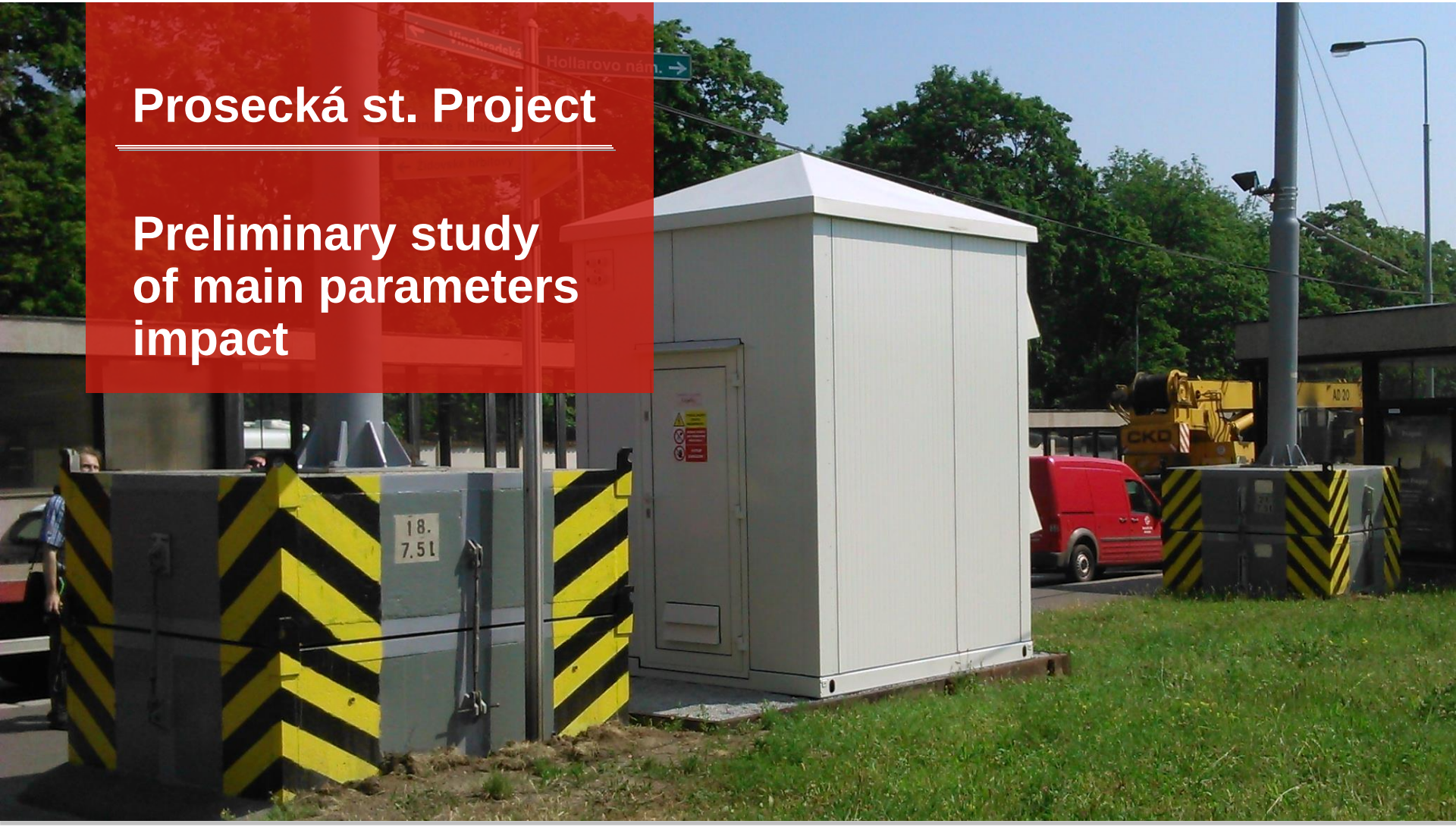
Prosecká st. Project

Preliminary study of main parameters impact



P. Snopek

Solingen | 22/11/2018

Content of the presentation

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Task definition, target of the sutdy

Task definition (defined by TA Prag in 2016)

- Existing line 140 (shortened to terminal Letňany)
- Overheadline dynamic charging in Prosecká street (from 600 VDC)
- „Overheadline“ static charging in terminal Palmovka (from 600 VDC)
- 12m „usual“ vehicle, not concrete type, emission free, „battery trolleybus concept“

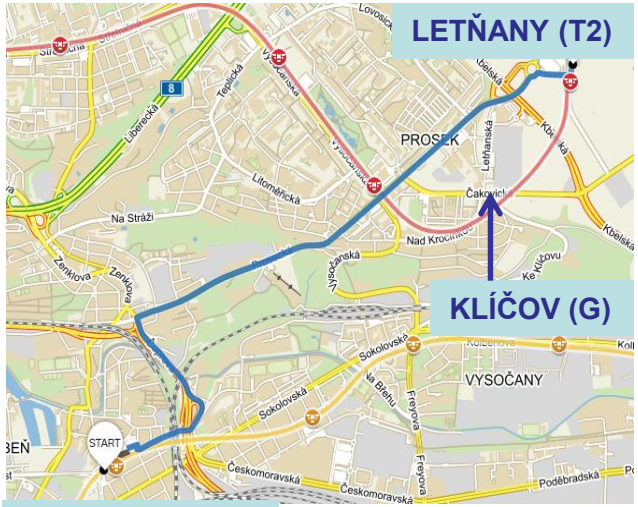
Target of the study

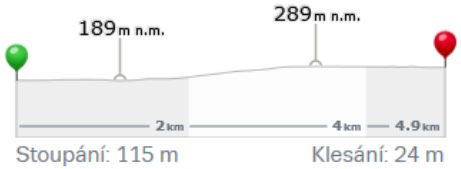
- Basic simulation of operational cycle
- Impact of significant parameters

Initial parameters

Line 140 (shortened)

- Length of shortened line: 5 km (T1-T2)
- Vertical drop: up 115 m, down 24 m
- Terminal to terminal: 12 min
- Garage Klíčov - terminals: 4,2 km, 1,5 km

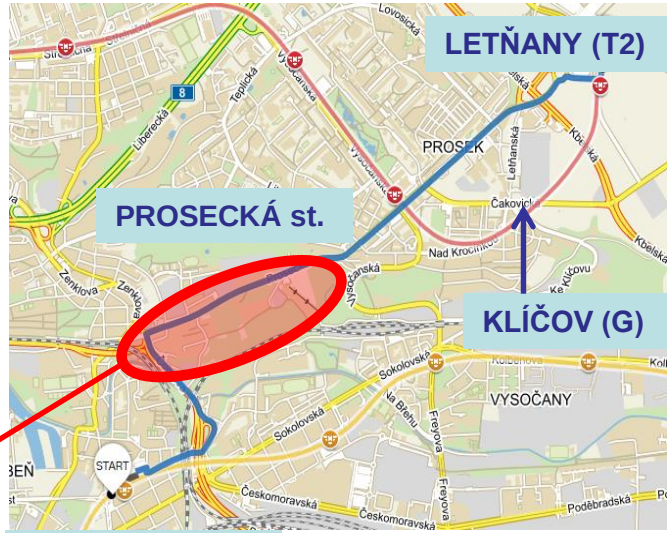


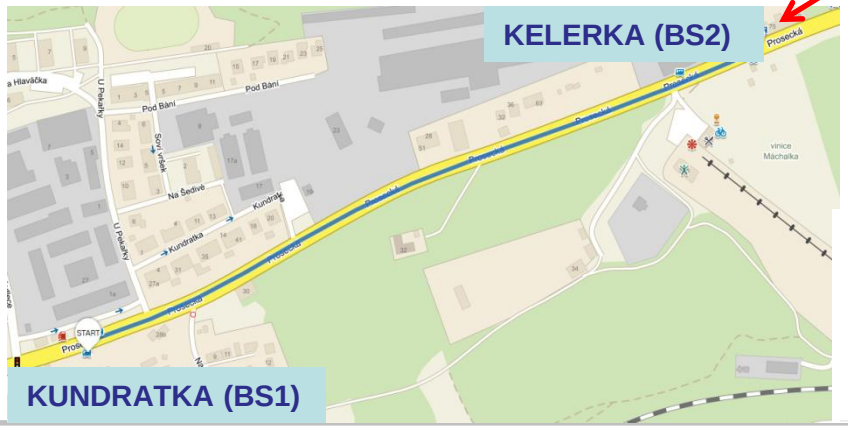


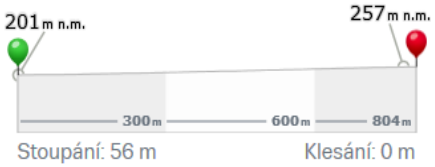
Initial parameters

Line 140 (shortened) with OHL

- Length of shortened line: 5 km (T1-T2)
- Vertical drop: up 115 m, down 24 m
- Terminal to terminal: 12 min
- Garage Klíčov - terminals: 4,2 km, 1,5 km
- Length of OHL (up only): **800 m** (1000 m)
- Stop to stop (app.): 2-3 min







Initial parameters

Estimation of parameters – shortened line

- Average speed on the line: 23 km/h
- Average speed under the OHL: 16 km/h
- Time on terminal Letňany (T2): **6 min**
- Time on terminal Palmovka (T1): **20 min**
- Time from Letňany (T2) to Palmovka (T1): 13 min
- Time of full round: 53 min

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Estimation of parameters – bus

- Average consumption of the bus (completely): **2 kWh/km**
- Heating : 20 kW
- Traction power: 200 kW
- Battery energy: **100 kW**
- Battery efficency: 96 %

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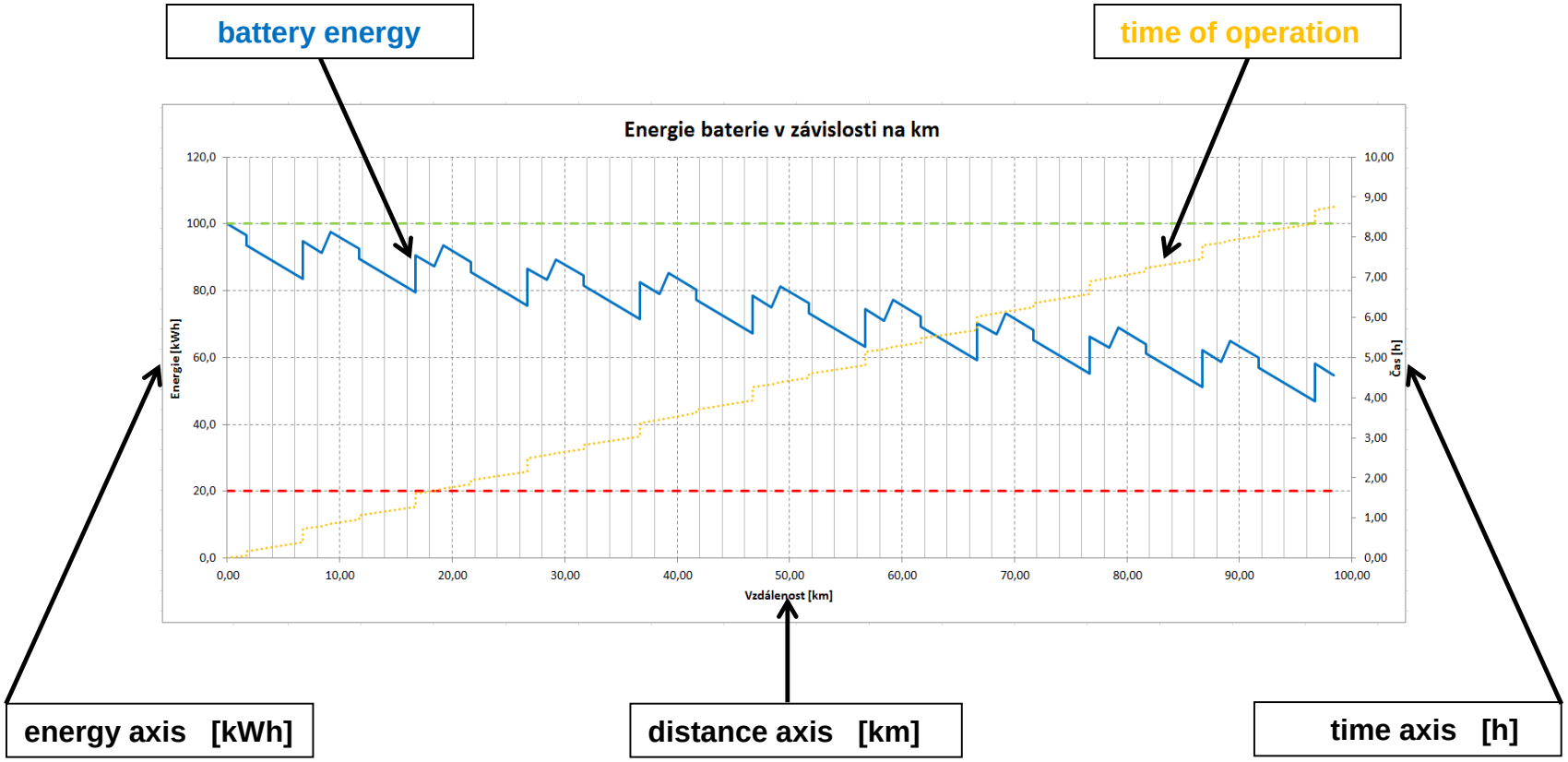
Estimation of parameters – charging

