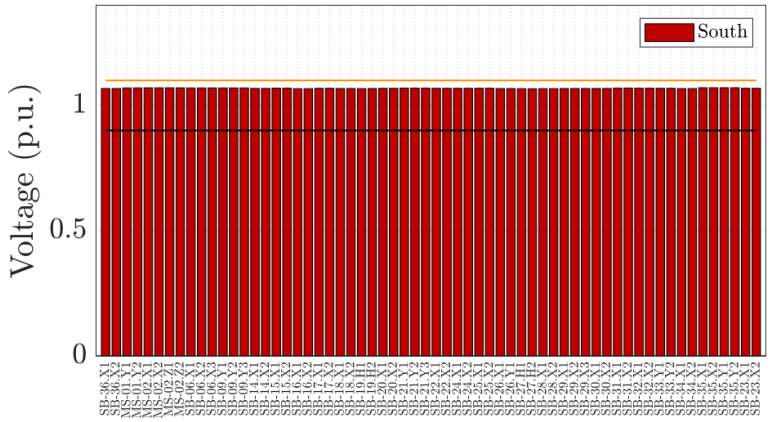
- Projection of the Peak Load for the next years ≈ 2500 MVA
  - Critical situation – not only overloaded cables, but also…..

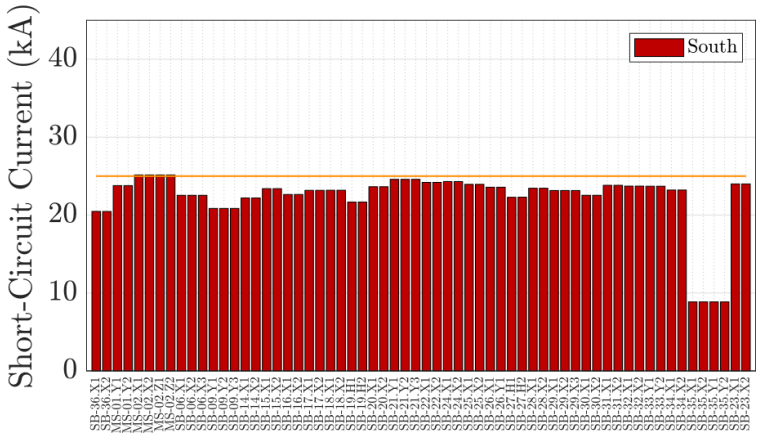






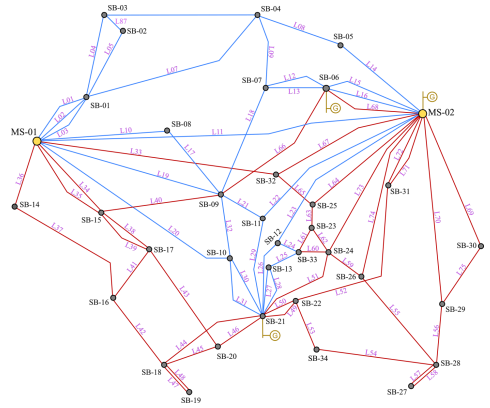






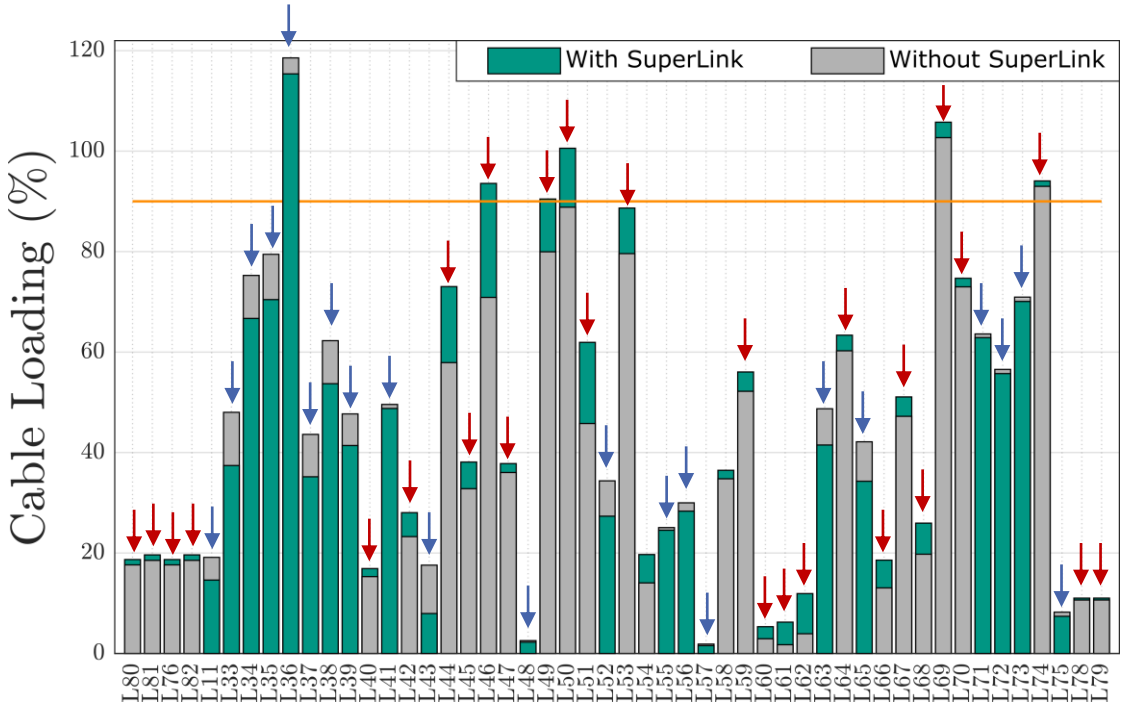
Munich 110 kV Network

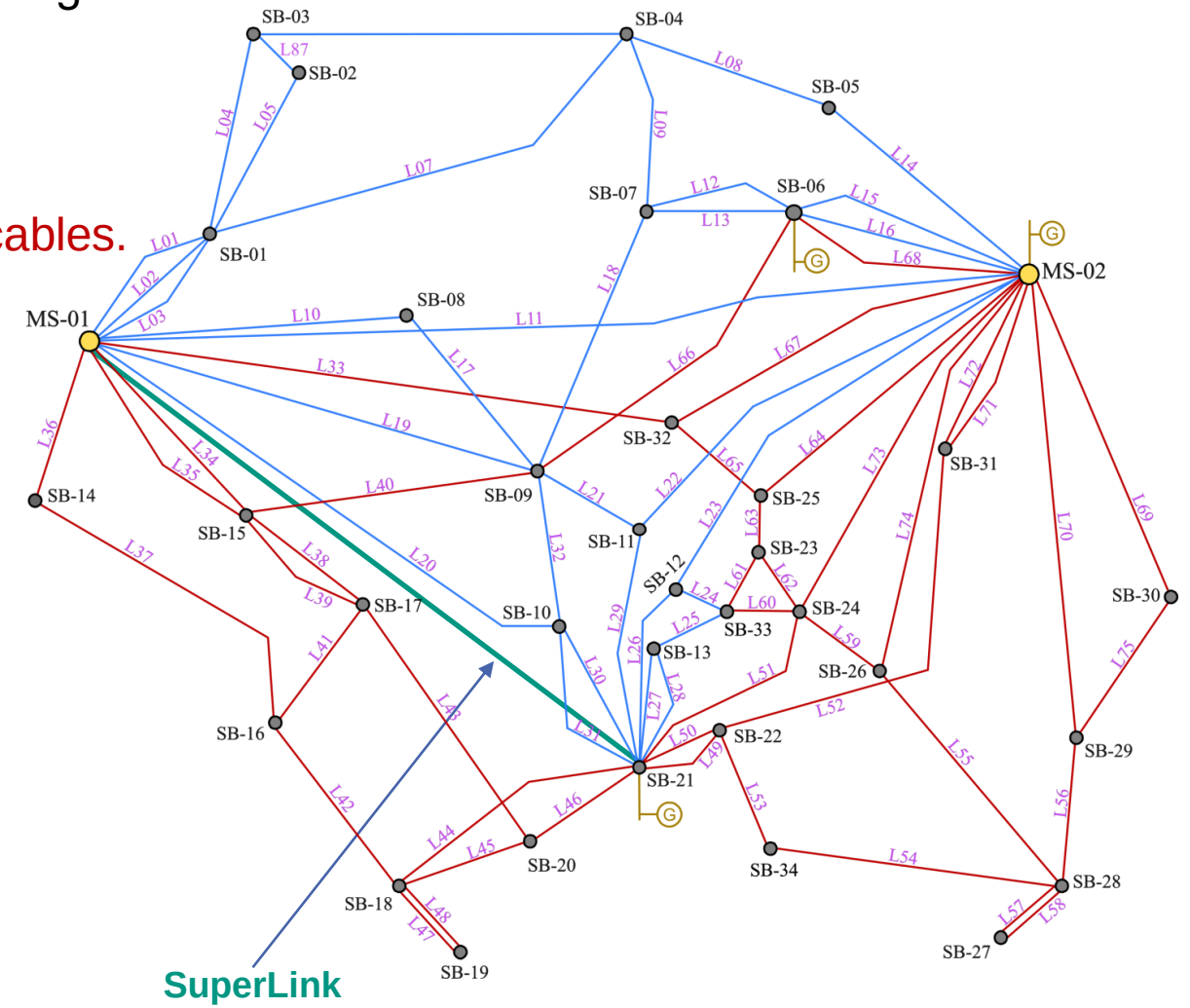
- Projection of the Peak Load for the next years ≈ 2500 MVA
- Besides the overloading of cables…
  - To supply such a high load, all the thermal power stations must be dispached
    - Not good from the economical point of view…
    - Not good from the ecological point of view…
- Network must be changed!



