Electric grid integration of a large scale overhead contact line ERS for truck applications

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Investigated Road topologies, Variants and Scenarios

Investigation of different traffic and infrastructures scenarios, with variable headways and road topographies

- Two highway topologies
  - Road A: flat highway
  - Road B: mountainous highway
- Two variants based on the electrification infrastructure models
  - S-95: 95% of the route is electrified
  - S-50: 50% of the route is electrified
- Two scenarios based on the truck traffic
  - s5: Penetration every 5s, all the trucks will be electrified (final expansion / worst case scenario)
  - s10: Penetration every 10s lower penetration of the e-trucks (partly expansion)
- A traffic jam scenario
Network modelling

Consideration for the network design by following network model

• Secondary substations with transformer and load
• Medium voltage (MV) cable connecting the secondary substations in a ring structure
• Primary substations (HV/MV)
• High voltage (HV) cable network

Assumption of the distance between the secondary substations from the simulation of each variant and scenario

**Diagram:**
- HV
- MV
- Secondary (traction) substation (partial/total expansion)
- Normal open point
Methodology
Stepwise dimensioning of the network components

1. Analysis and classification of the simulation results
2. Dimensioning of the secondary substation transformers
3. Dimensioning of the MV cable network
4. Dimensioning of the primary substation transformers
5. Dimensioning of the HV cable network
Methodology
Analysis and classification of the simulation results

For the dimensioning of the necessary network components following information have been extracted from the simulation results:

- The non-simultaneous maximal load in a section ➔ Rating of the secondary substation transformers

- The maximal value and duration of overload in secondary substations in case of a traffic jam ➔ Avoiding of the over dimensioning of the secondary substation transformers

- The simultaneous maximal load in a section ➔ Rating of the MV and HV cable as well as the primary substation transformers
Methodology
Dimensioning of the secondary substation transformers

- In traffic jams, e-Trucks need more power to drive up. This causes a brief punctual increase of the power demand.
- Transformer rating based on this power leads to over dimensioning and so higher investment costs
  ➔ The rating of the transformer rated power is based on the maximal non-simultaneous load
  ➔ Overload capacity of the transformers should be taken into consideration

Example:

<table>
<thead>
<tr>
<th>Scenario: Road-B S-95 s5</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td></td>
</tr>
<tr>
<td>$S_r$</td>
<td>3.5 MVA</td>
</tr>
<tr>
<td>$S_{max,normal}$</td>
<td>3.4 MVA</td>
</tr>
<tr>
<td>$S_{max,jam}$</td>
<td>4.04 MVA</td>
</tr>
<tr>
<td>$T_{Max,Overload, S_r=3.5MVA}$</td>
<td>200 min</td>
</tr>
<tr>
<td>$T_{Overload, S_r=3.5MVA}$</td>
<td>6 min</td>
</tr>
</tbody>
</table>

$S_r = 3.5$ MVA

$T_{UW8, S_r=3.5}$ MVA = 4 min
$T_{Max,Overload, S_r=3.5MVA} = 200$ min
Methodology
Dimensioning of the MV cable - scenario Road-B S-95 s5

- Maximal simultaneous load
  - approx. 57 MVA for a 20km-section
  ➔ Average power of 2,85 MVA in each secondary substation

- The cable systems have to fulfill the (n-1) criterium
  ➔ If a failure occurs close to one of the primary (bulk) supply stations, the MV cabling must supply all secondary substations

➔ Two cable systems of the type N2XS20 3x1x500 are needed
Methodology
Dimensioning of prim. substation transformers - Road-B S-95

- Maximal simultaneous load in 20 km section in scenario
  - traffic s5: approx. 57 MVA
  - traffic s10: only 28 MVA
- The primary substations have to fulfill the (n-1) criterion
  ➔ If a failure occurs close to one of the primary (bulk) supply stations, the neighbor primary substation needs to supply the entire section
  ➔ The primary substation should be able to cover 150% of the initial peak load
  ➔ Overload capacity of the transformer should be taken into consideration to avoid over dimensioning
  ➔ 2 x 40 MVA Transformers for s5 (s10 only one)
Conclusion

• The considered task has a high load density.

• In order to fulfill the supply task with this high load density, the voltage levels 33 kV and 110 kV as best combination were chosen.

• To avoid additional costs, the components were designed with corresponding overload capabilities.

• The partial expansion of the routes is possible.

• Supply grid cost:
  o All voltage levels have to be considered in the planning.
  o The variants with 95% and 50% of the route electrification are at the same level.
  o Depending on the existing HV grid infrastructure, this voltage level have the largest contribution to the cost.
Contact page

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