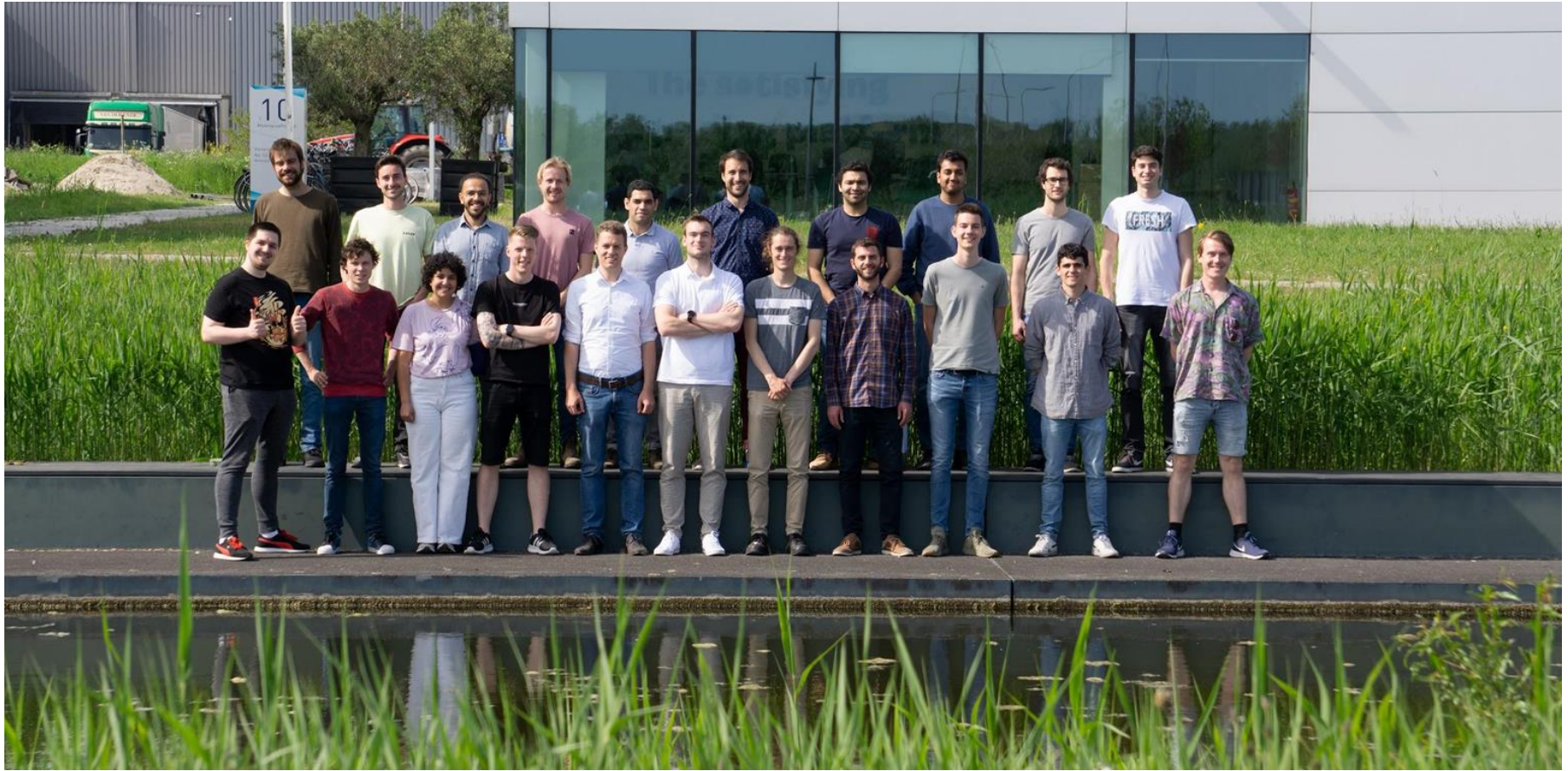


Power Capacity of DC Public Lighting Grids

22/09/2022

The Green Village, Delft
Dr. Laurens Mackay



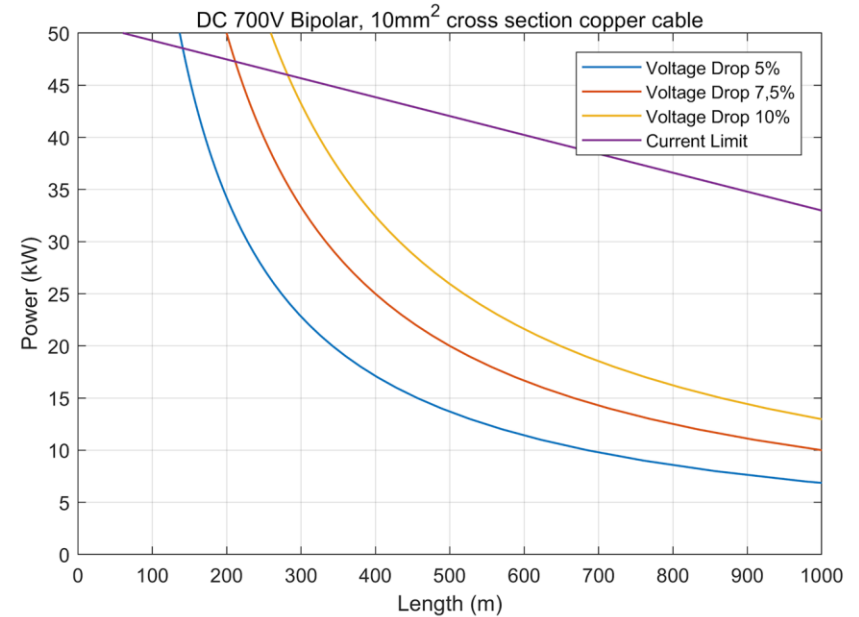