Munich 110 kV Network - Restructuring

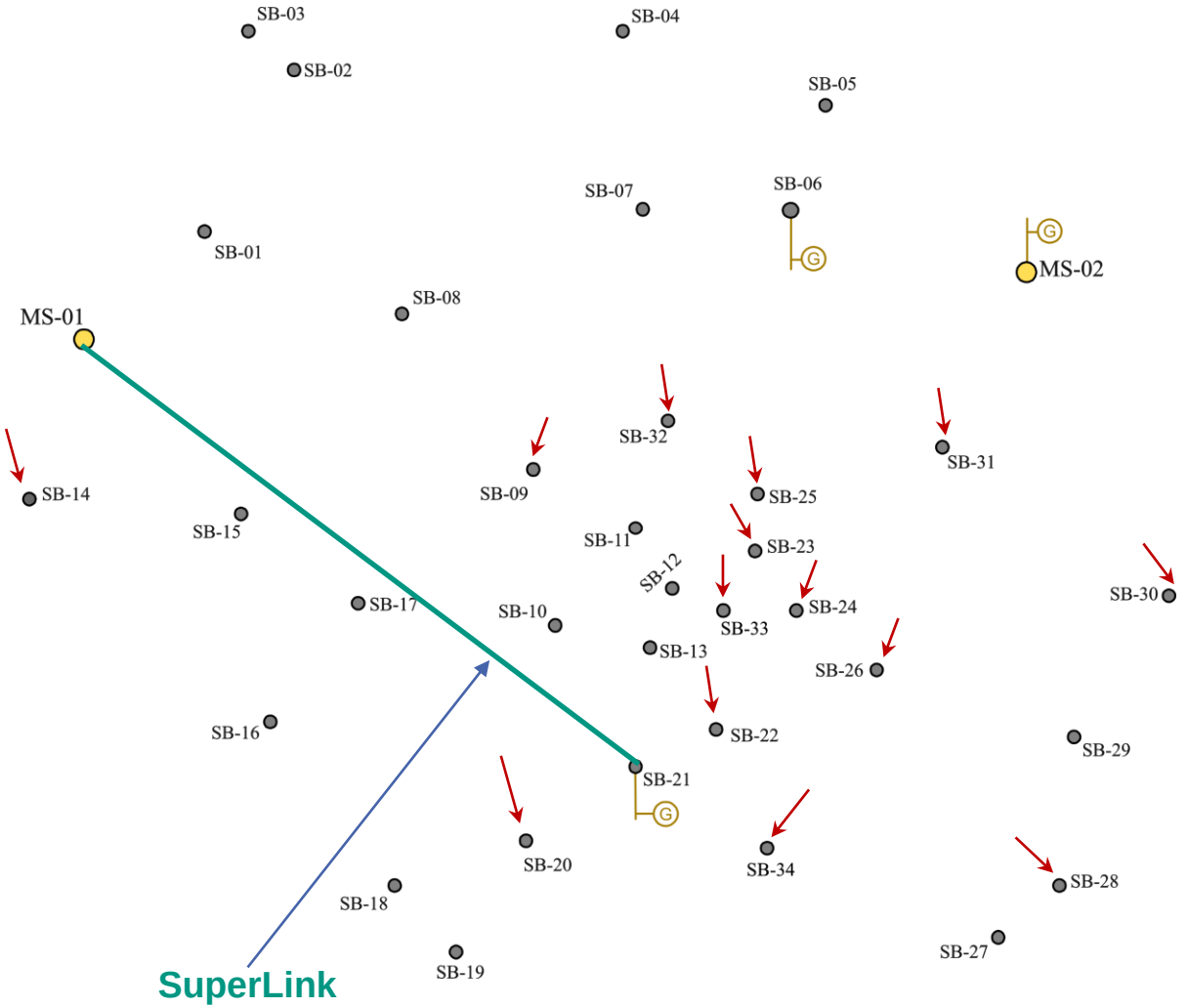
- Adding a superconducting connection to the high loaded grid will…
  - result on the relief of some overloaded cables.
  - But it will also result on the overloading of others cables.



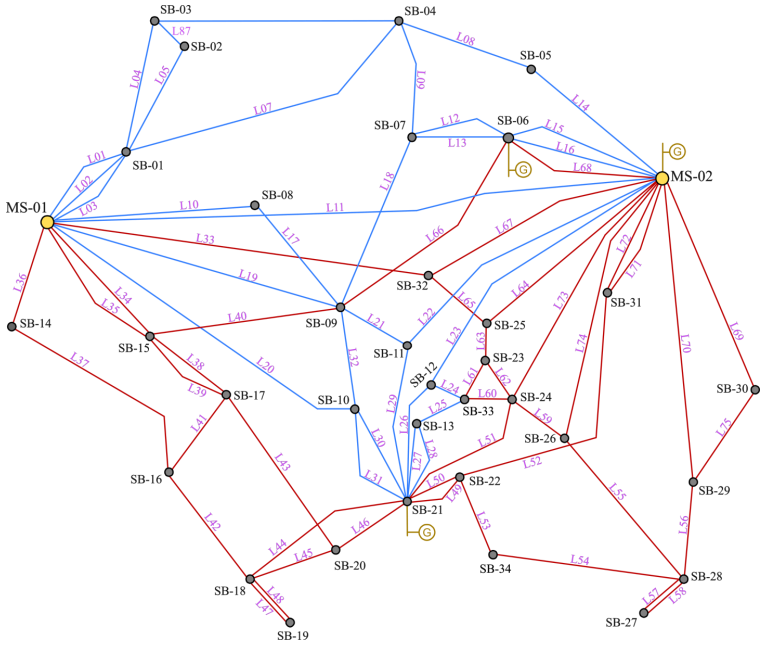


Munich 110 kV Network - Restructuring

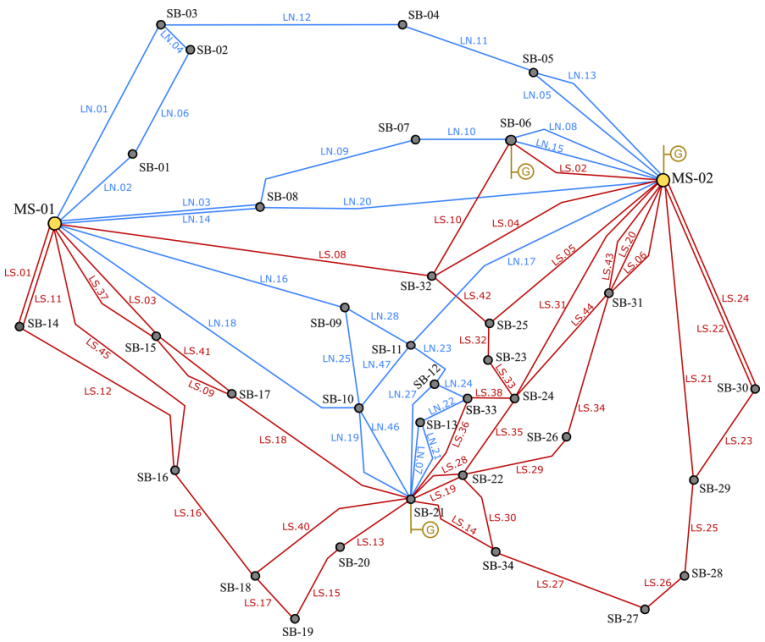
- Starting from scratch!
- Boundary Conditions:
  - Short-Circuit must remain < 25 kA
  - Minimize total lenght of cables
    - Try to use already available ducts
  - Cable cross section equal 500 mm^2 - (108 MVA, 0.565 kA)
  - Efficient power supply to dense loads (15 km)



