# RESEARCH FOR A MOBILE FUTURE

DRESDEN

# Energy-saving potential of energy storage systems in public transport networks - evaluation results from Eberswalde

Innovations by TROLLEY
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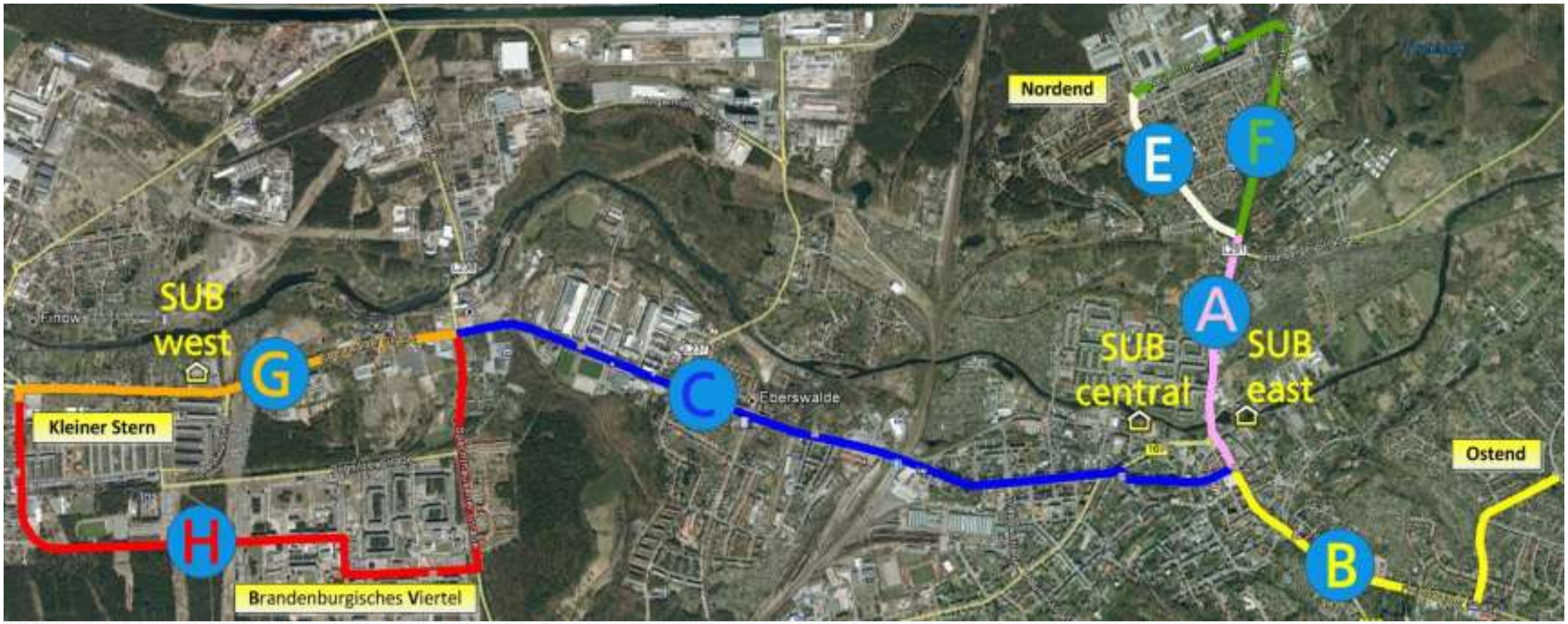
# Calculation example
## Trolley system, physical




Source : Google

- Three rectifier substations (west, central and east)
- Not illustrated: powered sections, input leads, couplings, breaker