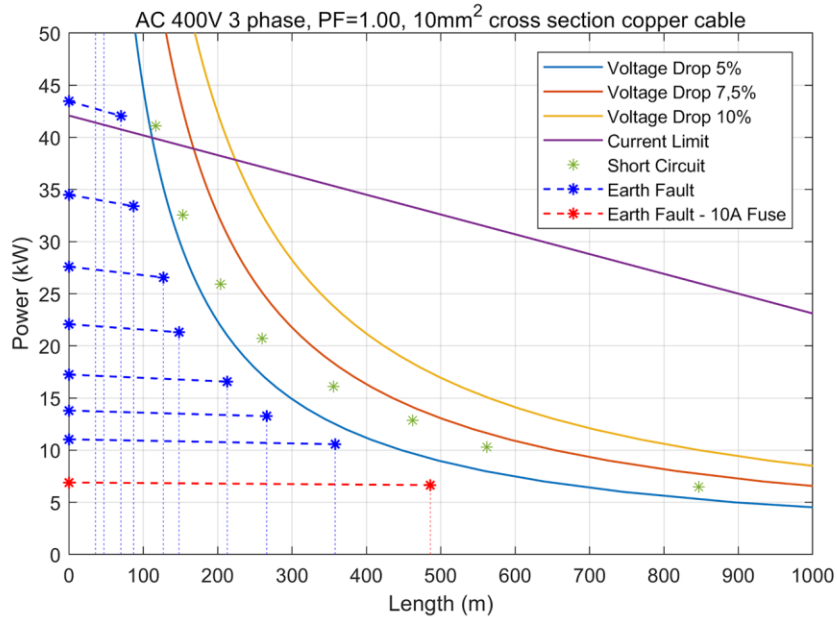
Case Study Zoetermeer

- What can we do with the public lighting infrastructure?
- 50 year old cables in the ground
- Energy Transition
- DC