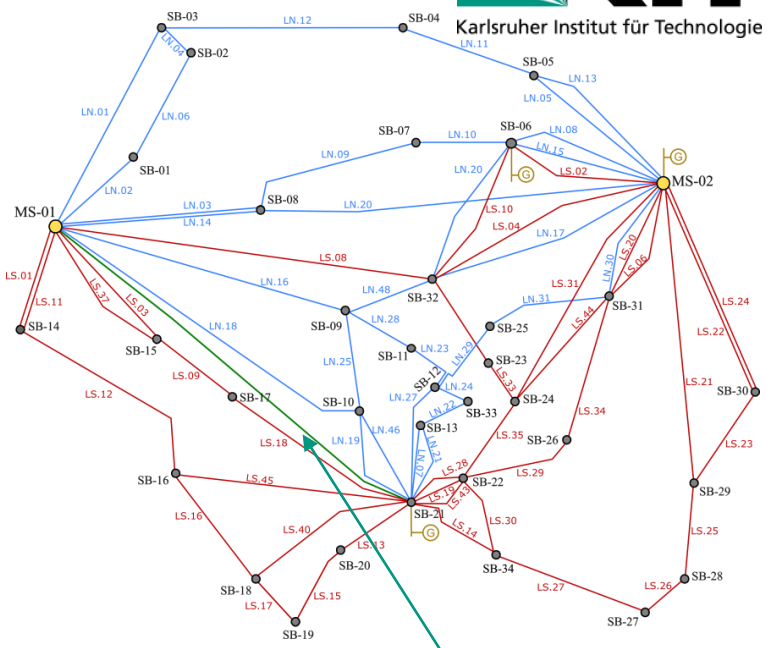
Munich 110 kV Network – Possible Designs



- **Net.00**
  - Current Network
  - 383 km
  - **No** HTS Cables



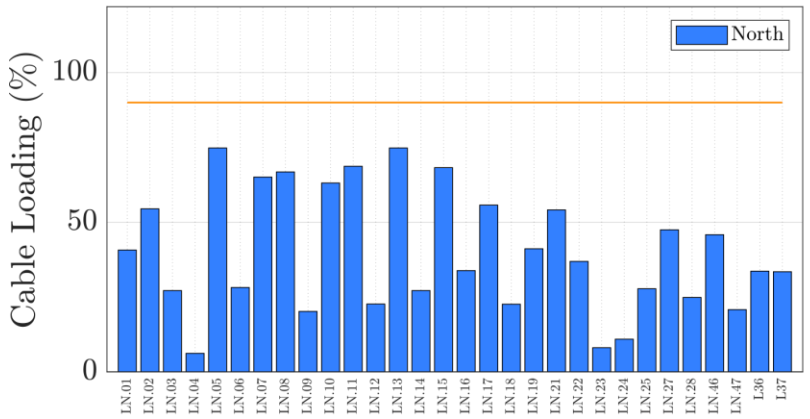
- **Net.01**
  - Optimized Grid
  - 339 km normal cables
  - **No** HTS Cables

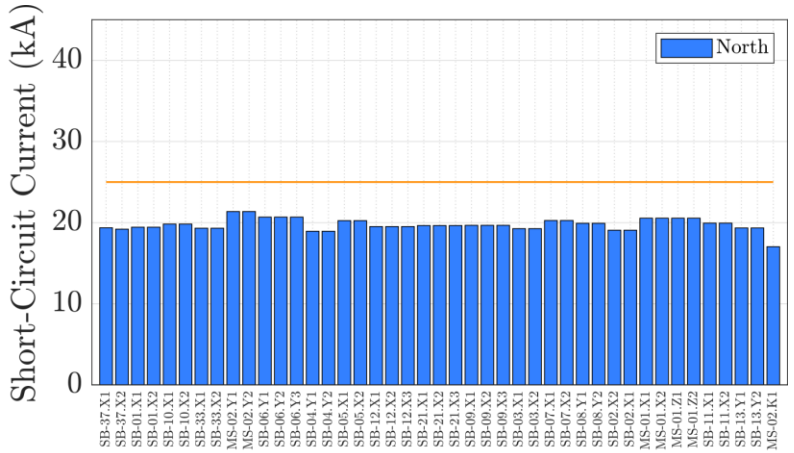


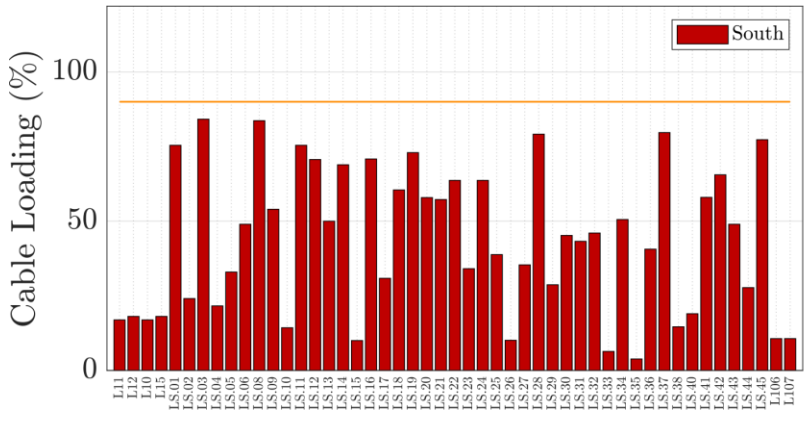
- **Net.02**
  - Optimized Grid with HTS
  - 316 km normal cables
  - 15 km HTS Cable **(SuperLink)**

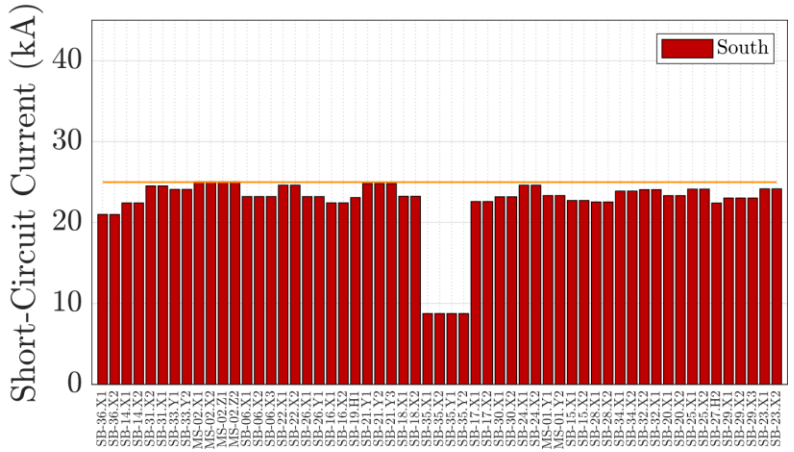
Munich 110 kV Network – Load Flow (2500 MVA)