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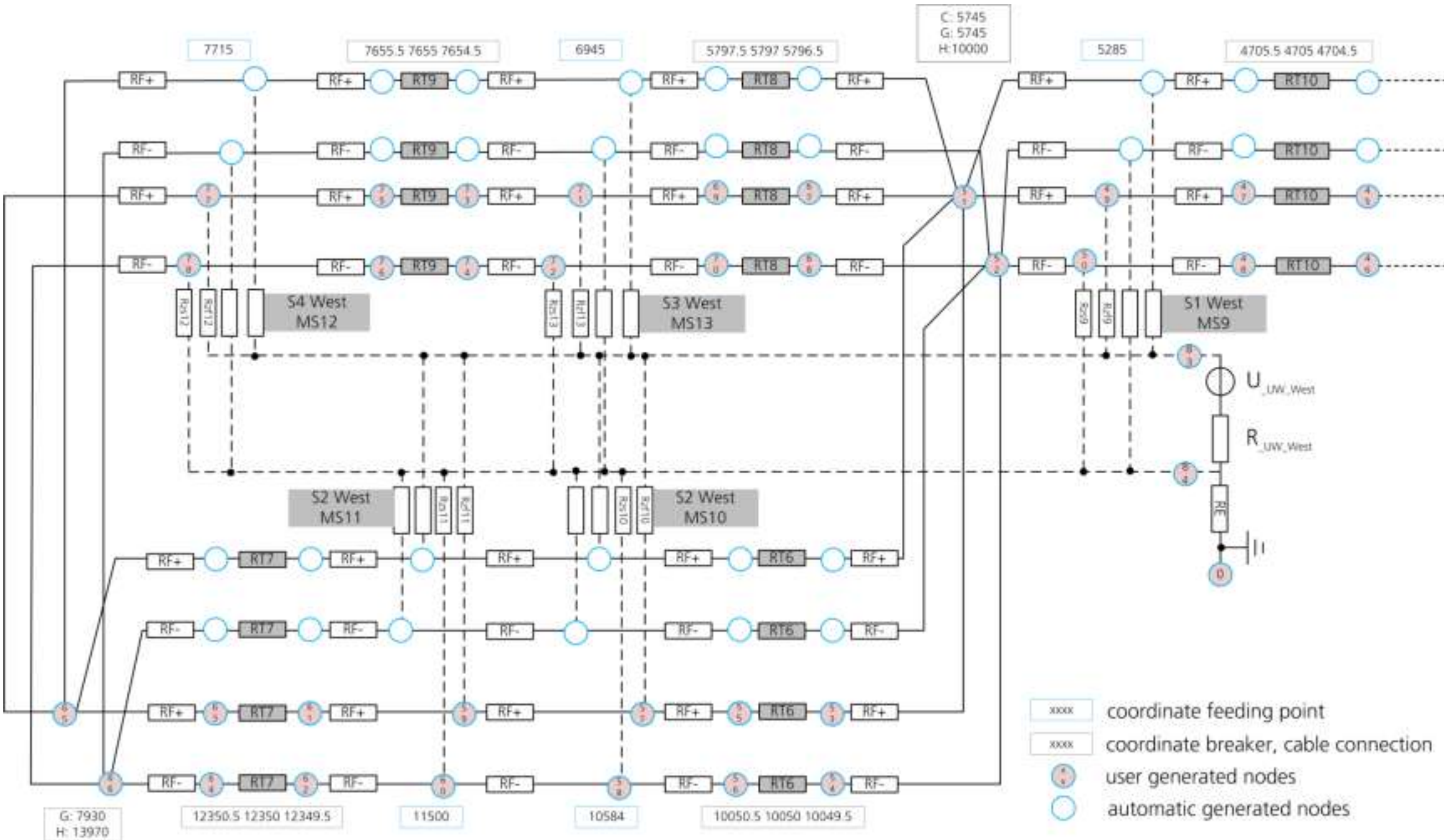
# Calculation example