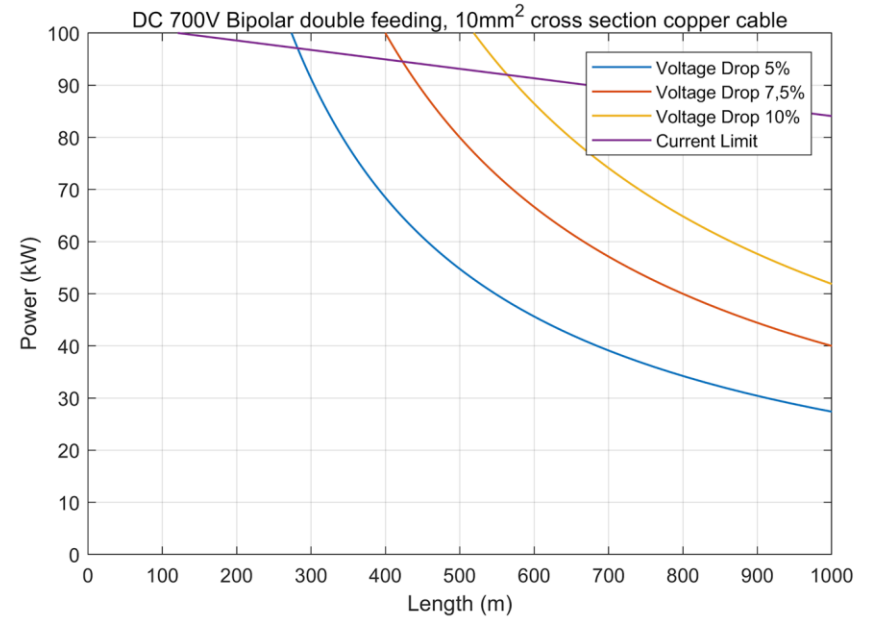
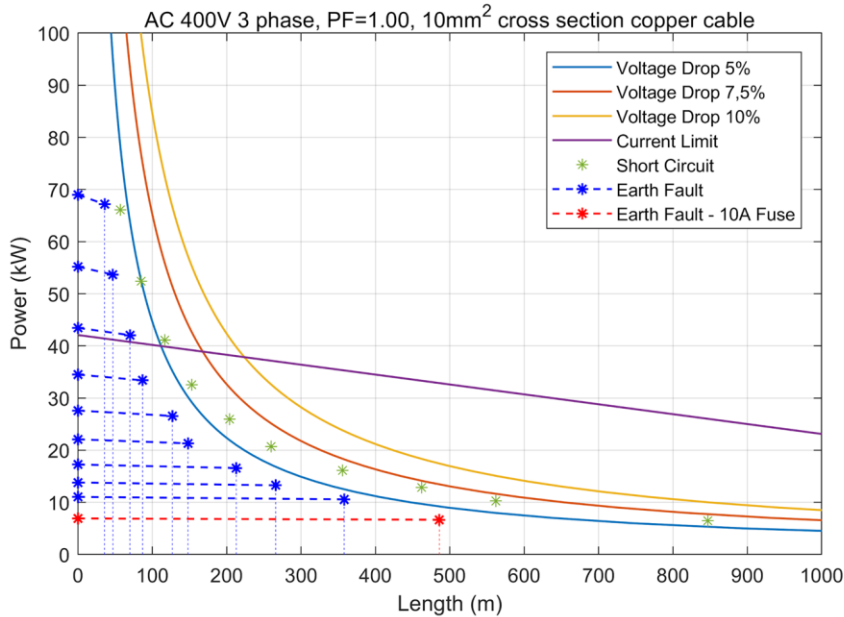


Comparison for 10mm² cross section copper cables

Three phase 400V AC and 700V bipolar DC



Comparison for 10mm² copper cables Single side fed, 3 phase 400V AC and two side fed 700V DC