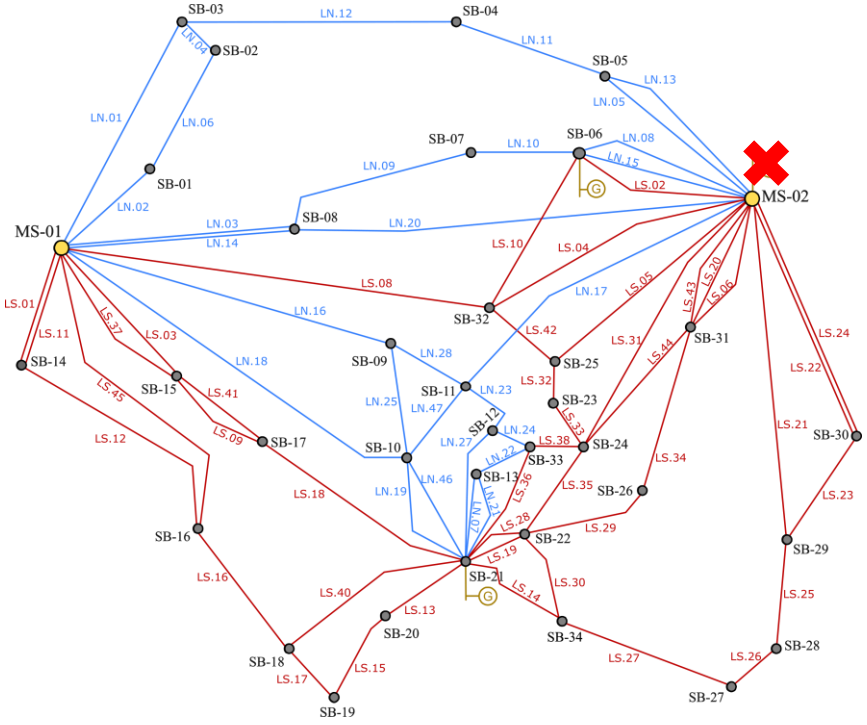
- **Net.01** – Optimized network **without** SuperLink (L_T = 339 km)







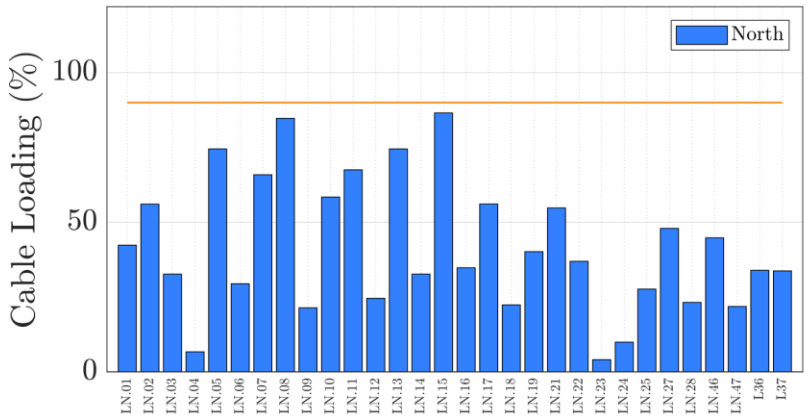


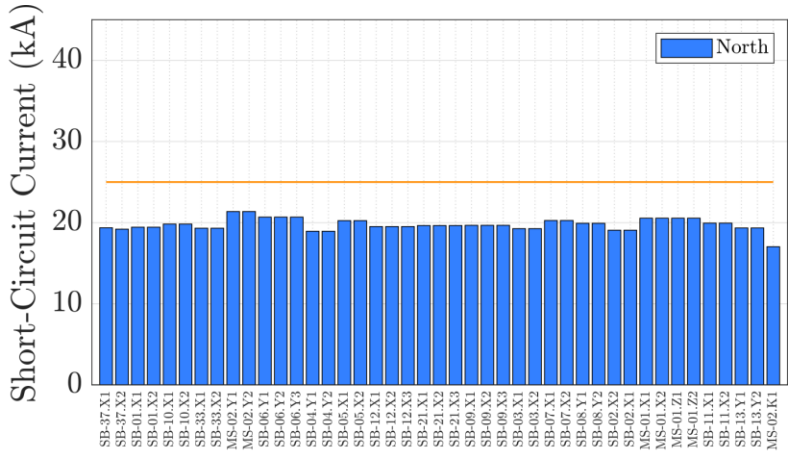


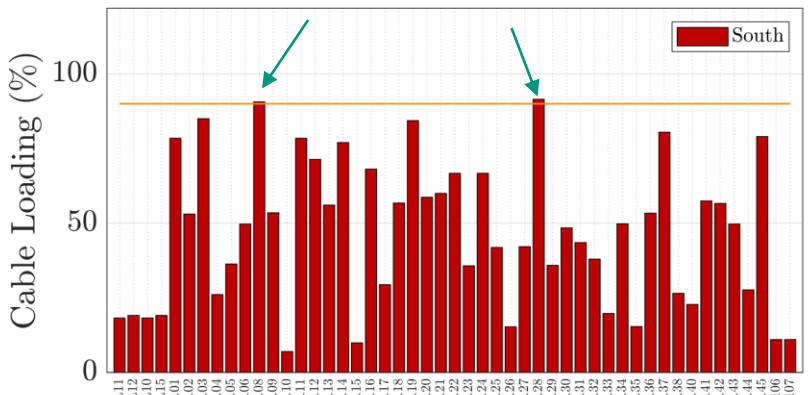
- Generators in MS-02 - offline
- Generators in SB-06 - online
- Generators in SB-21 - online

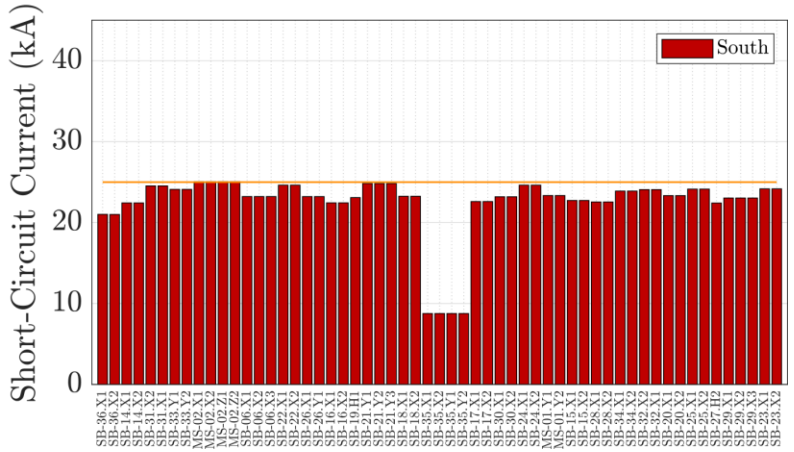
Munich 110 kV Network – Load Flow (2500 MVA)

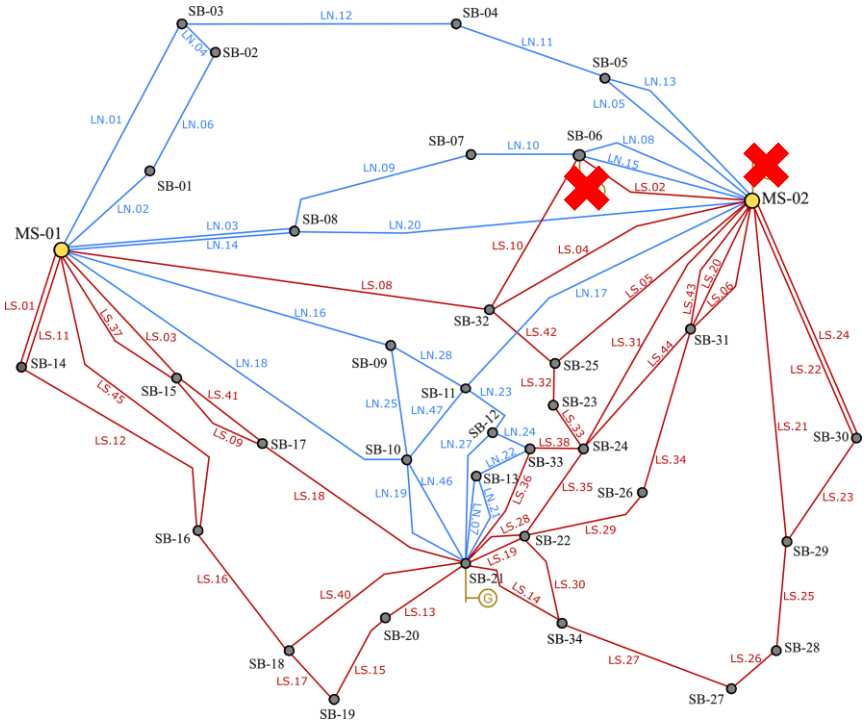
- **Net.01** – Optimized network **without** SuperLink (L_T = 339 km)







