

Heat dissipation of high voltage cable systems – A technical and agricultural study

**RGI Workshop: The role of grid infrastructure in delivering the objectives of
the National Energy and Climate Plans (NECPs)**

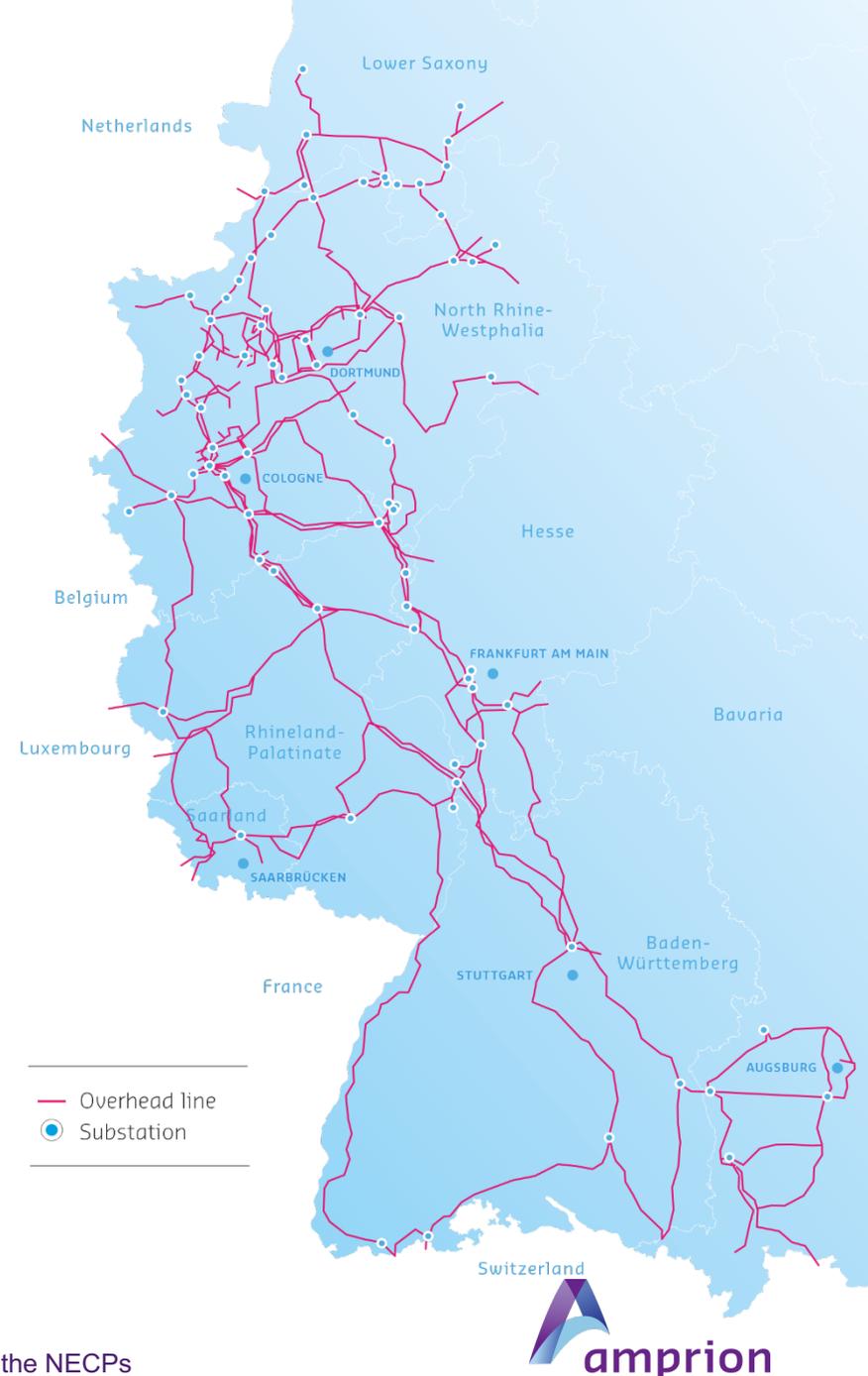
Jan Brüggmann, 29. October 2019, Rome



Our power grid – lifelines of the economy

A stable power grid provides the basis for a secure supply of energy and a strong, efficient economy. Responsibility for the high-voltage grid in Germany rests with four transmission system operators. Amprion is one of them.

Amprion GmbH is based in Dortmund. Our high-voltage grid transports the power for almost 29 million people in an area from Lower Saxony to the Alps.



Amprion in figures

29

MILLION PEOPLE

live in Amprion's grid area.

11,000

KILOMETRES

is the length of Amprion's transmission network.

~170

TERAWATT HOURS

of power were transported by Amprion in 2018.