Box: G6A1
Supplied Power: 189 kW
Voltage Level: 750 V

Box: G5B2
Supplied Power: 189 kW
Voltage Level: 750 V

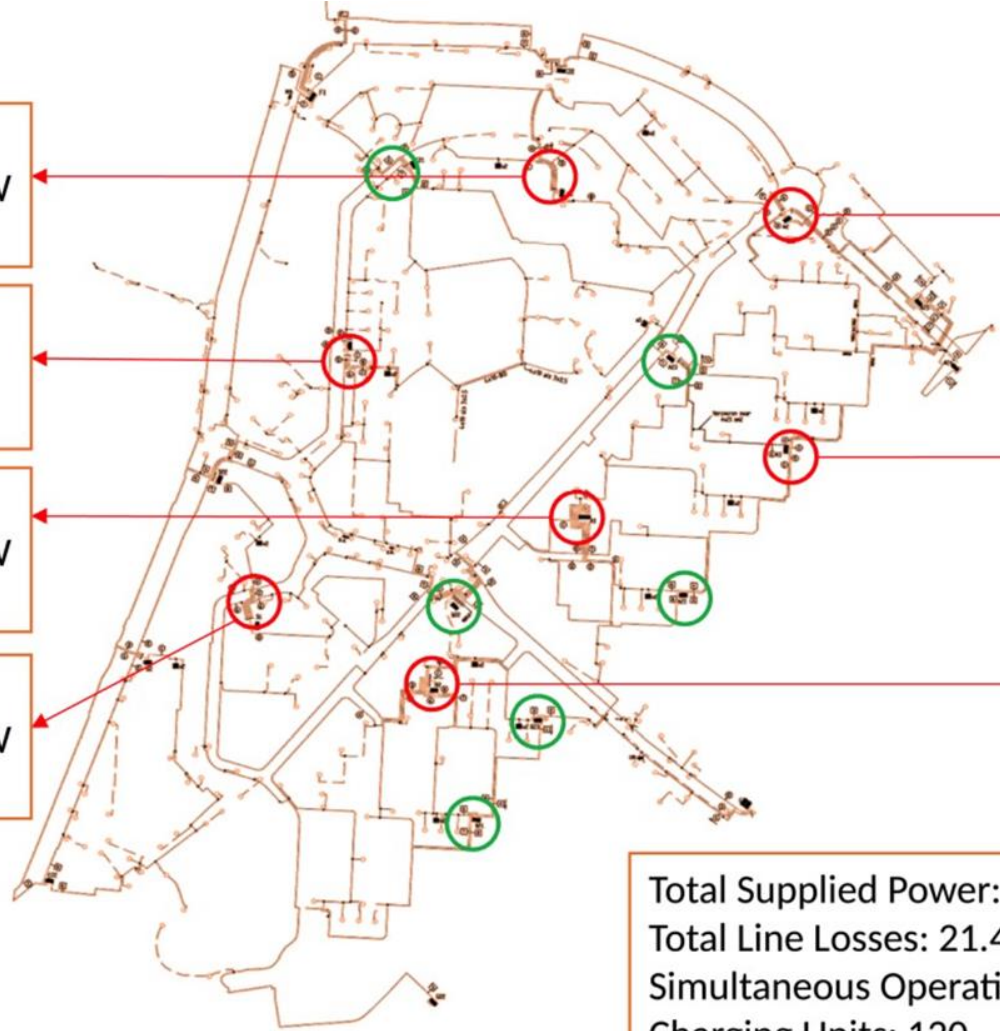
Box: G6C1
Supplied Power: 330 kW
Voltage Level: 750 V