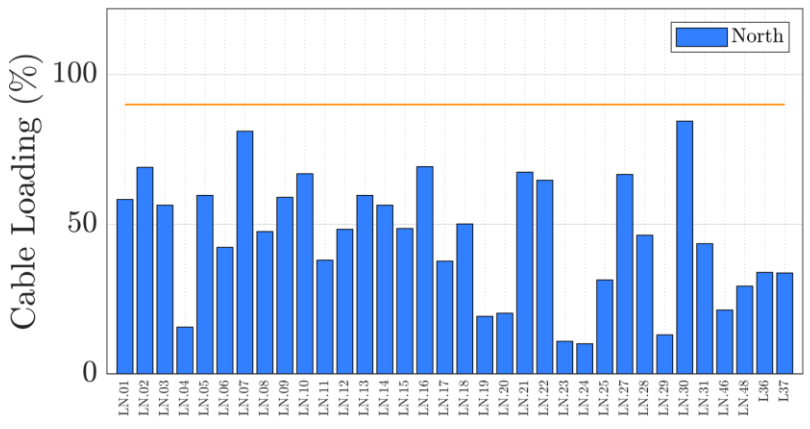


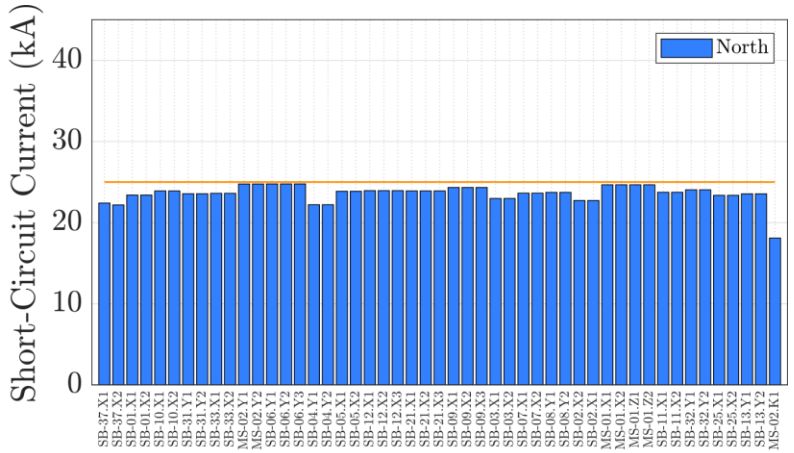


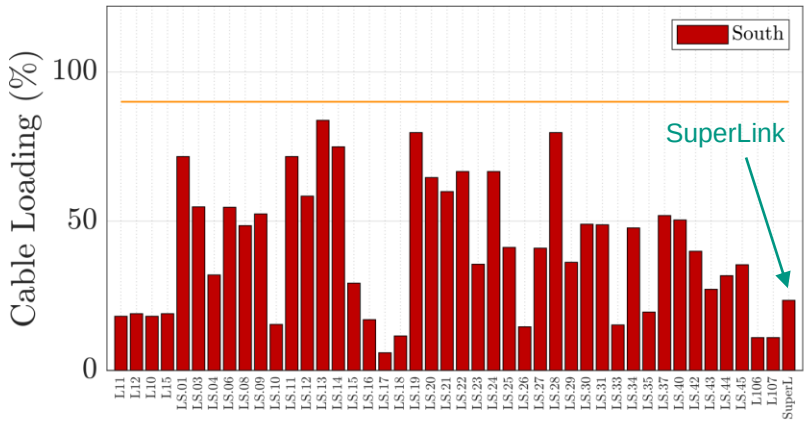
- Generators in MS-02 - offline
- Generators in SB-06 - offline
- Generators in SB-21 - online

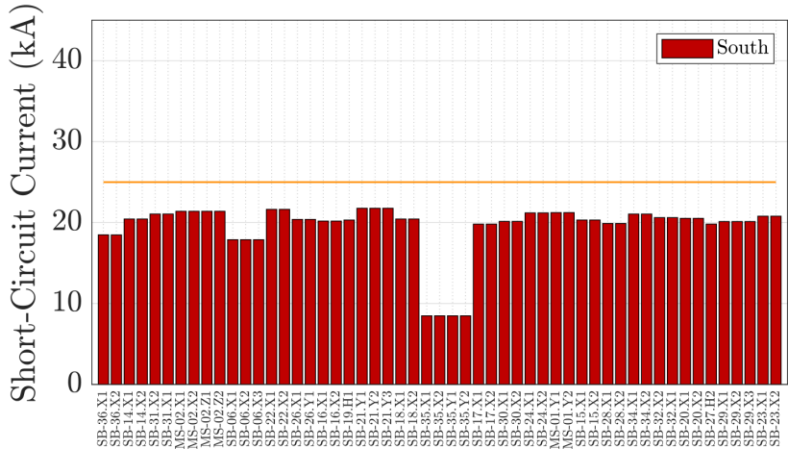
Munich 110 kV Network – Load Flow (2500 MVA)

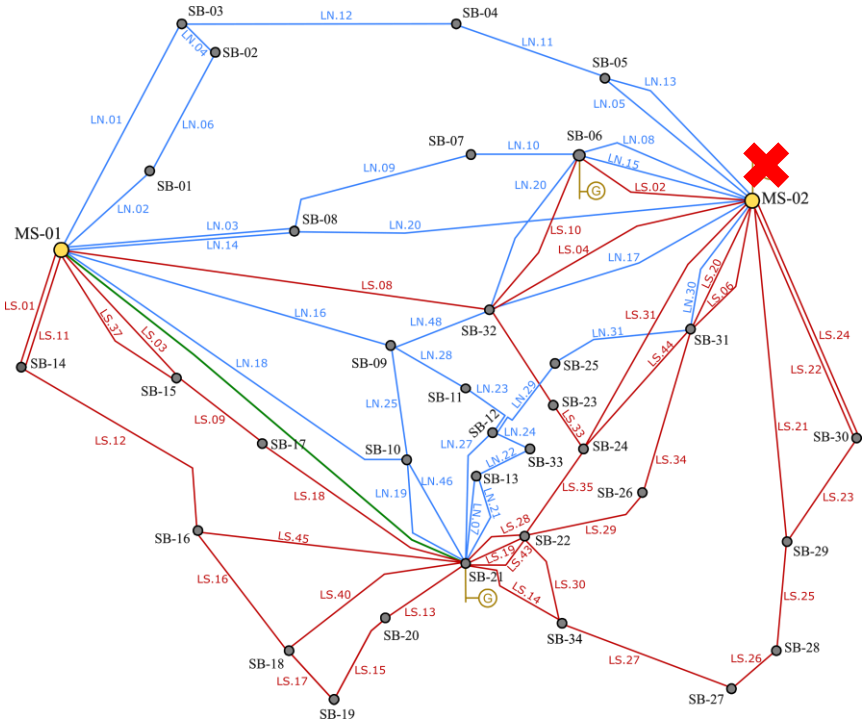
- **Net.02** – Optimized network **with** SuperLink (L_T = 331 km)