## Trolley system, modelled





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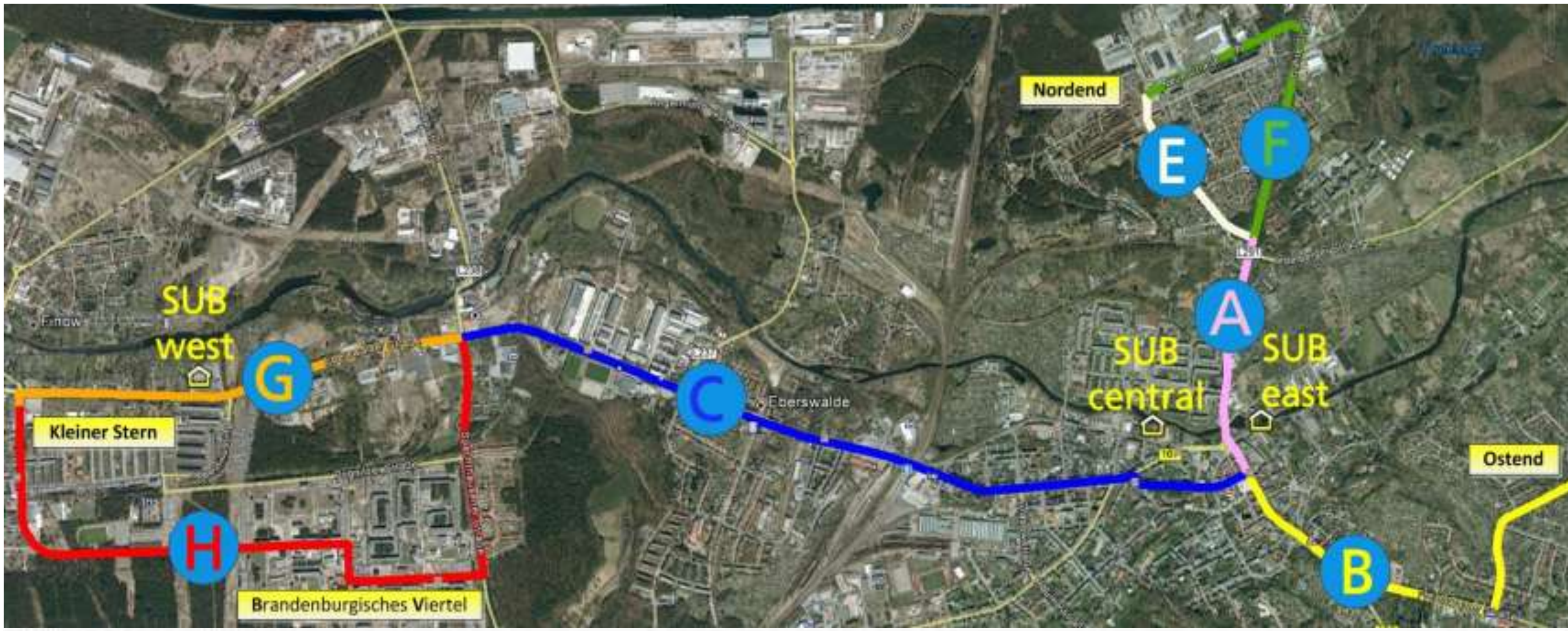
# Calculation example
## Route services




Source : Google

- 1 Forward: E → A → C → G  1 Backward: H → C → A → F
- 2 Forward: B → C → H  2 Backward: G → C → B