- Dynamic charging OHL voltage: **600 V**
- Static charging voltage: 600 V
- Dynamic charging OHL current: 600 A
- Static charging current: **120 A**
- Dynamic charging time coefficient: 1
- Time of charging on terminal Palmovka (T1): **18 min** (stay 20 min)

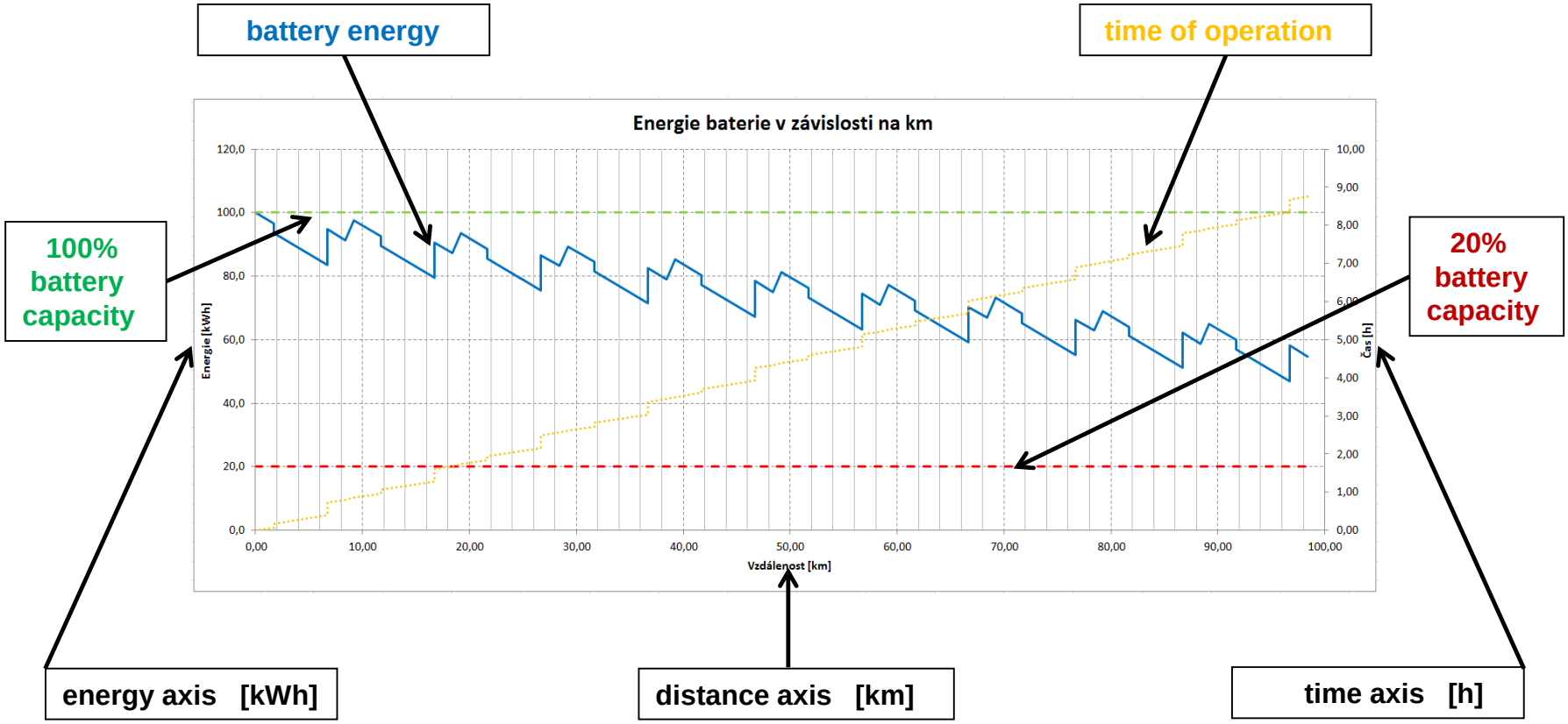
Study algorithm output structure

Curve of energy as a function of distance



Study algorithm output structure

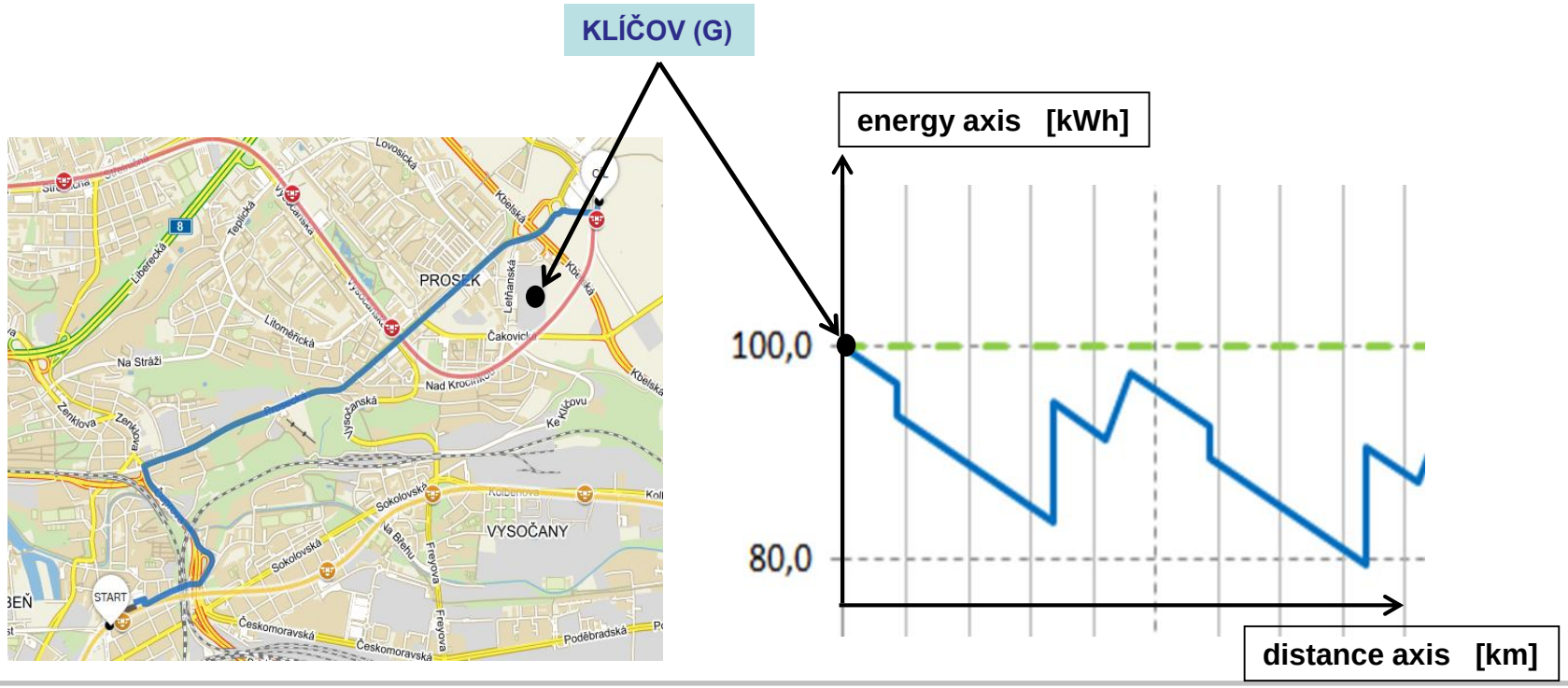
Curve of energy as a function of distance



Study algorithm output structure

Curve of energy

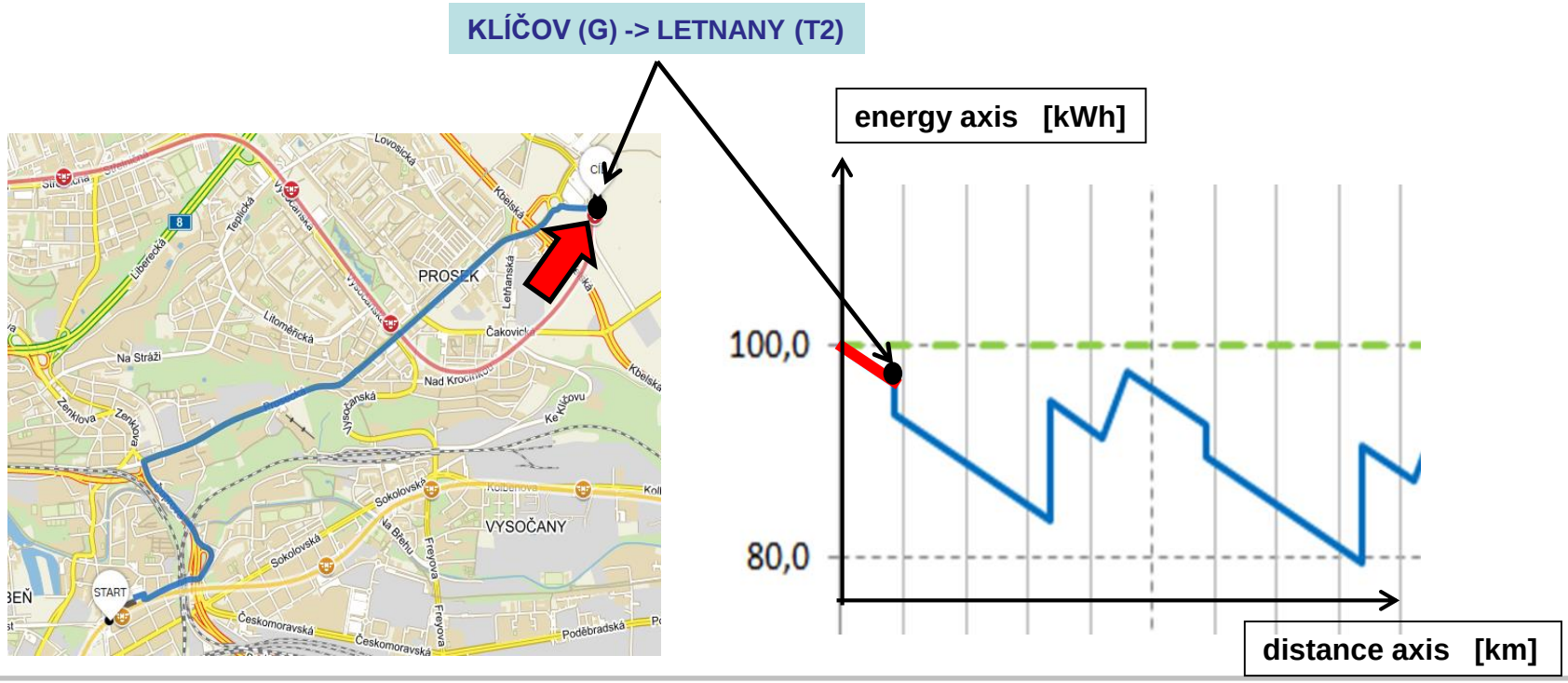
- Start of operation: **battery 100% charged**