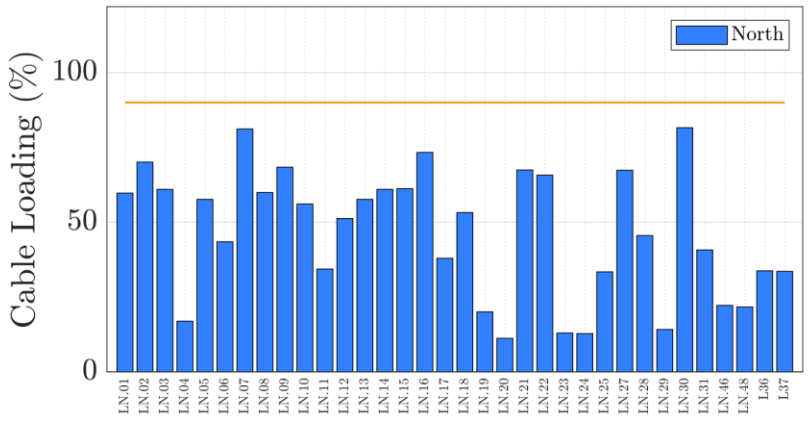


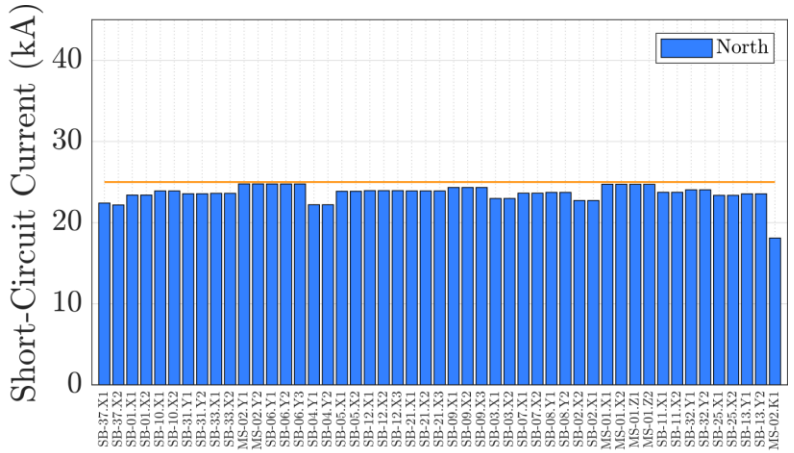


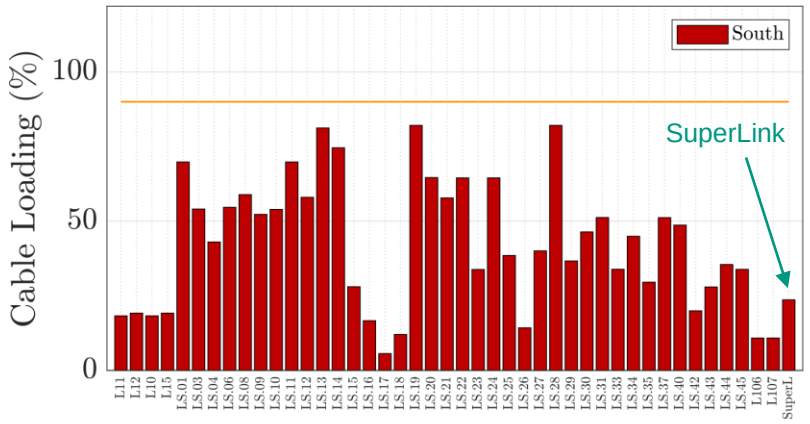
- Generators in MS-02 - offline
- Generators in SB-06 - online
- Generators in SB-21 - online

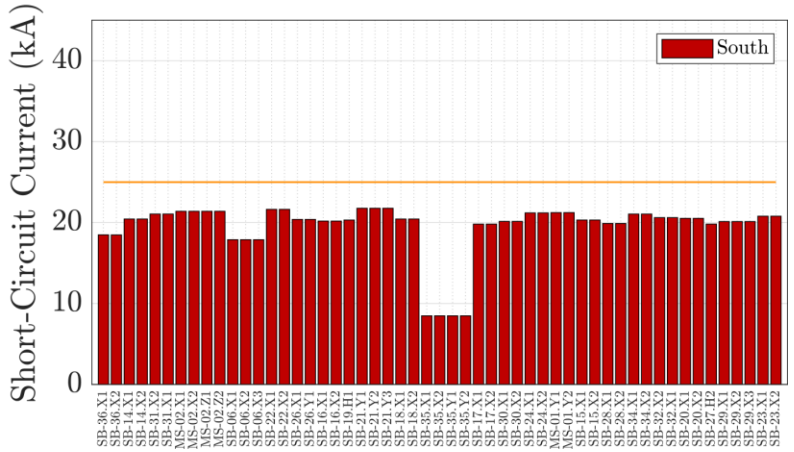
Munich 110 kV Network – Load Flow (2500 MVA)

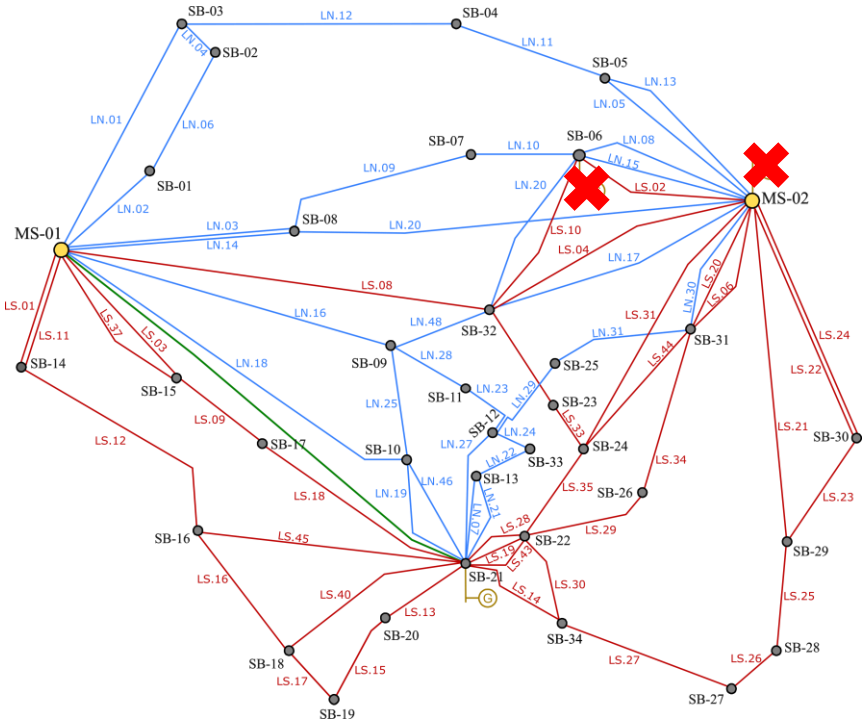
- **Net.02** – Optimized network **with** SuperLink (L_T = 331 km)