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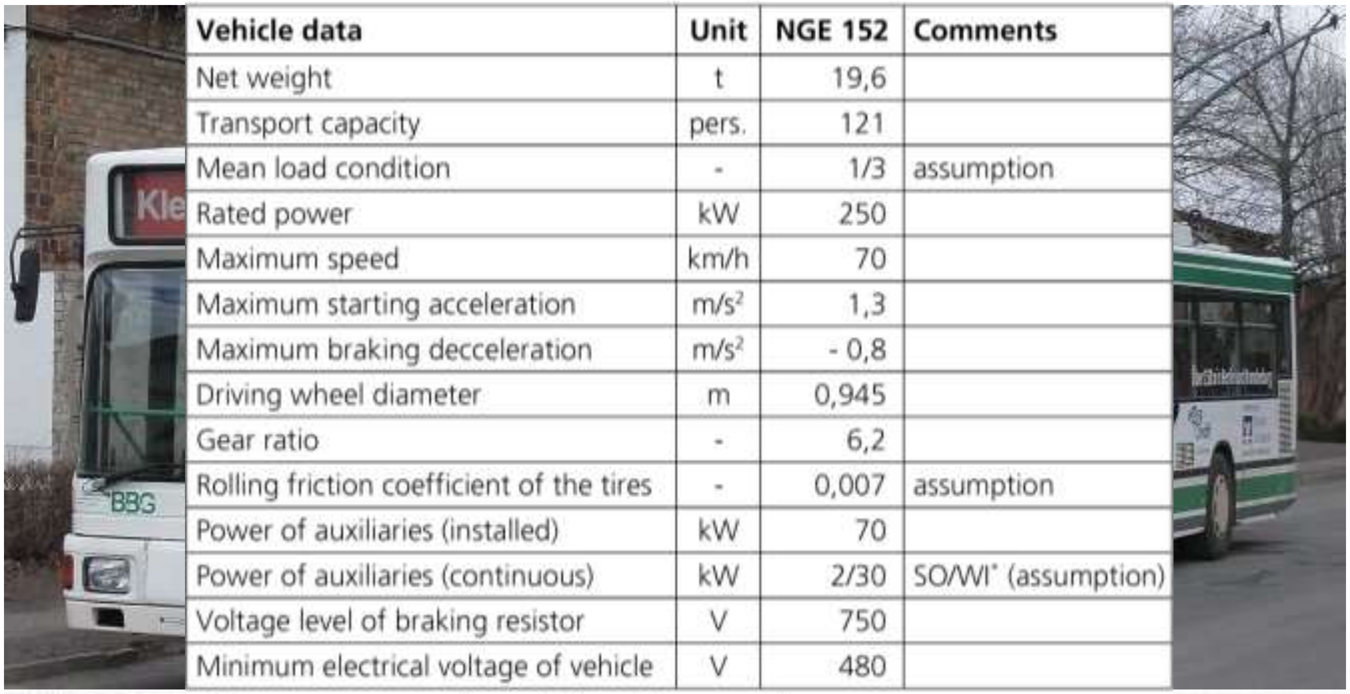
# Calculation example
## Schedule sections

| | Departure times | | | |
|---|---|---|---|---|
| Bus route | 1 Forward | 1 Backward | 2 Forward | 2 Backward |
| Scenario 1 | 7:00 | 7:00 | 7:06 | 7:03 |
| | 7:12 | 7:12 | 7:18 | 7:15 |
| | 7:24 | 7:24 | 7:30 | 7:27 |
| Scenario 2 | 9:30 | 9:24 | 9:15 | 9:15 |
| | 10:00 | 9:54 | 9:45 | 9:45 |
| | 10:30 | 10:24 | 10:15 | 10:15 |

- Scenario 1: »work traffic« Scenario 2: »holiday traffic«
- Annual mean: 65% »Scenario 1« / 35% »Scenario 2«