Study algorithm output structure

Curve of energy

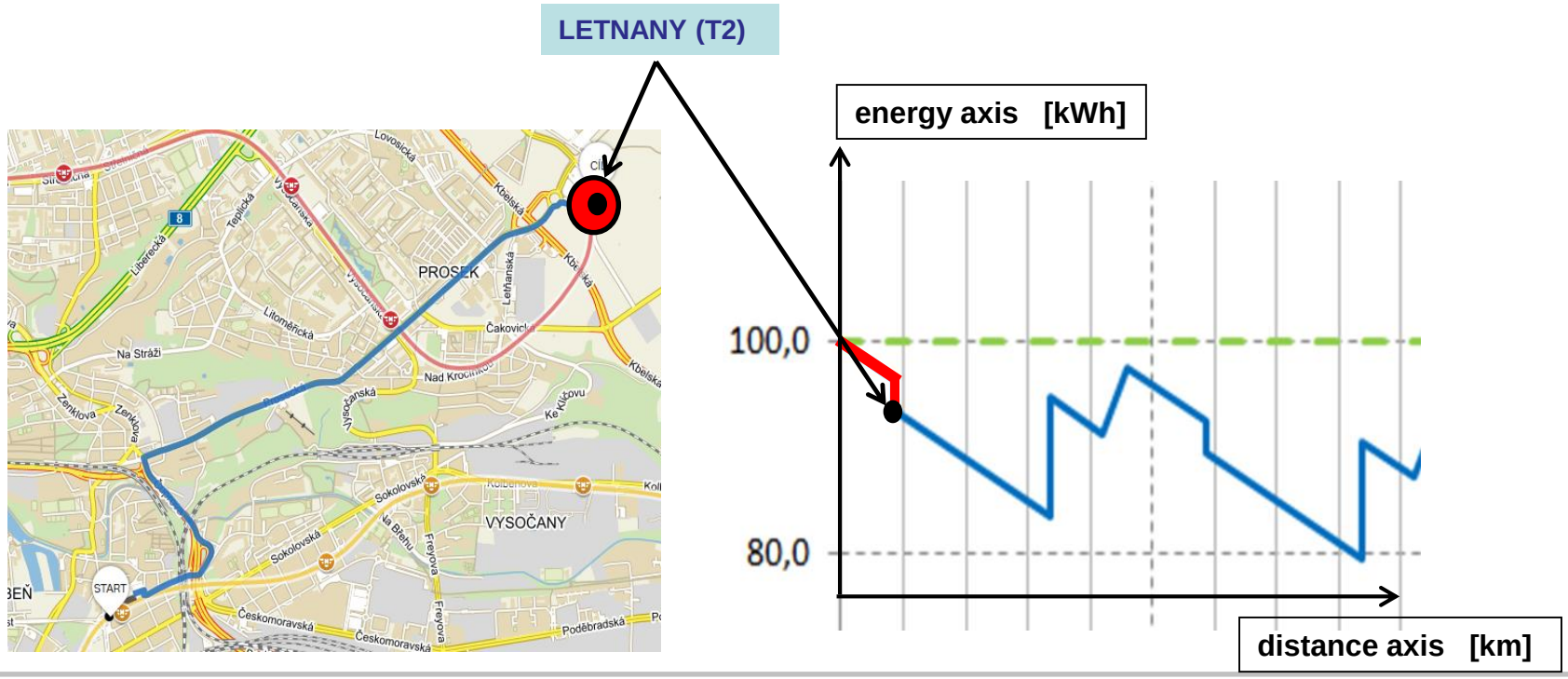
- Traction from garage G to terminal T2: **battery operation**
- Auxiliary consumption + traction covered from: battery



Study algorithm output structure

Curve of energy

- Stay at terminal T2: **battery operation**
- Auxiliary consumption covered from: battery

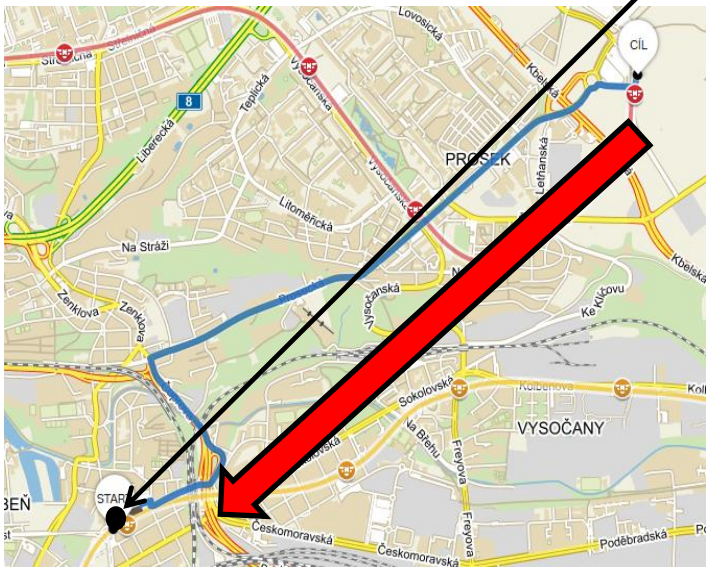


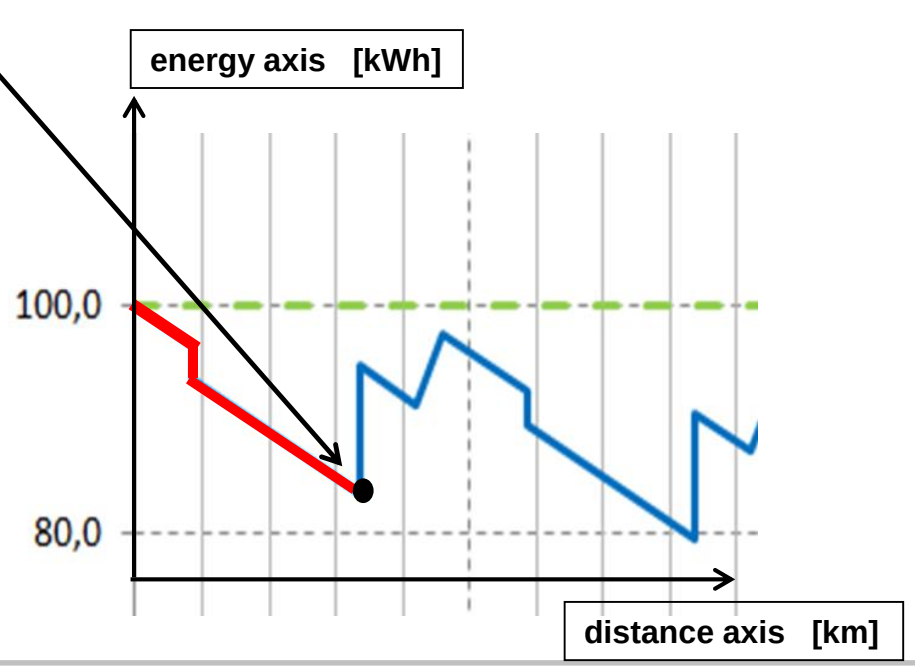
Study algorithm output structure

Curve of energy

- Traction from terminal T2 to terminal T1: **battery operation**
- Auxiliary consumption + traction covered from: battery

LETNANY (T2) – PALMOVKA (T1)





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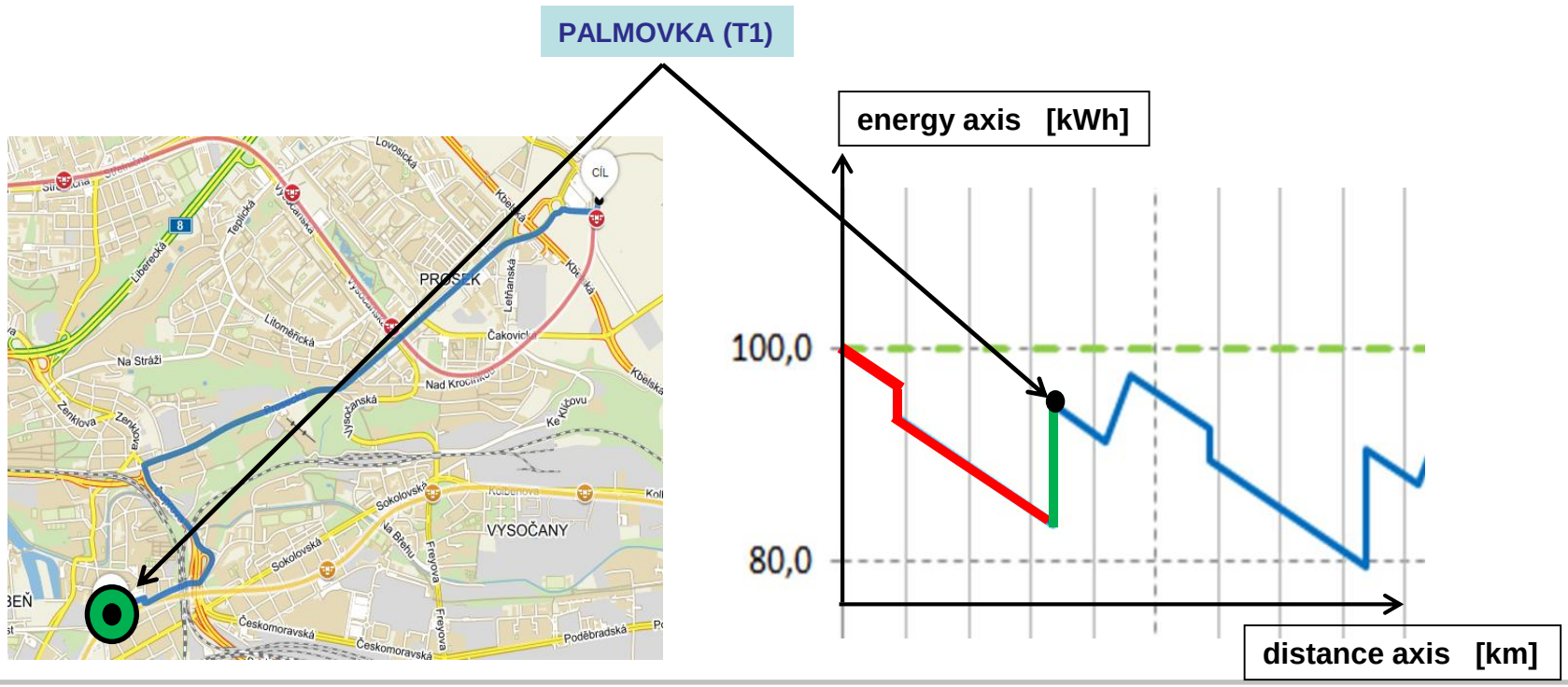
Study algorithm output structure

Curve of energy

- Stay at terminal T1: **battery charging**
- Auxiliary consumption covered from: static charging point

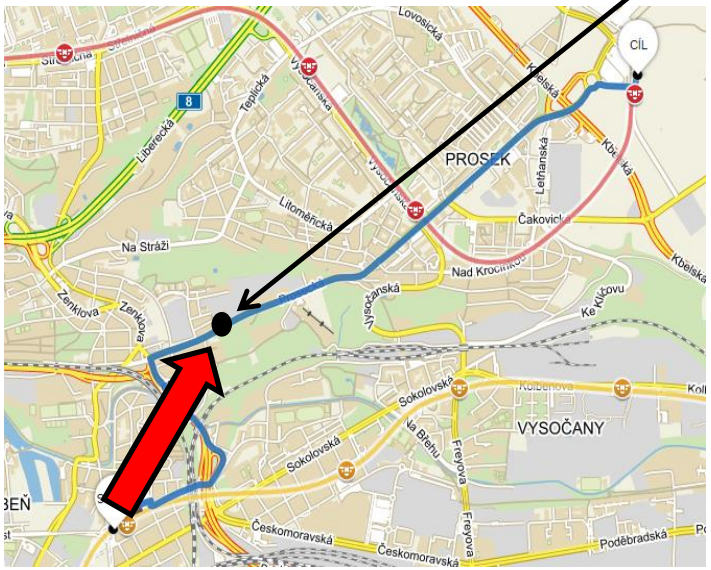


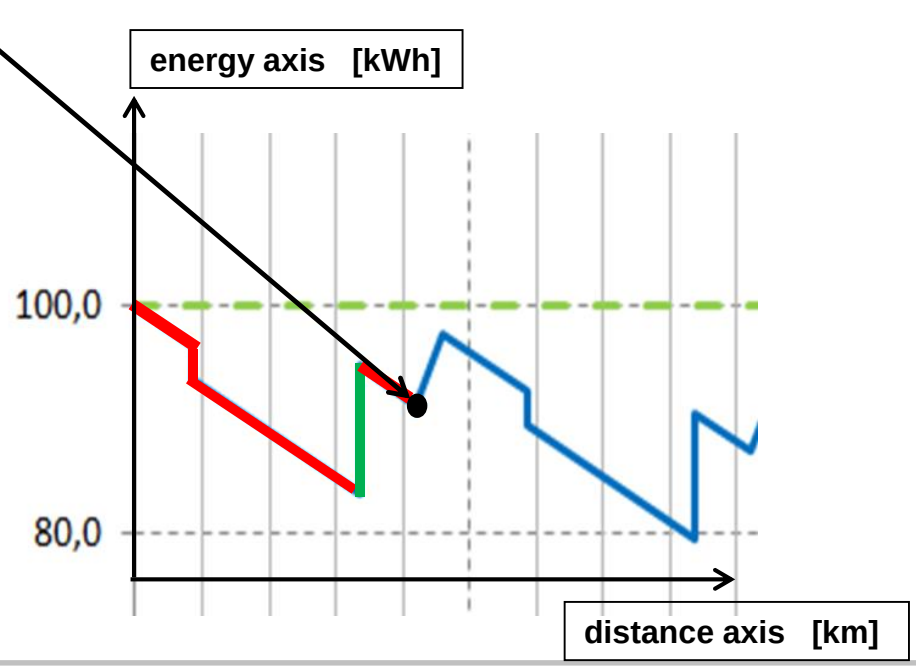
Study algorithm output structure

Curve of energy

- Traction from terminal T1 to stop BS1: **battery operation**
- Auxiliary consumption + traction covered from: battery