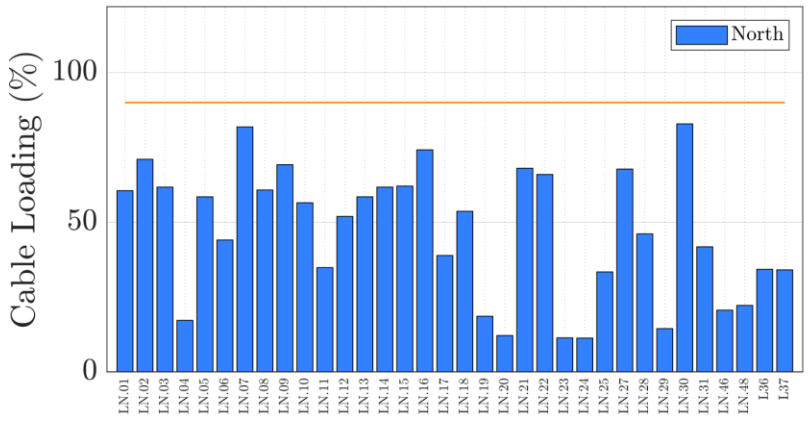


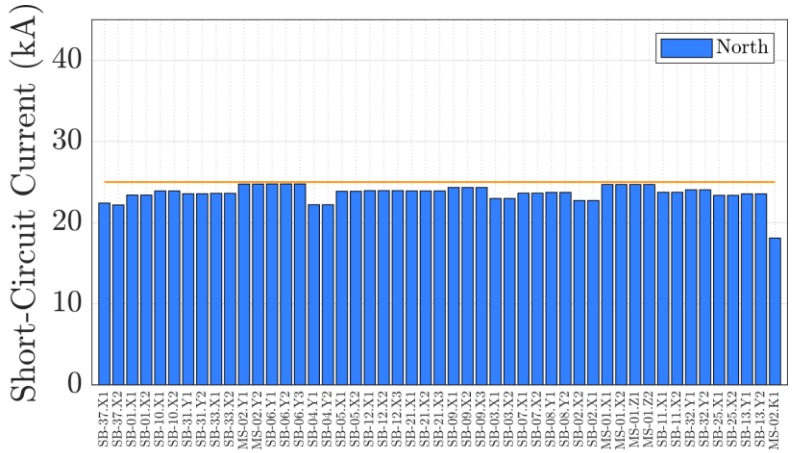


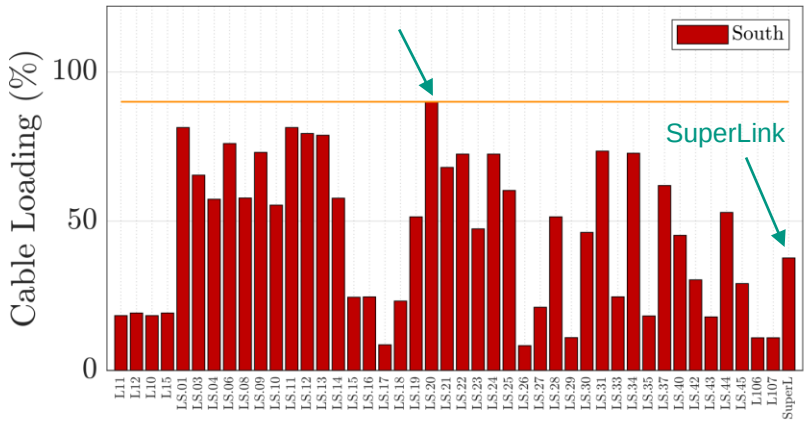
- Generators in MS-02 - offline
- Generators in SB-06 - offline
- Generators in SB-21 - online

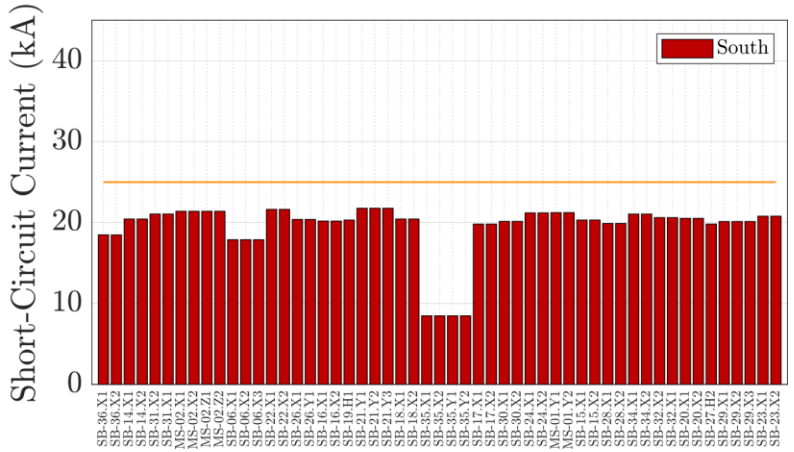
Munich 110 kV Network – Load Flow (2500 MVA)

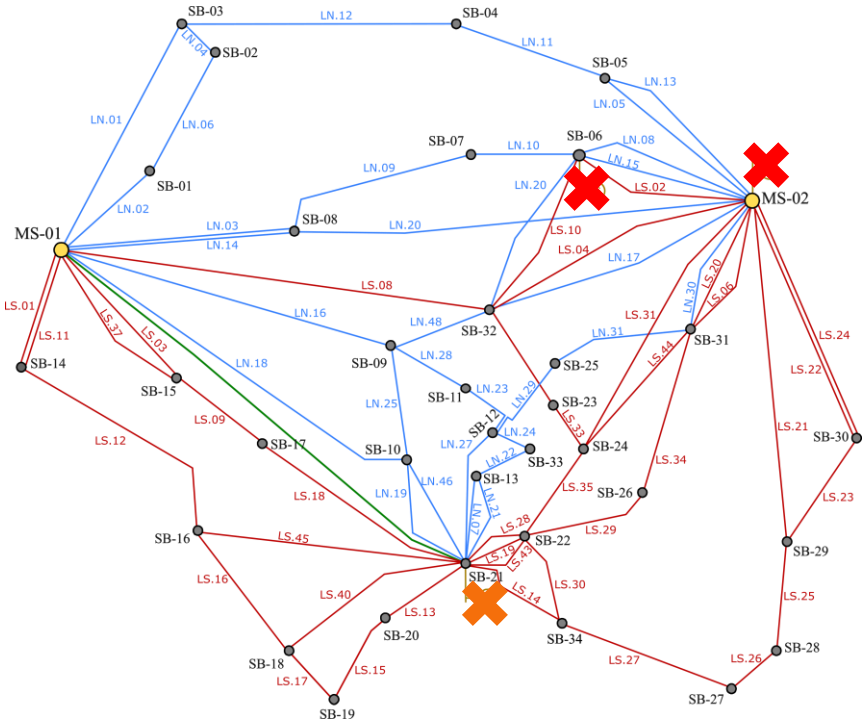
- **Net.02** – Optimized network **with** SuperLink (L_T = 331 km)









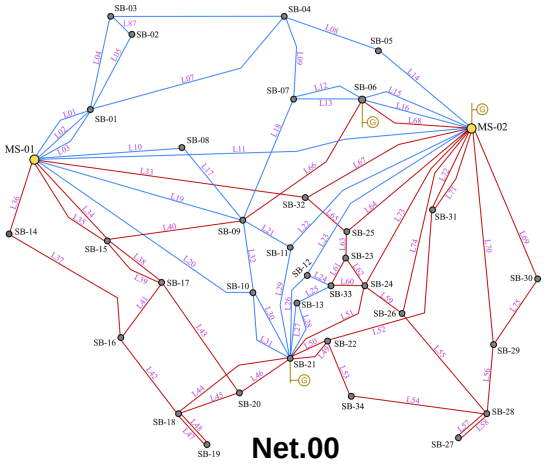


- Generators in MS-02 - offline
- Generators in SB-06 - offline
- Generators in SB-21 – at 65%

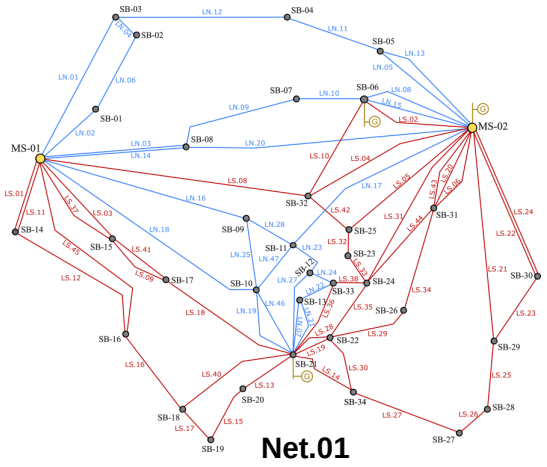
Munich 110 kV Network – Load Flow Outcome

- Main Outcomes for the load scenario 2500 MVA

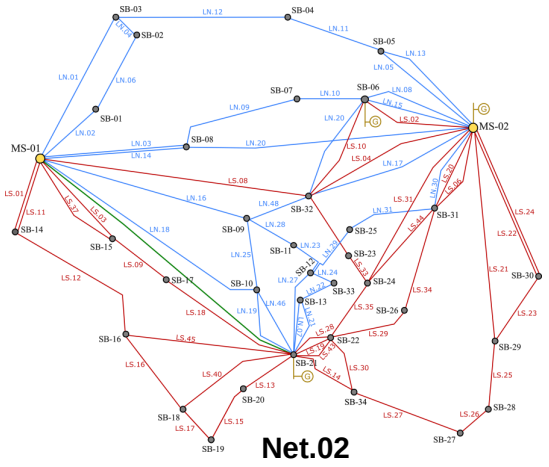
Grid	Description	Out of service			L_N	L_{HTS}	L_T
		MS-02	SB-06	SB-21 at 65%			
Net.00	Current 110 KV Network	☹	☹	☹	373 km	0 km	373 km
Net.01	Optimized grid without SuperLink	☺	☹	☹	339 km	0 km	339 km
Net.02	Optimized grid with SuperLink	☺	☺	☺	316 km	15 km	331 km