Box: G5D1
Supplied Power: 141 kW
Voltage Level: 750 V

Box: G6A2
Supplied Power: 95 kW
Voltage Level: 750 V

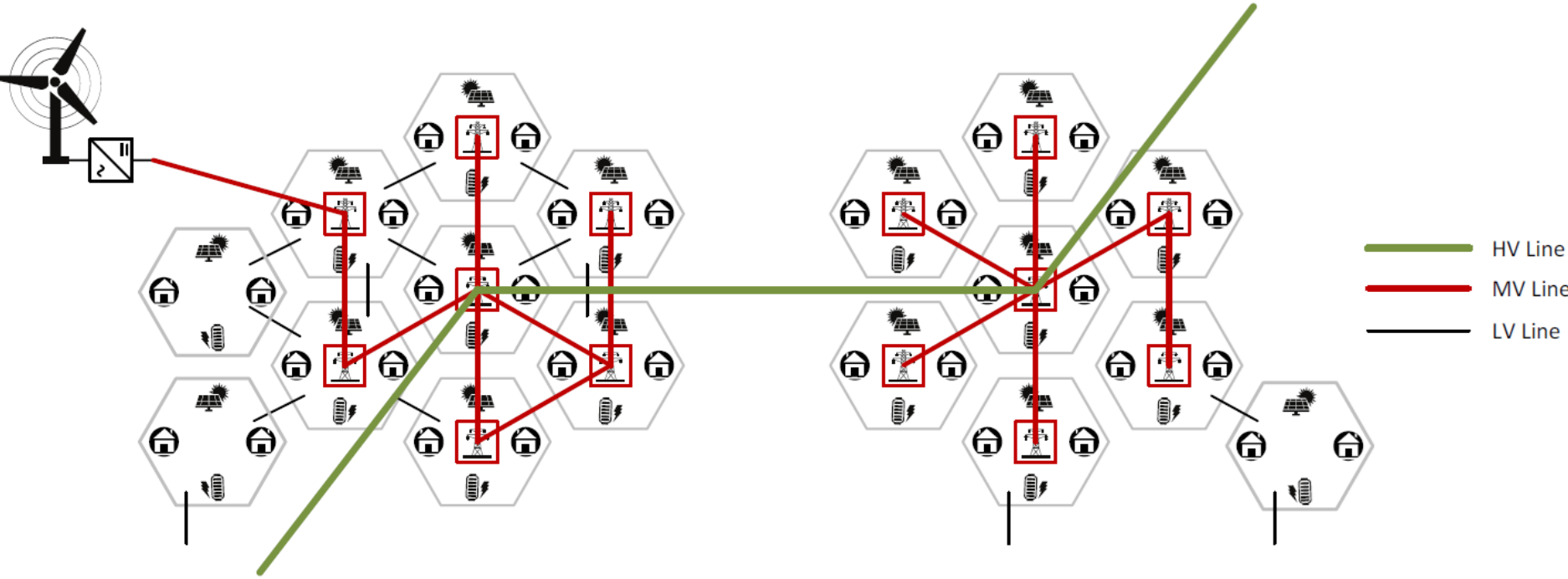
Box: G6A3
Supplied Power: 141 kW
Voltage Level: 750 V

Box: G6C2
Supplied Power: 330 kW
Voltage Level: 750 V



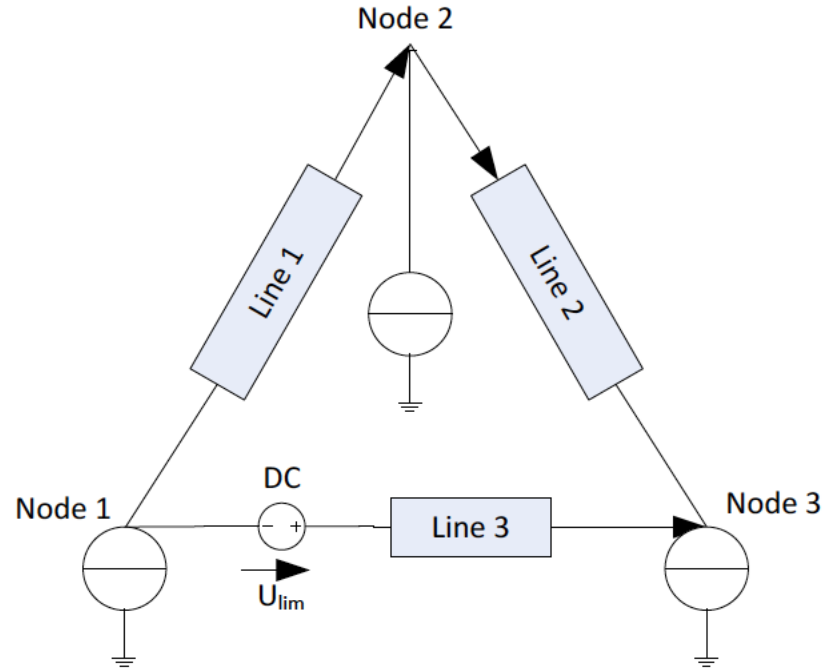
Total Supplied Power: 1.4185 MW
Total Line Losses: 21.48 kW ($\approx 1.514\%$)
Simultaneous Operational 10kW Electric Vehicle
Charging Units: 120

Meshed DC Distribution Grid



Power Flow Control Converter

- Control line impedance
- Compensate voltage drop
- Partial power converter
 - Lower cost
 - Lower losses