PALMOVKA (T1) -> KUNDRATKA (BS1)





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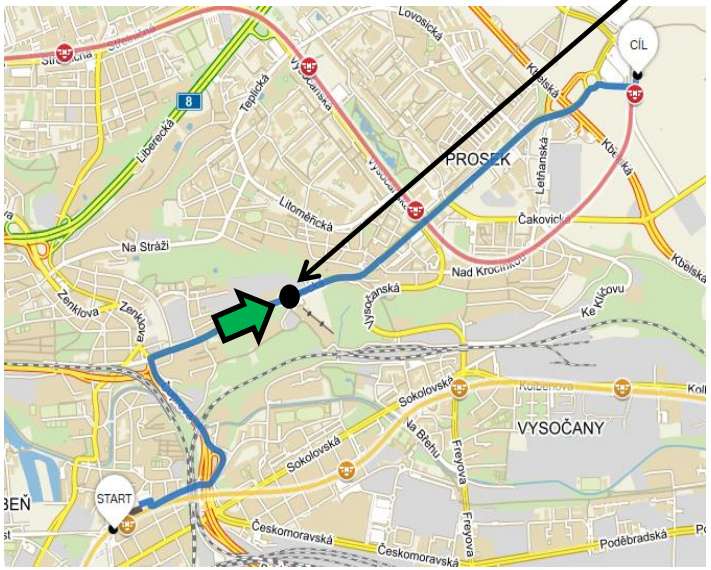
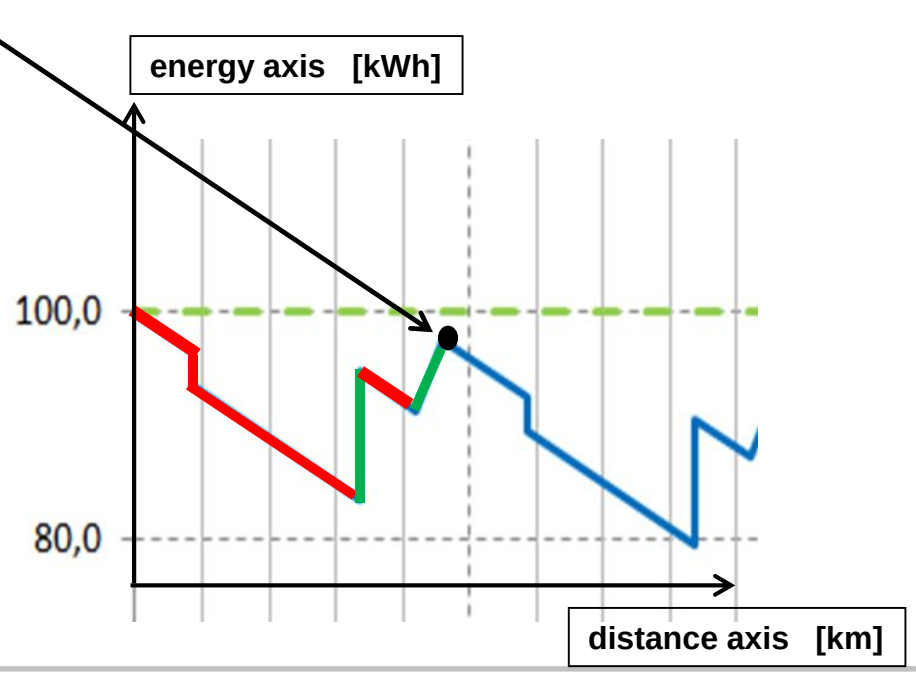
Study algorithm output structure

Curve of energy

- Traction from stop BS1 to stop BS2: **battery charging**
- Auxiliary consumption + traction covered from: dynamic charging OHL

KUNDRATKA (BS1) -> KELERKA (BS2)





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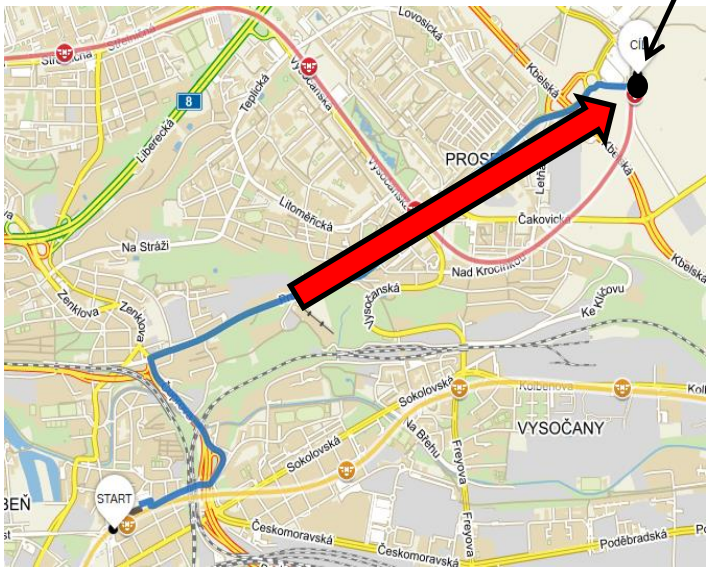
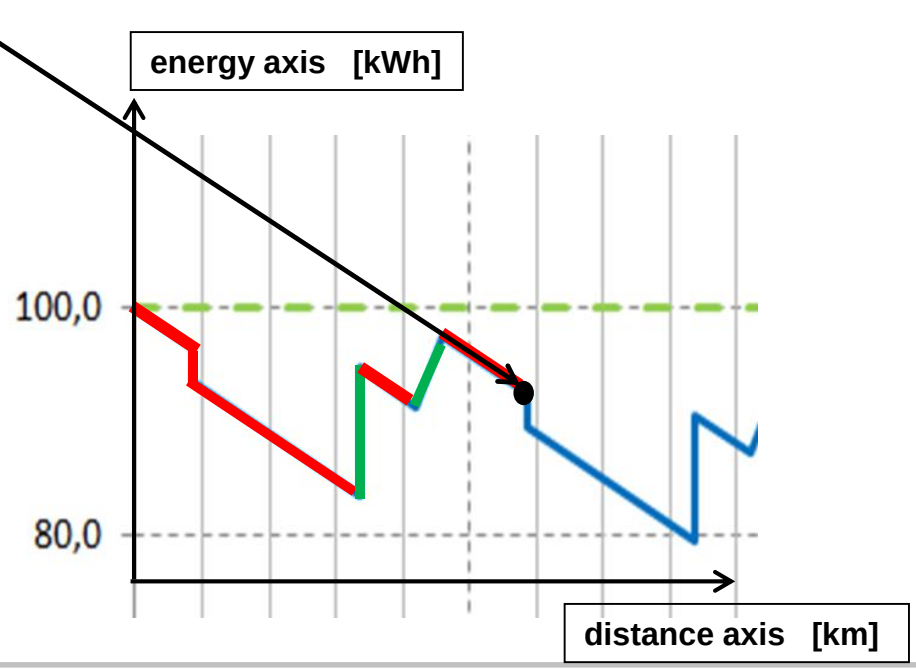
Study algorithm output structure

Curve of energy

- Traction from stop BS1 to terminal T2: **battery operation**
- Auxiliary consumption + traction covered from: battery

KELERKA (BS2) -> LETŇANY (T2)

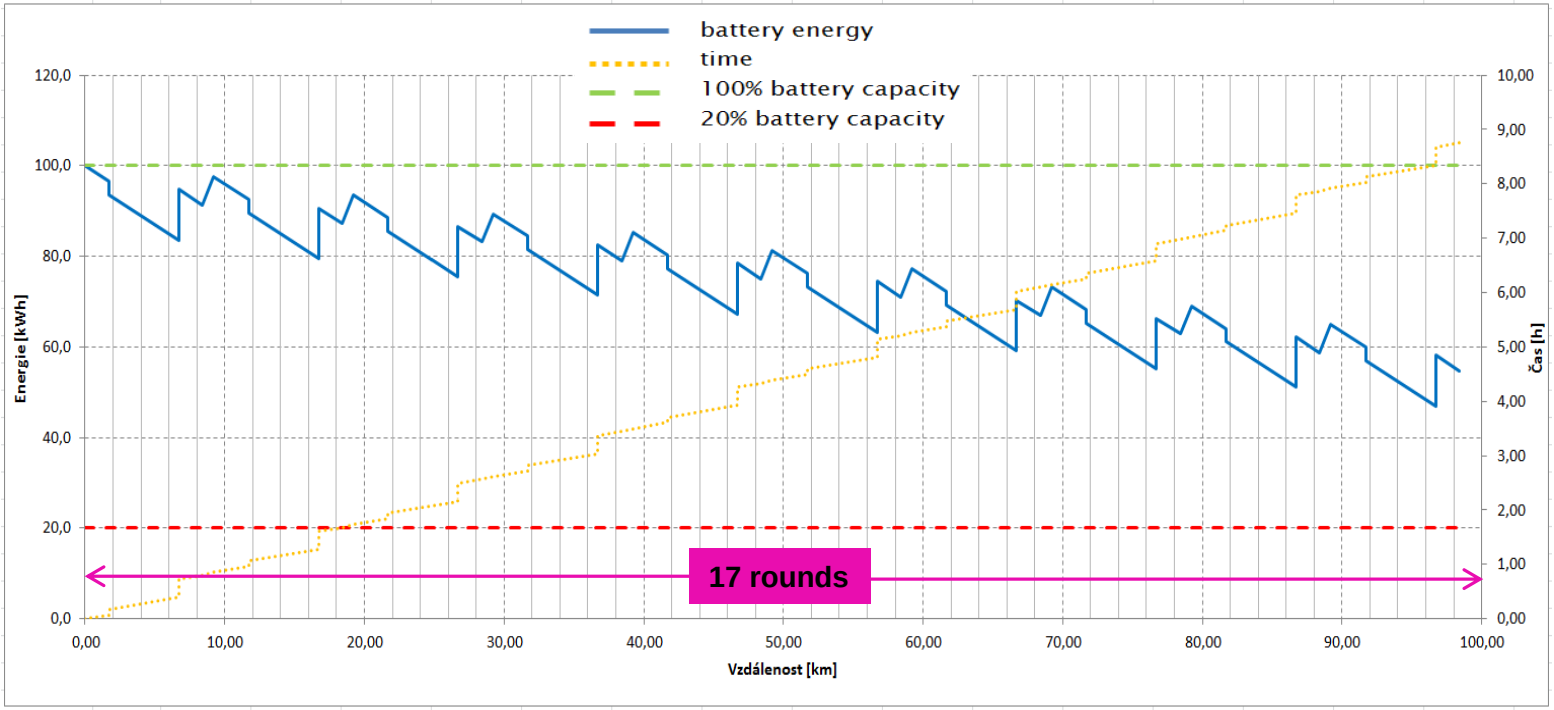




Outcome of the study

Simulation of operational cycle - estimated parameters

- Based on estimated parameters: 20 min + 6 min, 100 kW, 120 A, 600 V, 2 kWh/km, 800 m
- 20% of battery capacity: **15 hours, 170 km**