# Calculation example
## Vehicles



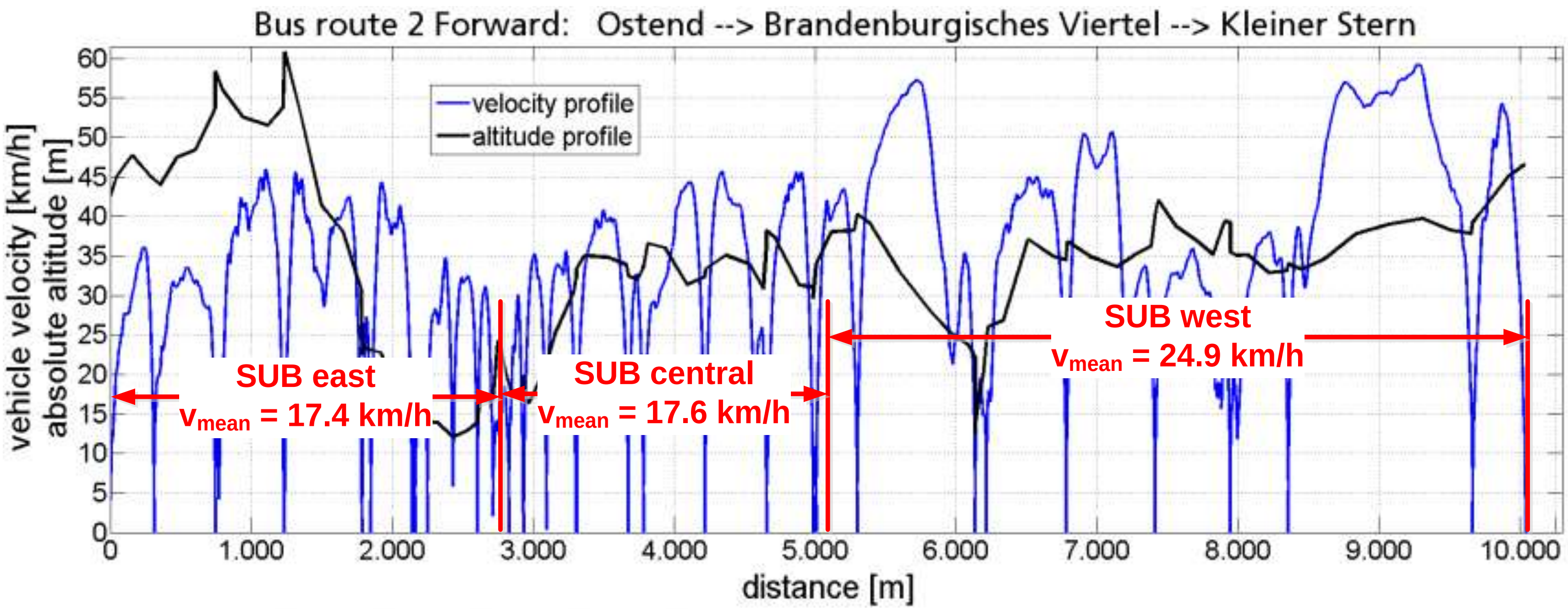

| Vehicle data | Unit | NGE 152 | Comments |
|---|---|---|---|
| Net weight | t | 19,6 | |
| Transport capacity | pers. | 121 | |
| Mean load condition | - | 1/3 | assumption |
| Rated power | kW | 250 | |
| Maximum speed | km/h | 70 | |
| Maximum starting acceleration | m/s² | 1,3 | |
| Maximum braking deceleration | m/s² | - 0,8 | |
| Driving wheel diameter | m | 0,945 | |
| Gear ratio | - | 6,2 | |
| Rolling friction coefficient of the tires | - | 0,007 | assumption |
| Power of auxiliaries (installed) | kW | 70 | |
| Power of auxiliaries (continuous) | kW | 2/30 | SO/WI* (assumption) |
| Voltage level of braking resistor | V | 750 | |
| Minimum electrical voltage of vehicle | V | 480 | |

* SO – summer operation  WI – winter operation

Source : bus-bild

- Prior use of braking energy for heating
- Annual mean : 42 weeks »summer« / 10 weeks »winter«

# Calculation example
## Operational profiles




- Measurement of operational profiles over a period of 6 weeks
- Derivation of the 4 required profiles by data processing