63

GIGAWATTS

is the total capacity of all power stations in the Amprion grid area.

160

SUBSTATIONS

connect the Amprion grid with the downstream distribution system operators.

Motivation

- Amprion is in charge to build several new cable connections.
- Bedding materials have a crucial impact on the current rating.
- Beside sand, several new bedding materials are available, but there is a lack of experience!
- For qualifying these new bedding materials, a field experiment was launched.
- The applied bedding materials were chosen with respect to their performance as well as their acceptance by authorities.
- Additionally: Gain insight in the influence of the cable system on soil used for agricultural purposes

Opportunity: Use of a new build cable connection in a substation for agricultural and thermal experiments!

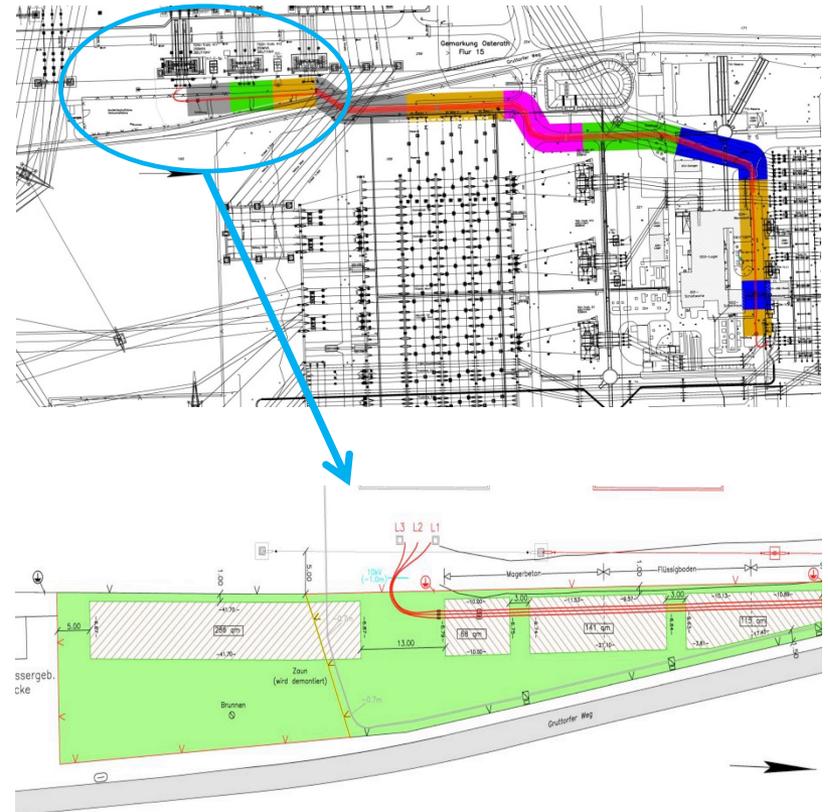
Cable system for test setup

- Three 380 kV / 110 kV transformer connections
- 110 kV cable systems with segmental conductors (2000 mm² copper, nominal current 1312 A, 3 systems)
- **Laying depth: 1.4 m**
- Partial drying is considered
- Need for artificial heating circuit
- Built in 2011, commercial operation since 2013



Test setup

- Route length: 460 m
- Bedding heights 0.5 m and 0.8 m
- Applied Bedding materials:
 - Sand (grain size 0-4 mm)
 - Weak concrete
 - Fluidized Backfill
 - Gravel (0-8mm) with bentonite
 - Thermally improved concrete
- Three agricultural plots



Agricultural experiments

- Crops: potatoes, catch crop (mustard), corn, winter wheat, rape, winter barley
- Power losses of up to 210%
- Average application of fertilizer, fugitives and herbicides at
- Comparison to adjacent control plots
- Comparison to regional average values