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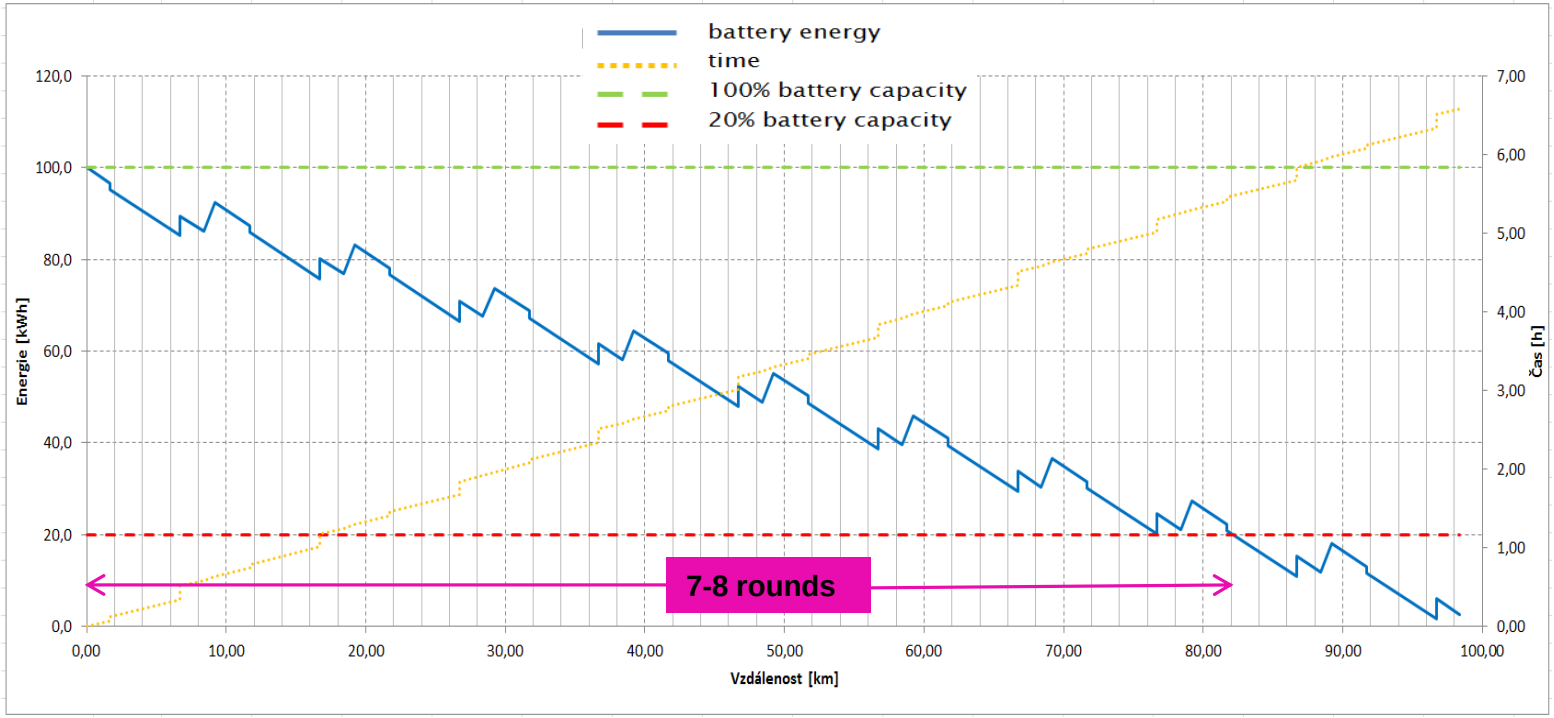
Outcome of the study

Simulation of operational cycle - influence of terminal time

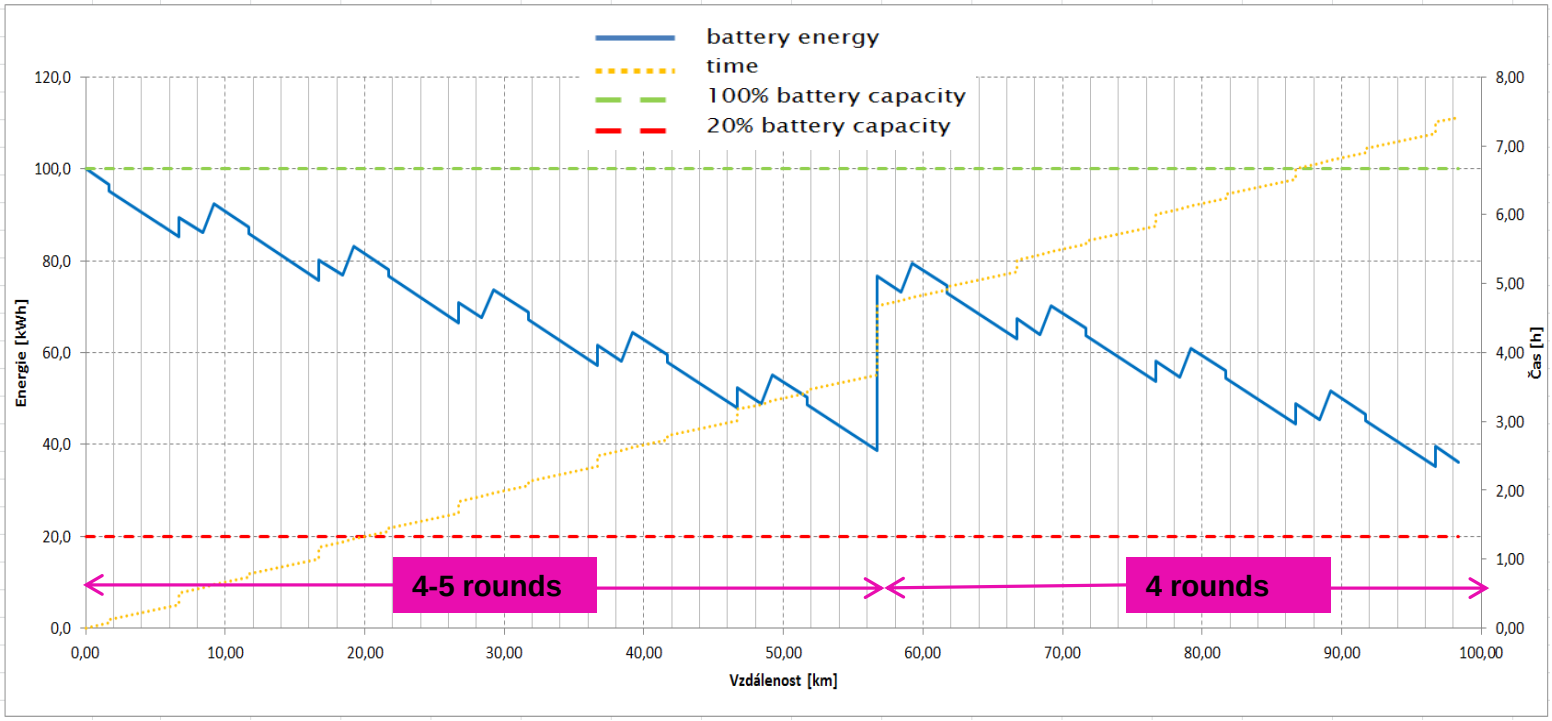
- 50% time on terminals: T1: **10/8 min**, T2: **3 min**
- 20% of battery capacity: **5 hours, 80 km**



Outcome of the study

Simulation of operational cycle - influence of terminal time

- 50% time on terminals + add. time: T1: **10/8 min**, T2: **3 min**, + add. T1: **60 min / 3,5 h**
- 20% of battery capacity: necessary **next 60 min charging** after **3,5 hours**



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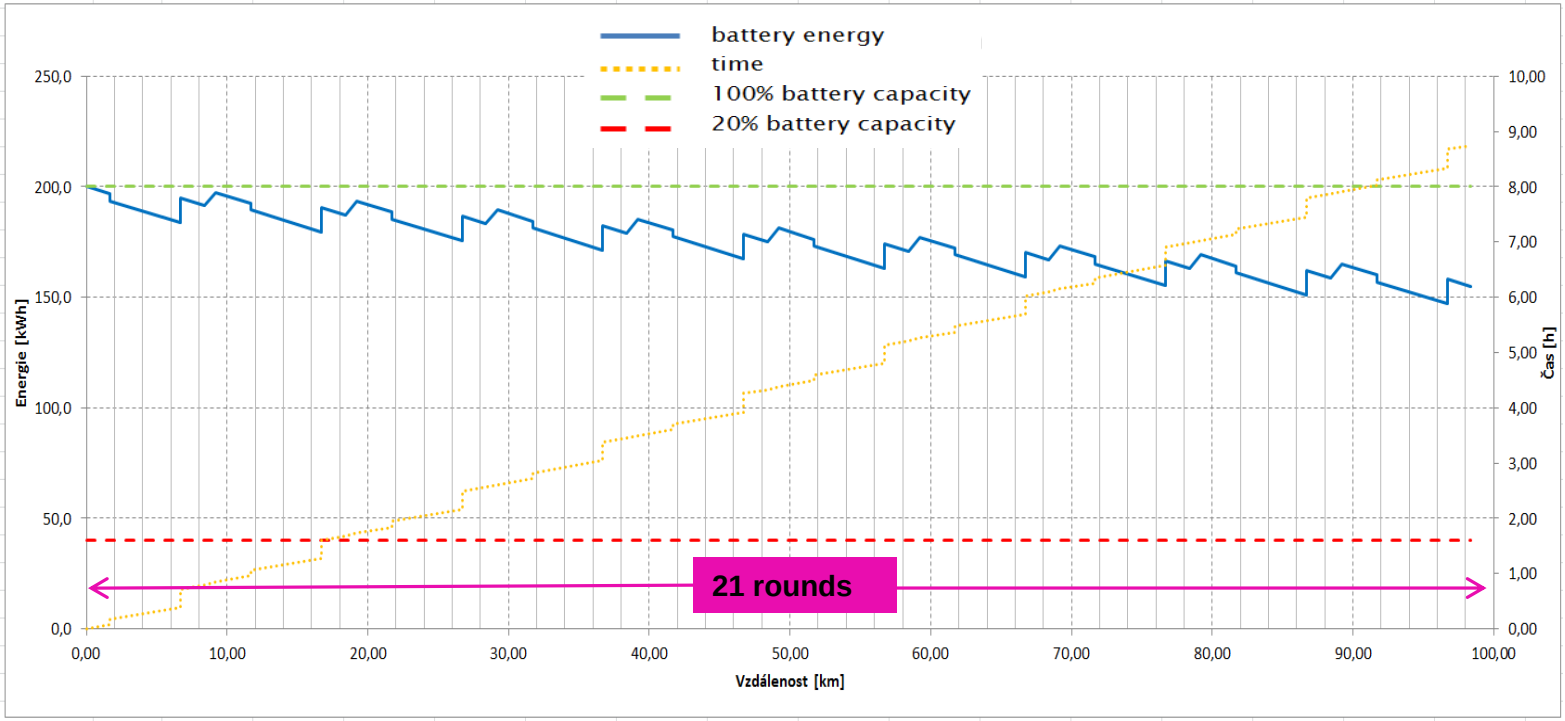
Outcome of the study

Simulation of operational cycle - influence of battery size

- 200% battery size: **200 kWh** (50% time on terminals)
- 20% of battery capacity: **19 hours, 215 km** (10 hours, 160 km)