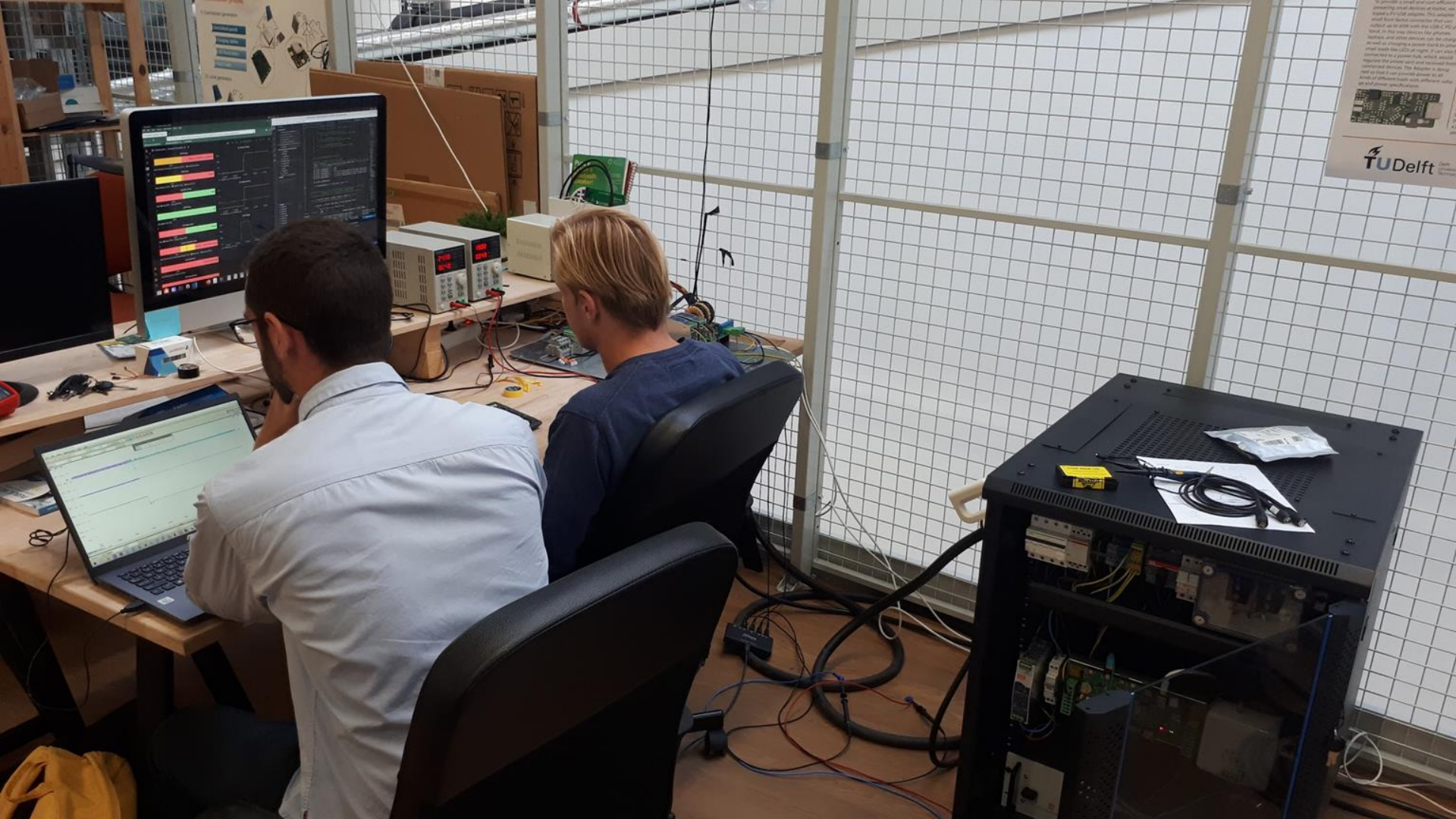
L. Mackay, T. Hailu, L. Ramirez-Elizondo, and P. Bauer, "Decentralized Current Limiting in Meshed DC Distribution Grids," in DC Microgrids, IEEE First International Conference on, 2015.