Potatoes: Upper picture: control plot
Lower picture: experimental plot

Agricultural results

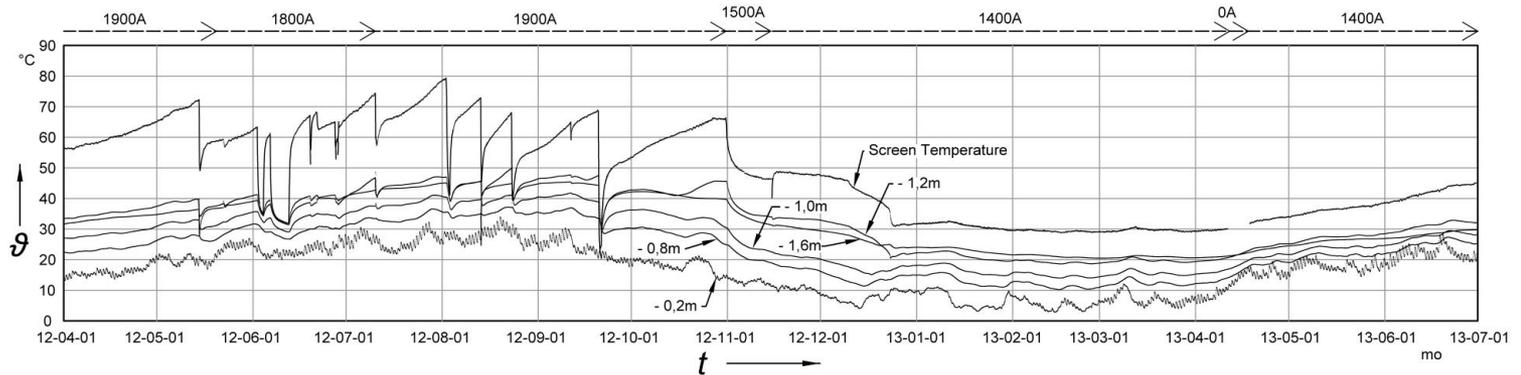
- Evaluation in rows
- Potatoes: higher yields on experimental plots, no deviation in quality
- Corn: Accelerated growth above the centre cable, yields from experimental plots are slight higher
- Other experiments conducted at lower currents: no thermal effects on yields



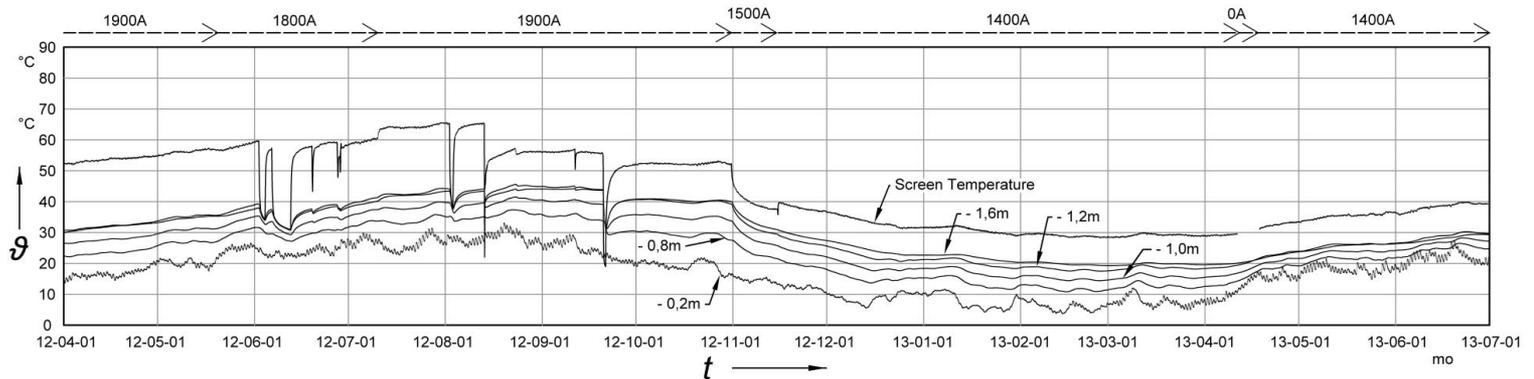
Corn: early maturity right above the centre cable at 210% power losses

Thermal results (1)

Sand:

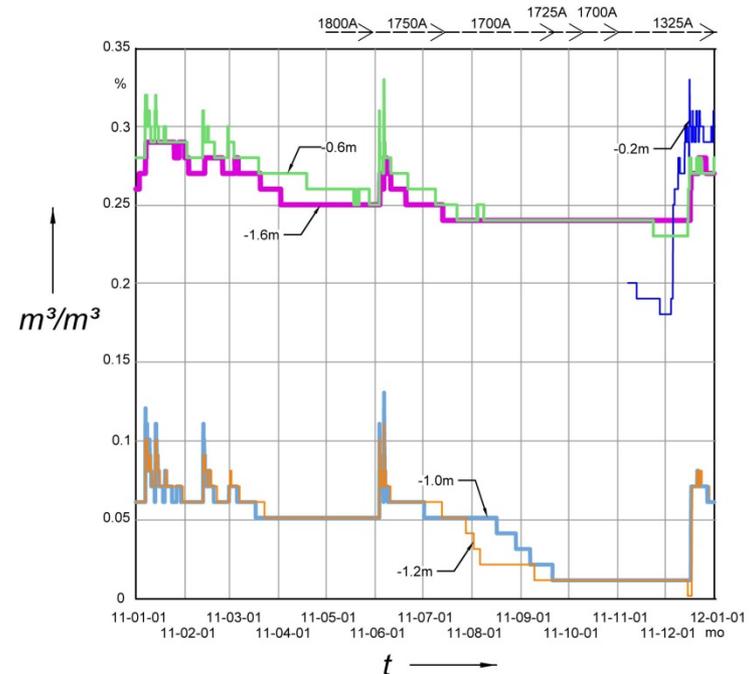


Fluidized Backfill:



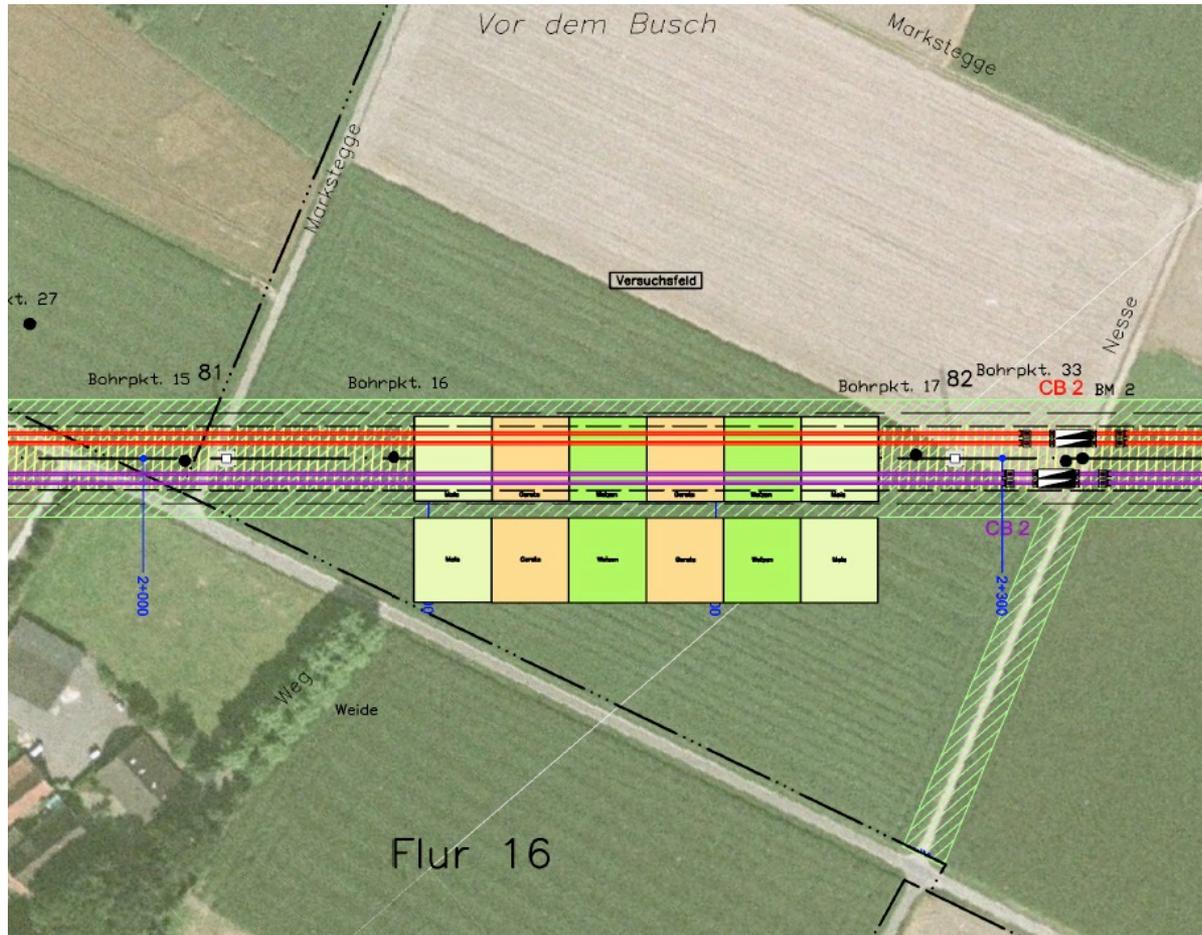
Thermal results (2)

- Sand: Partial drying limited to close vicinity of cables
- Temperature rise in a depth of 0.2 m
 - 4-6 K at 210 % power losses
 - < 2 K at 100 % power losses
- Thermal influence is very limited to regions adjacent to the cable axis



Moisture content in sand in 2011

Long term monitoring - Agricultural test setup



Summary and outlook

- A cable system was operated at maximum conductor temperature of 90°C
- A maximum temperature rise of 6 K was reached in the main root zone.
- No negative effects on the yield occurred.
- The moisture content was only influenced in close vicinity of the cables.
- Five bedding materials were applied, but a generalization of the gained results is dangerous, very local site specifics have to be considered.
- **Acceptance of applied bedding materials of land owners / authorities must be considered!**

Thank you for your attention!
Questions?

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