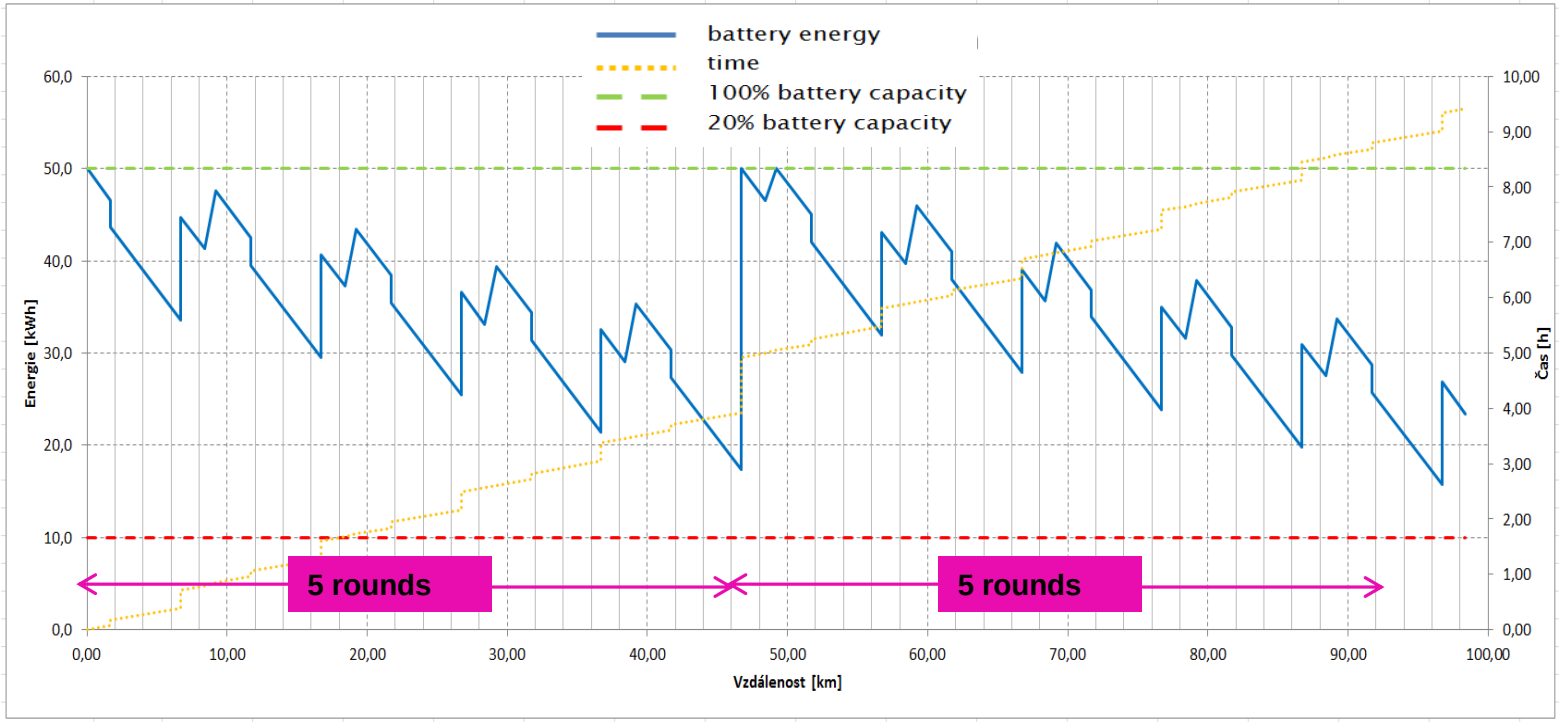


Cegelec

Outcome of the study

Simulation of operational cycle - influence of battery size

- 50% battery size + add. time: **50 kWh**, + add. T1: **60 min / 4 hours**
- 20% of battery capacity: **5,5 hours**, **60 km** (reserve!)

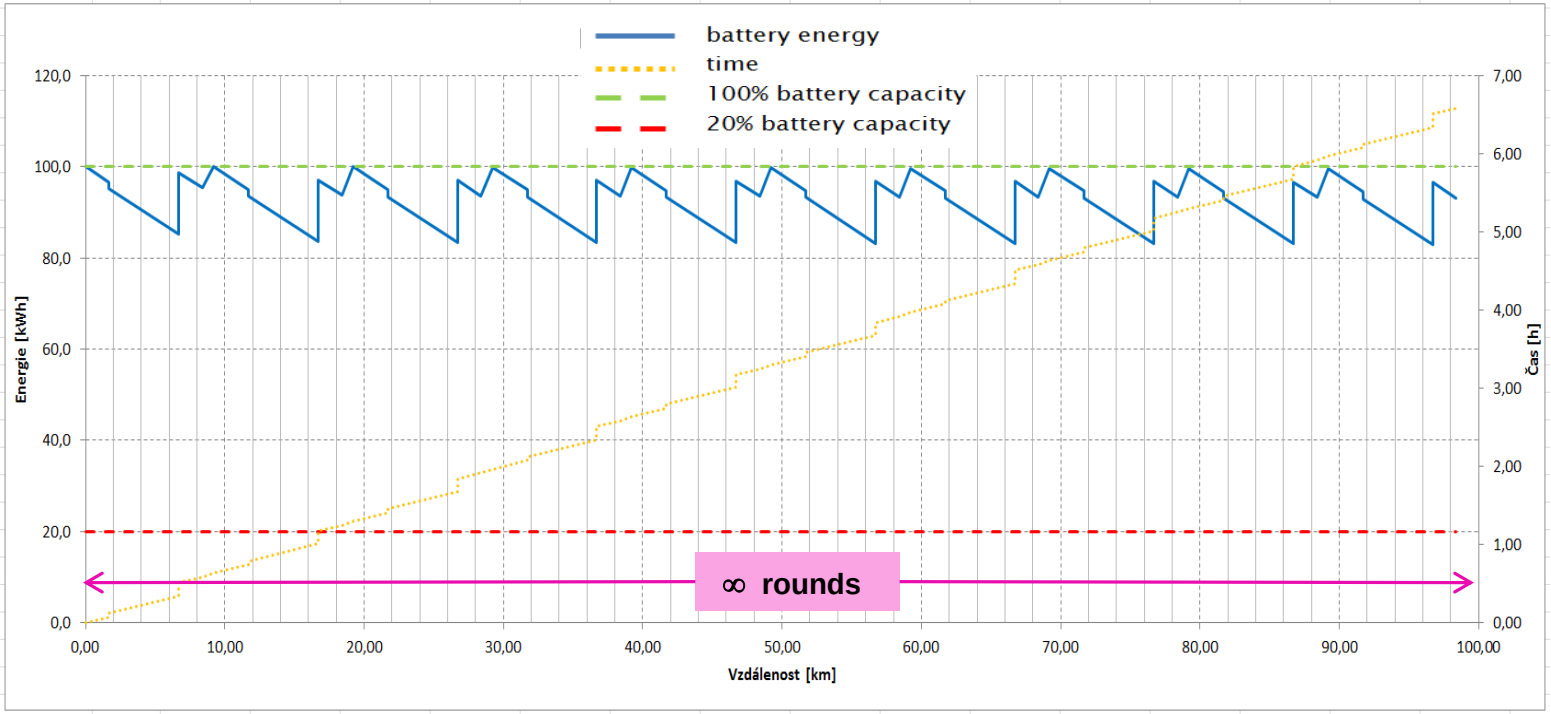


Cegelec

Outcome of the study

Simulation of operational cycle - influence of static charging current

- 200% static charging current (T1): **240 A** (50% time on terminals)
- 20% of battery capacity: **∞ hours, ∞ km** (after 24 hours reaches 80% battery capacity)

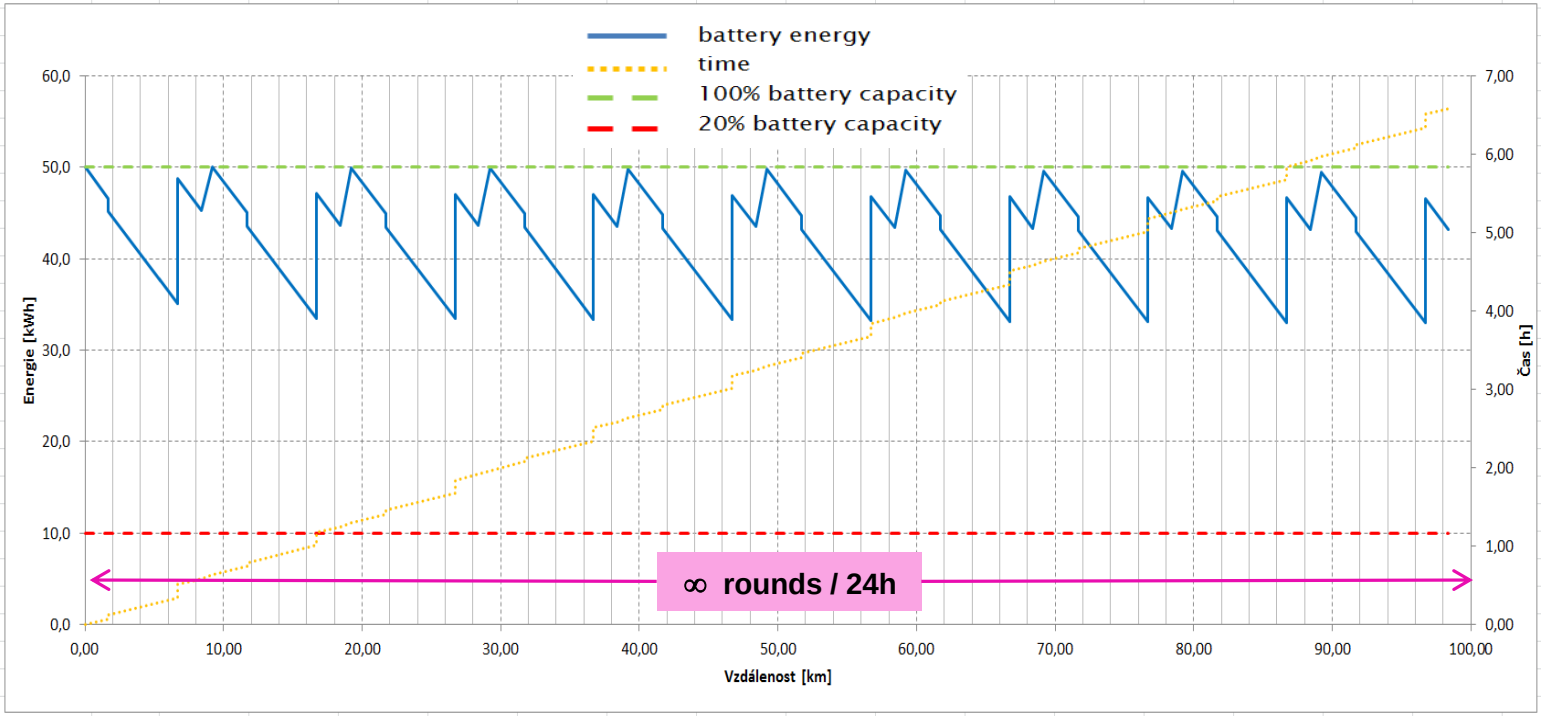


Cegelec

Outcome of the study

Simulation of operational cycle - influence of static charging current

- 200% static charging current (T1): **240 A + 50%** battery, **50%** time on terminals
- 20% of battery capacity: ∞ **hours** / 24 hours, ∞ **km** / 24 hours (reserve!)



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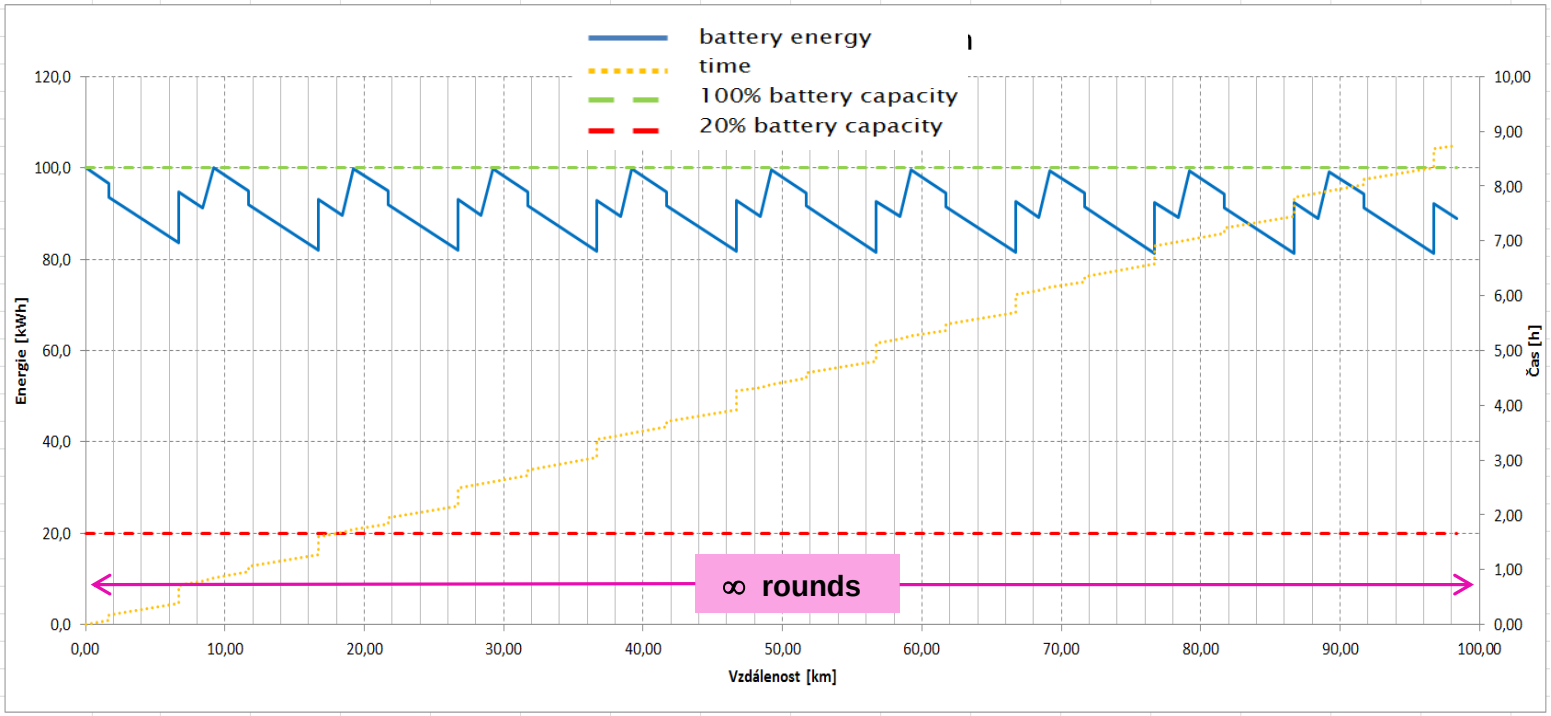
Outcome of the study