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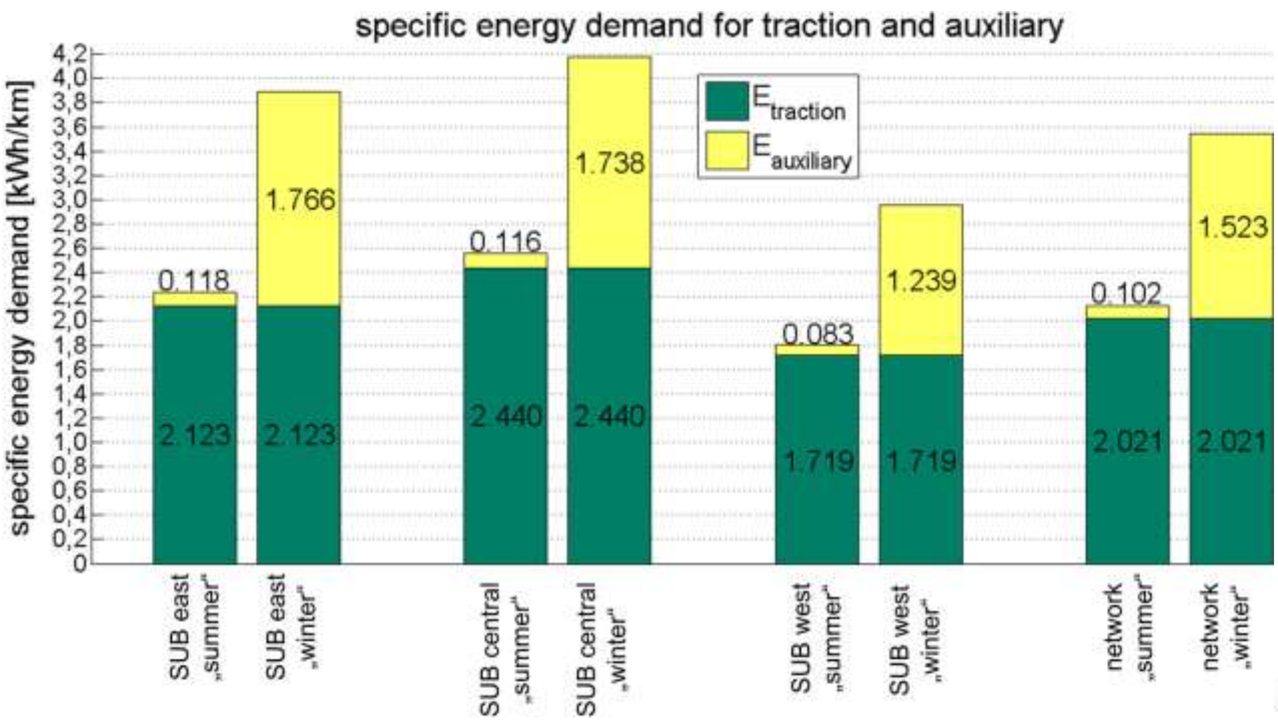
# Evaluation results

## Specific energy demand




- High sensitivity of auxiliary demand against ambient temperature
- Significant influence of velocity within the area of substation west

# Evaluation results

## Energy-saving potential by stationary SCAP systems

| | | | SUB east | | SUB central | | SUB west | | network | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *energy supply of SUB* | | SO | WI | SO | WI | SO | WI | SO | WI |
| Scer | with ES | [kWh/km] | 1,046 | 2,567 | 1,539 | 3,157 | 1,042 | 2,275 | 1,169 | 2,587 |
| | *Reduction of energy supply by substation* | | | | | | | | | |
| | | [%] | 46,3 | 17,8 | 41,9 | 16,9 | 43,2 | 16,9 | 43,7 | 17,2 |

| | | | SUB east | SUB central | SUB west | network |
|---|---|---|---|---|---|---|
| annual mean | Energy supply of SUB, without ES | [kWh/km] | 2,096 | 2,722 | 1,902 | 2,167 |
| | Energy supply of ES | [kWh/km] | 0,740 | 0,893 | 0,638 | 0,733 |
| | Energy supply of SUB, with ES | [kWh/km] | 1,340 | 1,793 | 1,249 | 1,413 |
| | Reduction | [%] | 36,0 | 34,1 | 34,3 | 34,8 |





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# Evaluation results

## Amortization of stationary SCAP systems

| | | | Substation east | Substation central | Substation west |
|---|---|---|---|---|---|
| overhead line | 1 forward | [km] | 2,525 | 2,180 | 3,215 |
| | 1 backward | [km] | 3,440 | 2,180 | 5,010 |
| | 2 forward | [km] | 2,700 | 2,180 | 5,140 |
| | 2 backward | [km] | 2,700 | 2,180 | 3,225 |
| services »year« | 1 forward | [-] | | 18528 | |
| | 1 backward | [-] | | 18528 | |
| | 2 forward | [-] | | 17472 | |
| | 2 backward | [-] | | 17232 | |
| | Kilometrage | [km] | 204220 | 156437 | 297772 |
| | Potential | [kWh/km] | 0,755 | 0,929 | 0,653 |
| | Monetary potential | [T€/year] | 21,6 | 20,3 | 27,2 |
| | Procurement costs | [T€] | 236,3 | 168,8 | 202,5 |
| | Maintenance costs | [T€/year] | 4,7 | 3,4 | 4,0 |
| | Amortisation period | [years] | 14,0 | 10,0 | 8,7 |

- Assumption: energy supply price of 14 ct/kWh

# QUESTIONS AND COMMENTS

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