Net.00



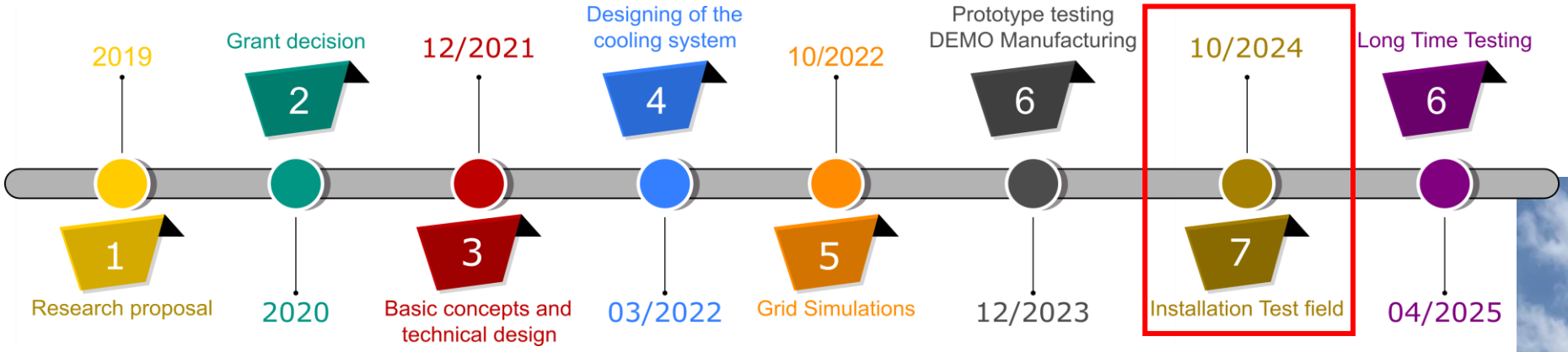
Net.01

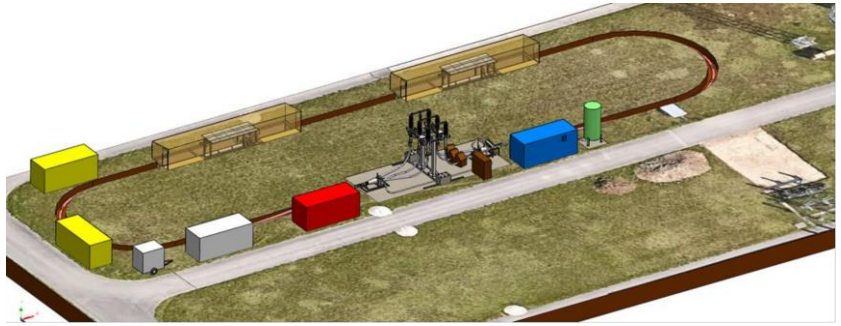


Net.02

- L_N = length of normal cables
- L_{HTS} = length of the HTS cable
- L_T = Total length

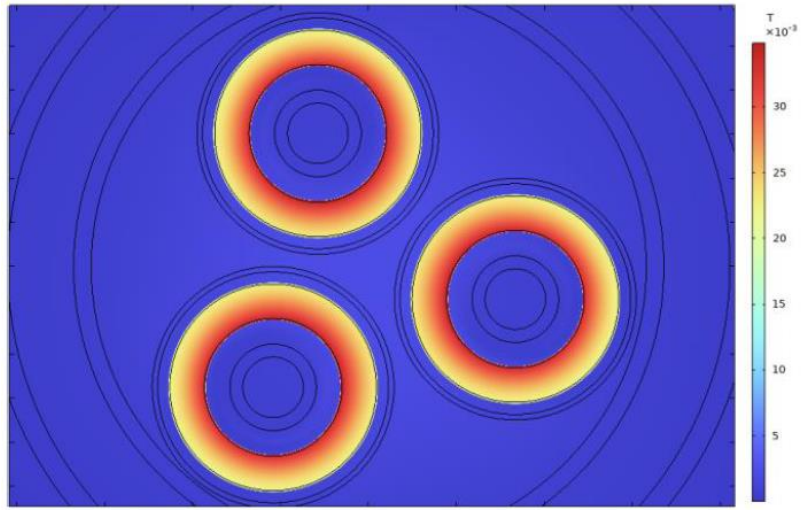
SuperLink Project – Current Status



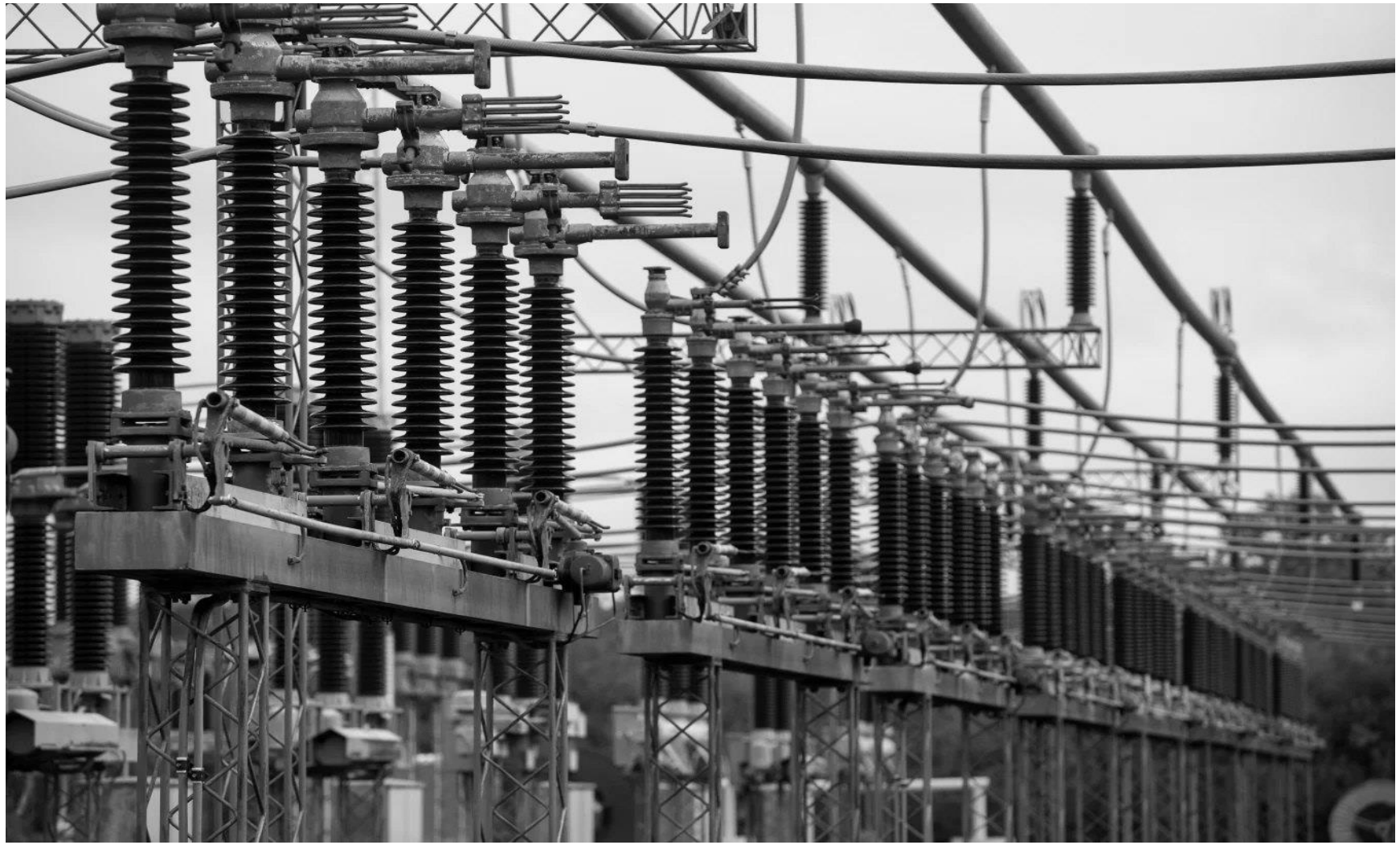


Summary

- The integration of the SuperLink cable combined with a network optimization appears as an attractive solution for future high loaded grids
- Without SuperLink, the grid still remains very dependent on the thermal power plants
- Grid optimization and total cable length reduction can be further investigated if more superconducting cables comes into consideration
- Network remains stable
  - No increase on fault current levels



Thank you very much for your attention!



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SuperLink

Questions?

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SuperLink

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