Simulation of operational cycle - influence of dynamic charging voltage

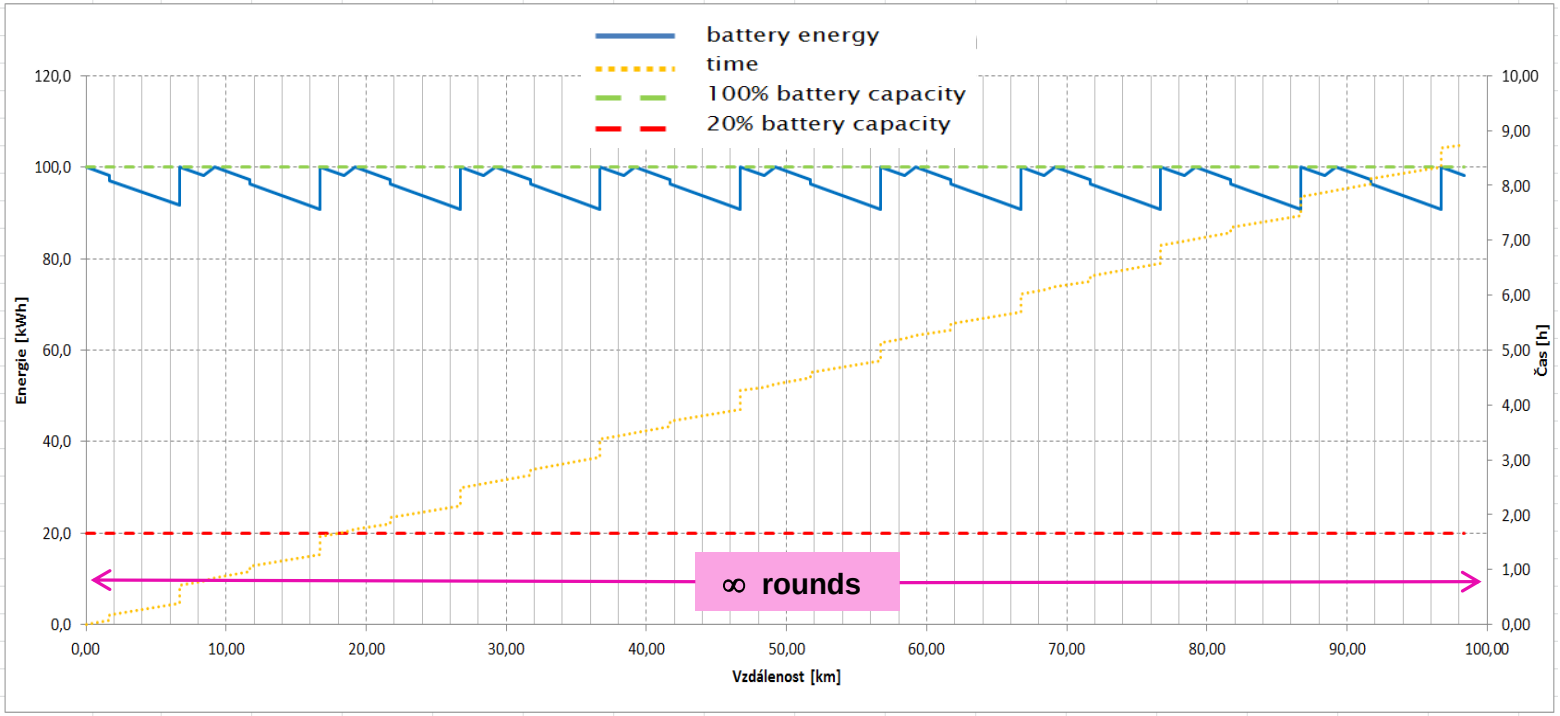
- Increasing of OHL voltage: **750 VDC**
- 20% of battery capacity: **∞ hours, ∞ km**



Outcome of the study

Simulation of operational cycle - influence of vehicle consumption

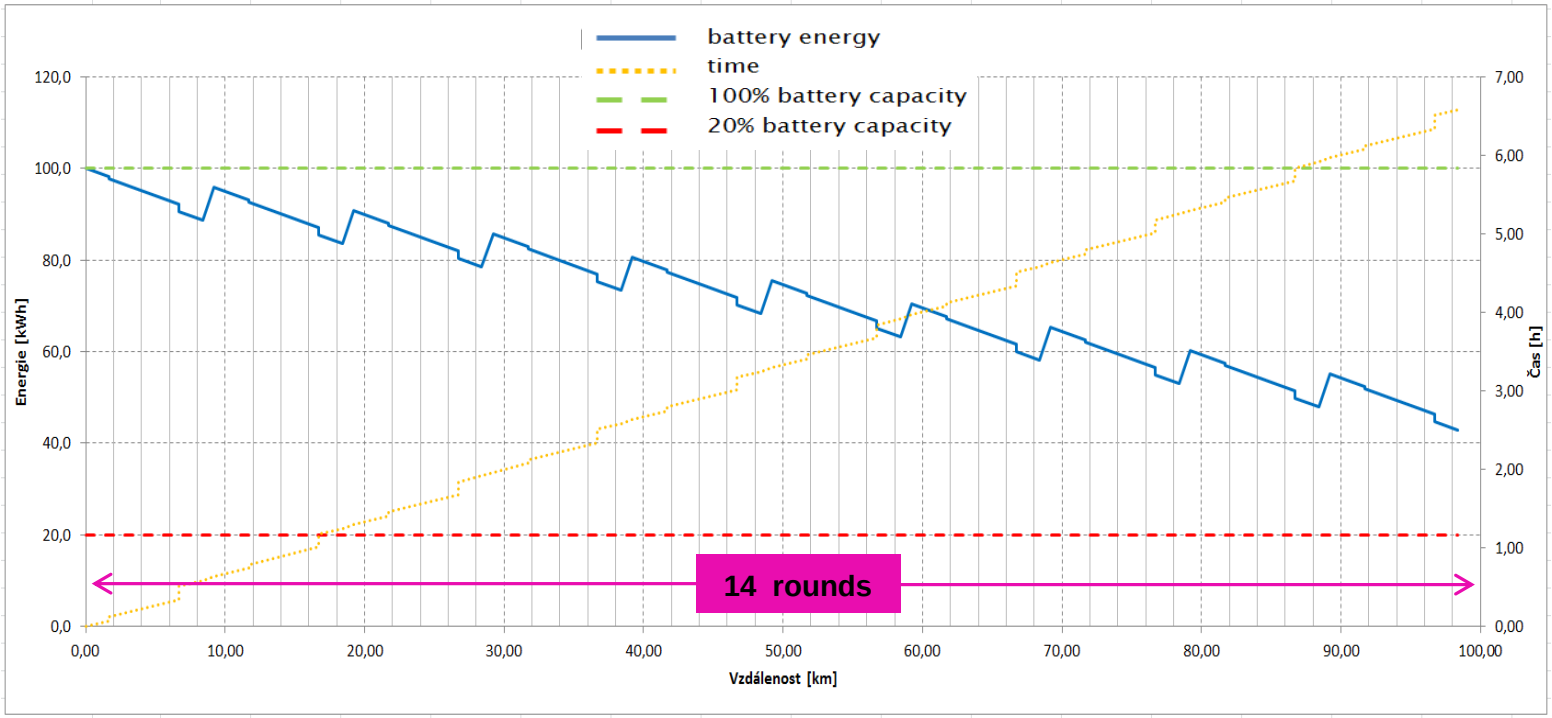
- 55% consumption (heating OFF): **1,1 kWh/km** (50% time on terminals)
- 20% of battery capacity: **∞ hours, ∞ km** (**∞ hours, ∞ km**)



Outcome of the study

Simulation of operational cycle - influence of vehicle consumption

- 55% consumption (no T1 charging): **1,1 kWh/km, 50%** time on terminals, **no charging T1**
- 20% of battery capacity: **9,5 hours, 150 km**



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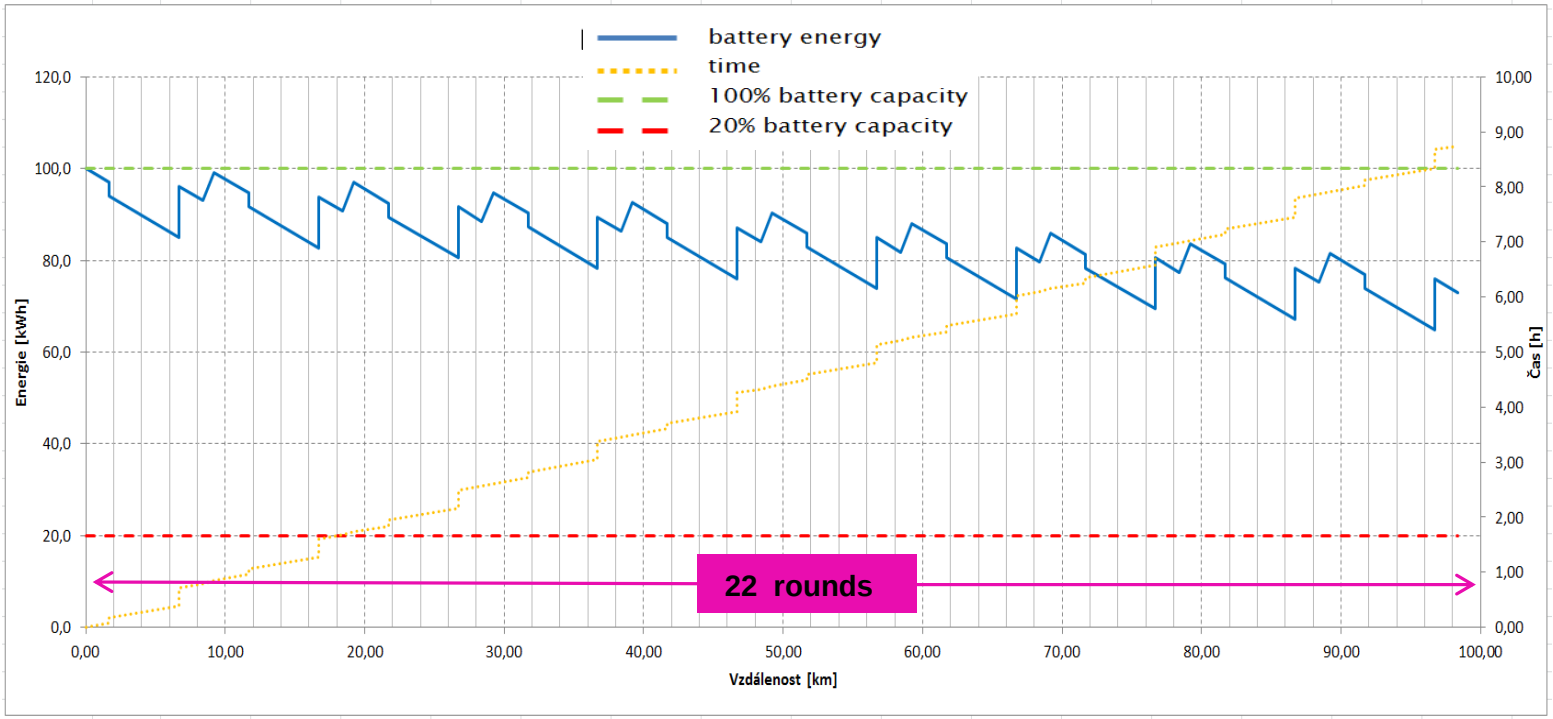
Outcome of the study

Simulation of operational cycle - influence of vehicle consumption

- 90% consumption (incl. heating): **1,8 kWh/km**
- 20% of battery capacity: **19,5 hours**, **230 km** (+60 km compared to initial param.)