P. Purgat, L. Mackay, R. Adilardi Prakoso, L. Ramirez-Elizondo and P. Bauer, "Power flow control converter for meshed LVDC distribution grids," 2017 IEEE Second International Conference on DC Microgrids (ICDCM), Nuremberg, 2017

DC/DC V2G EV Charger

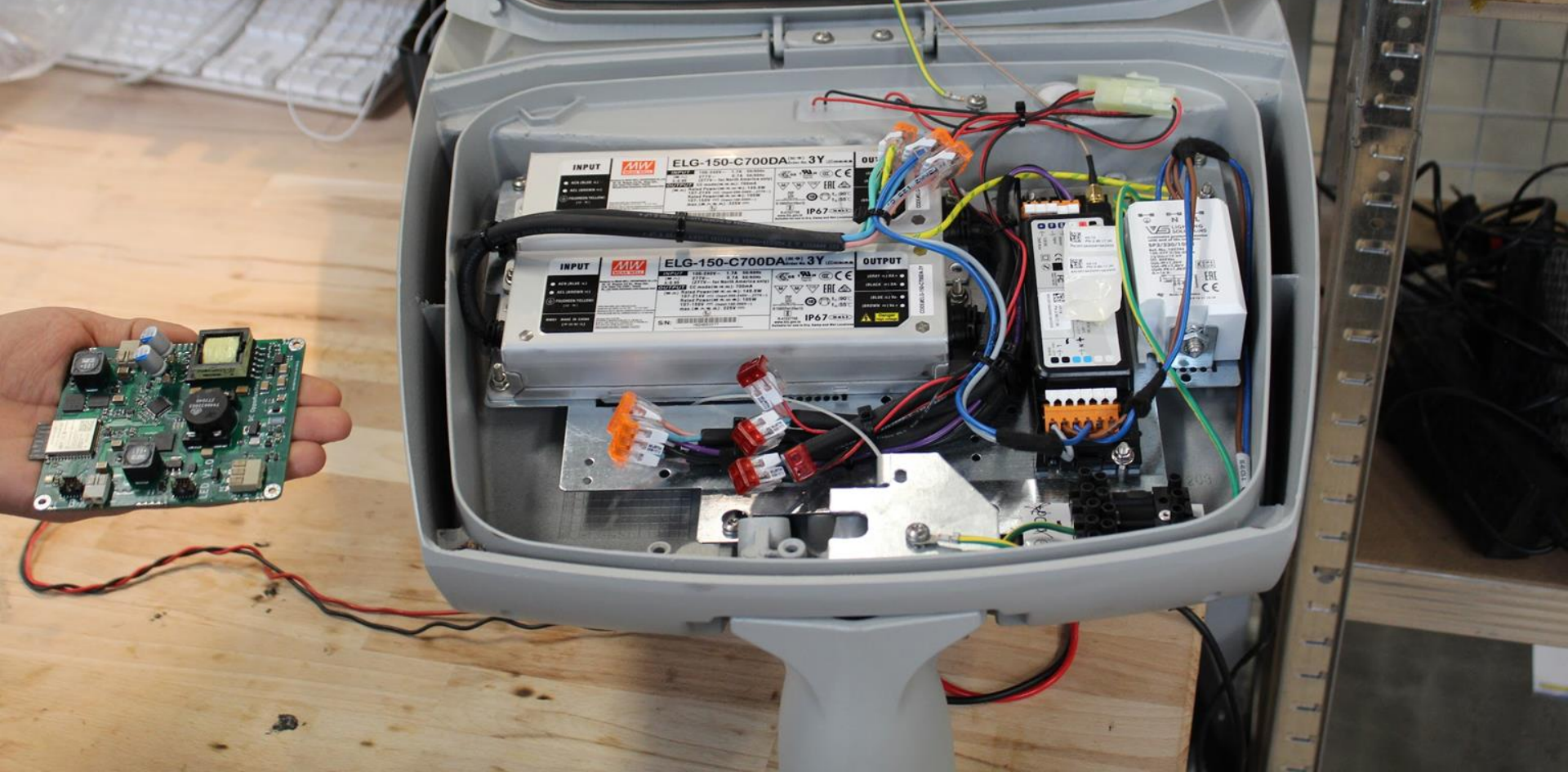
- 700V DC
- 2x 5.5kW or 1x 11kW
- V2G





For a small and low-cost, affordable, and portable, the proposed architecture is designed to be a low-cost solution. This solution is based on the use of the USB-C PD protocol, which allows for the use of a single cable for both power and data. As well as integrating a power bank, the proposed architecture can be used to power a wide range of devices, including smartphones, tablets, and laptops. The architecture is designed to be a low-cost solution, and is based on the use of the USB-C PD protocol. The architecture is designed to be a low-cost solution, and is based on the use of the USB-C PD protocol.

TU Delft





50% Warm vs Added Cold White at 100% Power



Low Short-Circuit Current Protection Philosophy for DC Distribution Grids

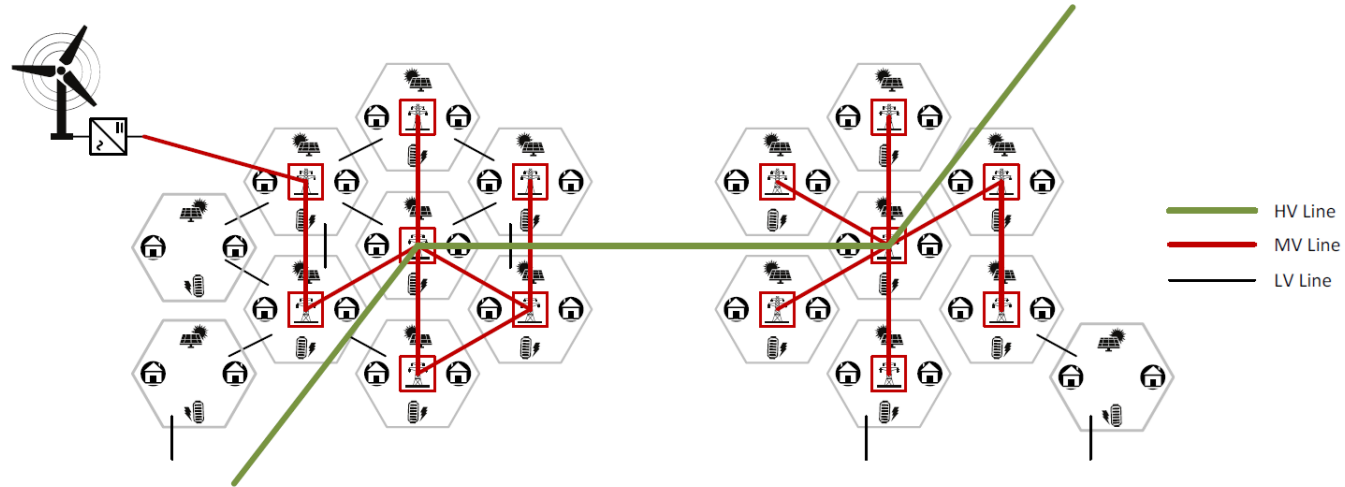
1. Avoid oversizing of converters and capacitors by not requiring high short-circuit current capability for fault detection.
2. Prevent high short-circuit currents if capability is available, e.g., fast fault clearance.
3. Adapt system and component design to allow the realization of the previous.

Over Current Protection

- Bidirectional Power Flow
- Not time critical if not too high (i^2t)
- Congestion Management
- Dynamic Overloading

Protection of Meshed DC Distribution Grids

- Bidirectional power flow
- Selectivity
- Clear short circuit faults on transient
- Islanding
- Solid State Protection for Bipolar Grids





Street-Lights
Line

Light Pole
No 3

Long Line

Short Line

HUBBARD
STATION

Conclusion

- Using DC allows for better usage of existing infrastructure
- Capacity increase is especially high in long lines
 - Where capacity in AC was limited by protection constraints
 - Earth fault time
 - Short circuit current
- Electric Vehicle charging on DC street lighting poles
 - Overnight charging in residential areas
 - On every street lighting pole
 - Could be used to cover up to 50% of parking lots along sides of street
 - 2 cars per pole and 2 cars in between not able to connect