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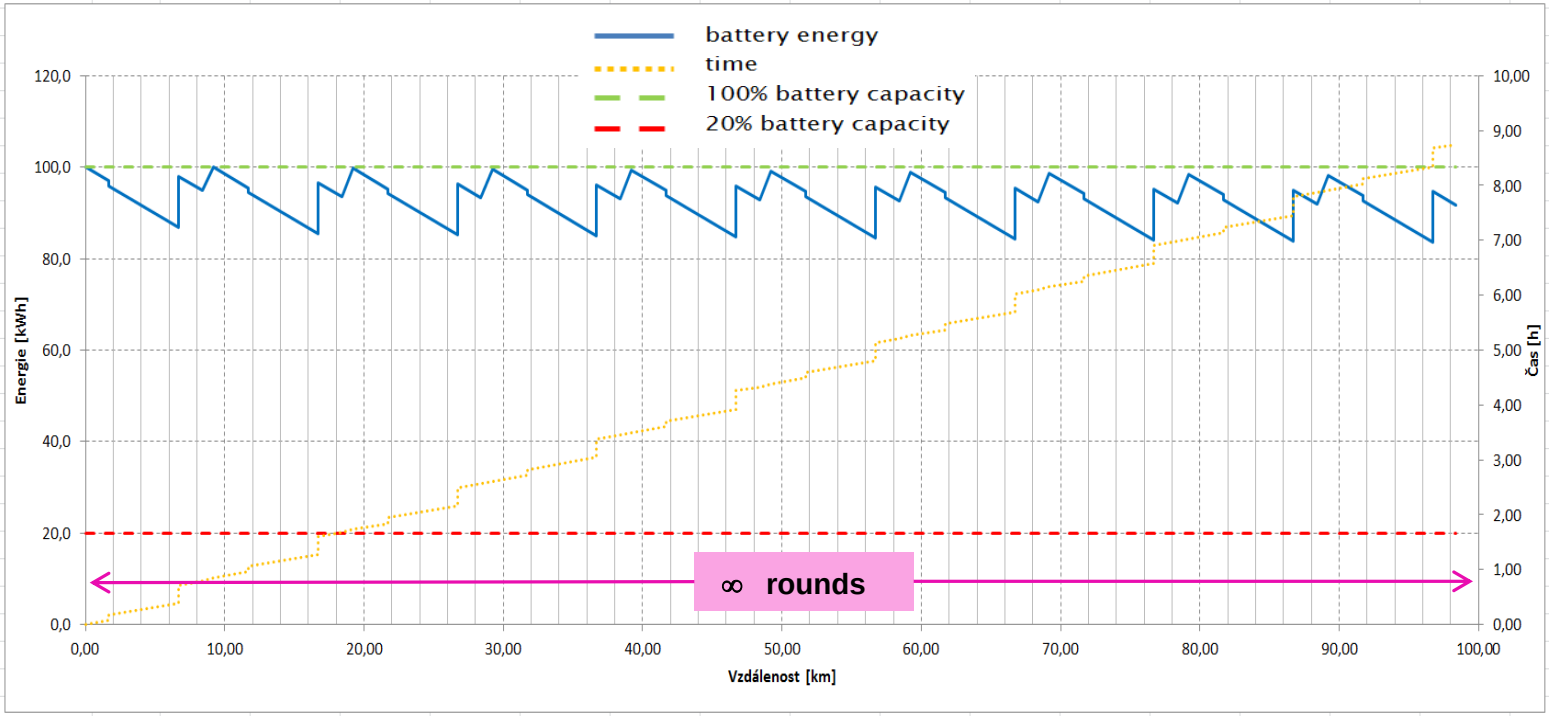
Outcome of the study

Simulation of operational cycle - influence of vehicle consumption

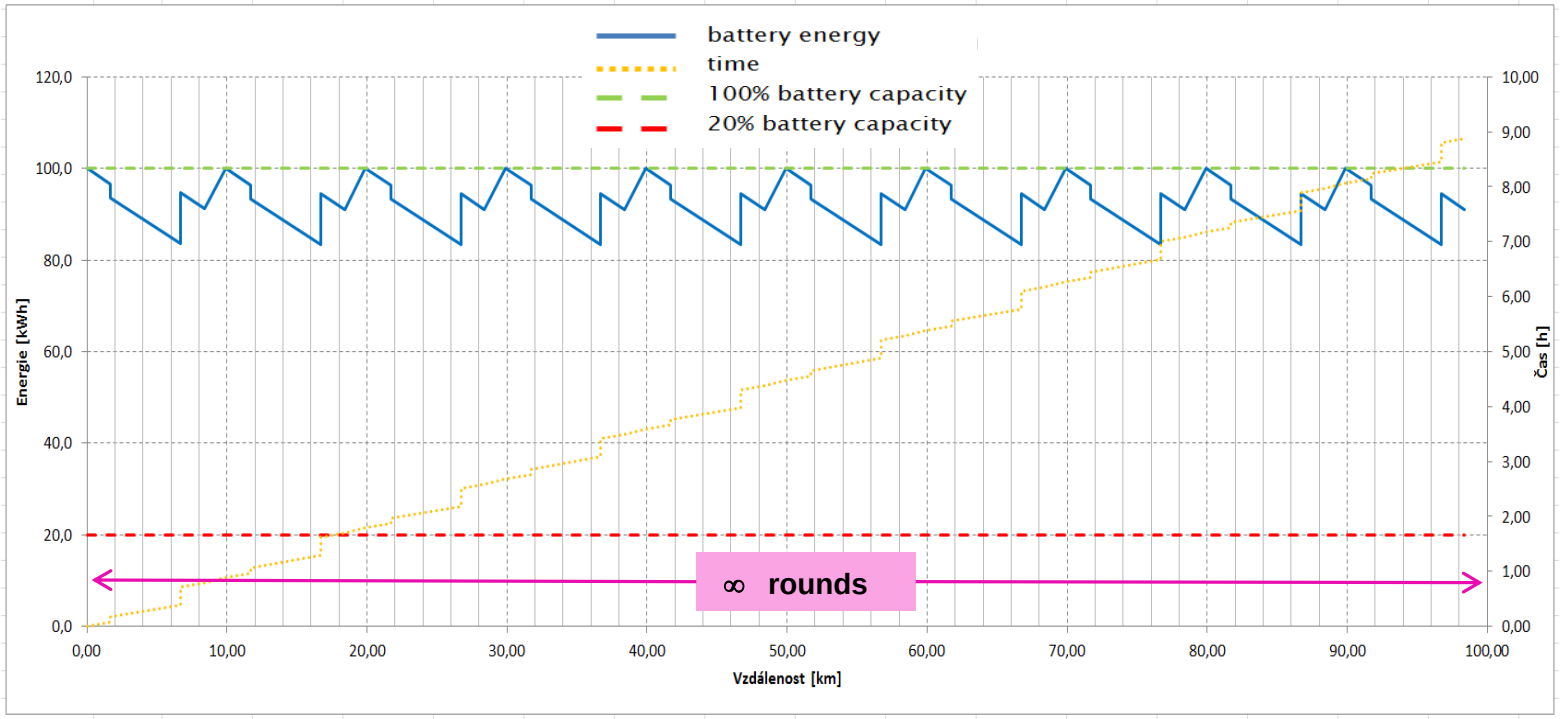
- 90% consumption (incl. heating): **1,8 kWh/km** + no heating on T2
- 20% of battery capacity: **∞ hours, ∞ km**



Outcome of the study

Simulation of operational cycle - influence of OHL length

- 88% OHL more (1500 m / 1700 m): **+700 m**
- 20% of battery capacity: **∞ hours, ∞ km**



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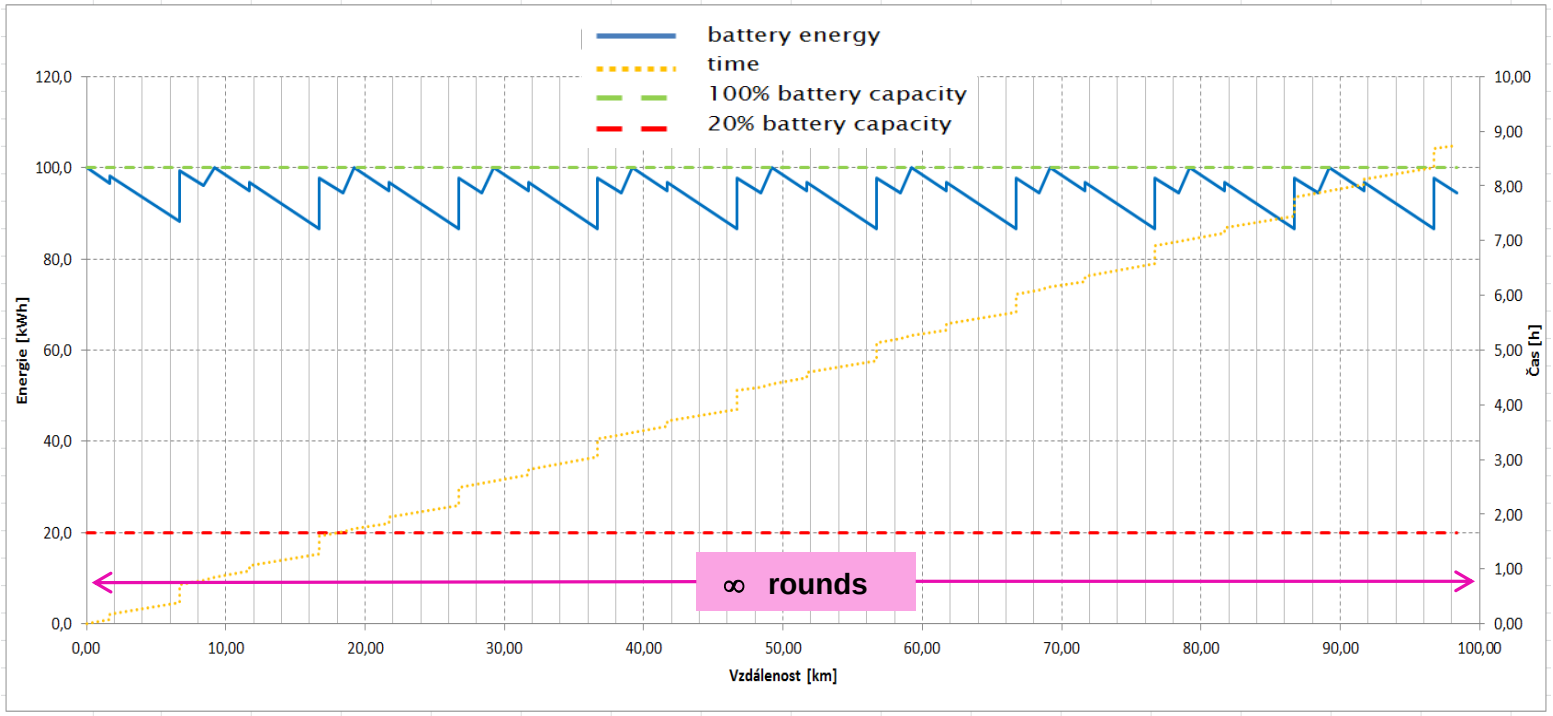
Outcome of the study

Simulation of operational cycle - influence of additional static charging (T2)

- Additional charging place at T2: **120 A / 4 min** (10 / 8 min each terminal!)
- 20% of battery capacity: **∞ hours, ∞ km** (17 hours, 215 km)
- 

Conclusion

General conclusion

- Dynamic charging could bring new possibilities of operation

  => Define your intentions and possibilities carefully

- Many parameters have an impact on operation of the bus/line

  => Optimize all parameters („project“)

- Design (consumption) of the heating is one of the „key“ parameters

  => Put emphasis on design and control („management“) of the heating

- Charging voltage and current determine energy and charging time

  => OHL and bus parameters should go „hand in hand“

- There is no „the best“ solution for everybody…

  => … but there is just „the best“ solution for each …

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Thank you for your attention