

**TURKU AMK**

TURKU UNIVERSITY OF  
APPLIED SCIENCES



# Electric Buses in Turku

**Linkker**

Markku Ikonen 30.11.2018  
TransDigi



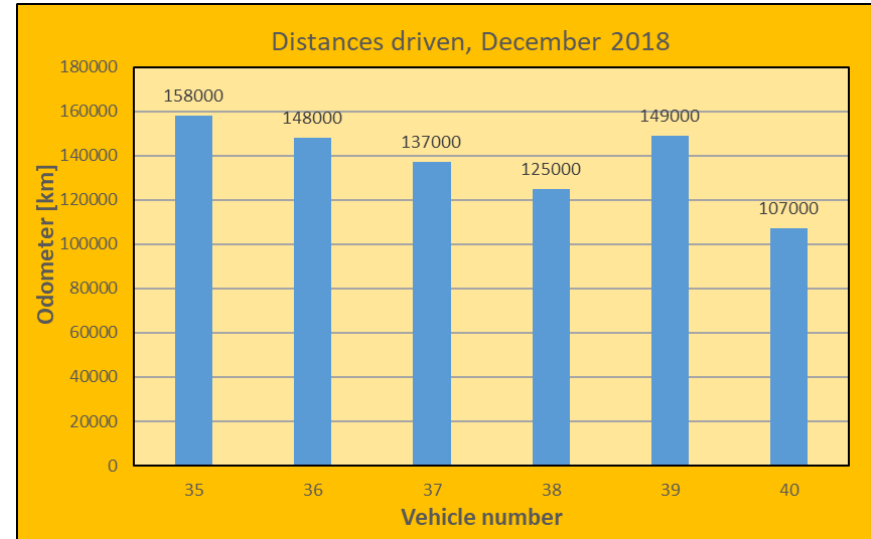
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# General Facts of Operation

- Bus line n:o 1 (Airport – Market Square – Harbor, about 12.5 km)
  - First fully electrified bus line in Finland
  - Service started Oct 1, 2016
  - Six buses in service, last one started in May 2017
  - Total distance driven (six buses): over 820 000 km
  - Maximum daily distance per bus: ~ 350 km





# Linkker 13LE Electric Bus Specifications

- Length 12.8 m, width 2.55 m, wheelbase 6.75 m
- Both body and chassis made of Aluminium
- Curb mass 10 100 kg, payload 5 400 kg, total mass 15 500 kg
- Passenger capacity  $36 + 42 = 80$
- Permanent magnet motor, made by Visedo, 180 kW
- Fixed lowering gear, no transmission
- Programmable instrument cluster with LCD display



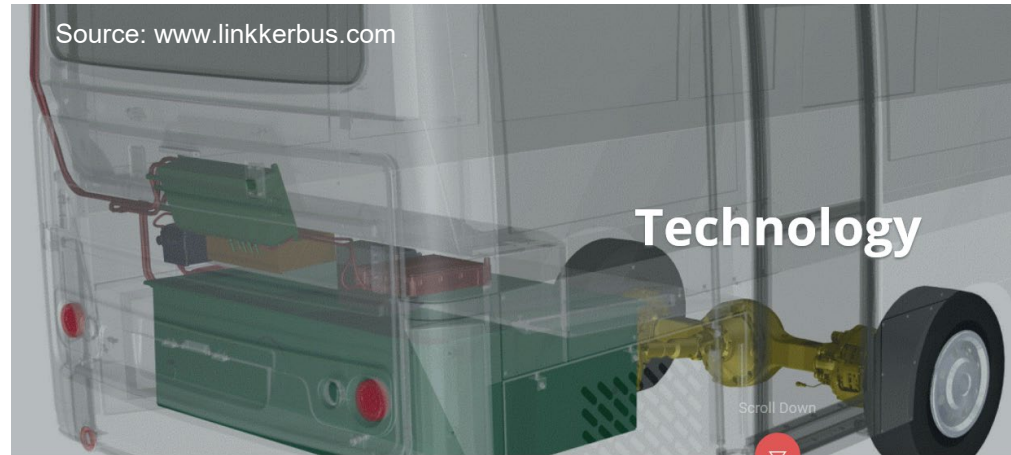
Linkker



# Linkker 13LE Electric Bus

## Battery and Recharging

- Lithium-titanate-oxide battery, 55 kWh
  - Manufacturer Actia, France
  - Recharging power 300 kW
  - Driving range 30 – 50 km
- Fast Charging
  - Inverterd pantograph
  - Both ends of line (12.5 km)
  - Every time, 3 – 5 min
  - No slow-down of operation
  - Max sessions per day:  
30 – 35
- Slow Charging
  - 6 chargers at depot, 22 kW / 50 kW
  - 2 – 3 h / 1 – 1.5 h





# Linkker 13LE Electric Bus Auxiliaries

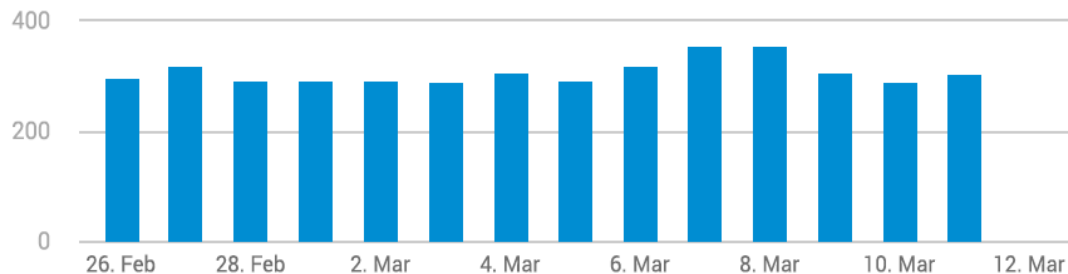
- High voltage also used for
  - Heat pump (15 kW / 15 kW)
  - Air Compressor
  - Power Steering
  - DC / DC Converter (for 24 V)
- Diesel fueled additional heater (Eberspächer 24 kW) for temperatures below  $-5^{\circ}\text{C}$ 
  - Fuel tank 40 liters



# Linkker 13LE Electric Bus

## Examples of Data Collection

### Daily distance/recharging, 2 weeks



● Series 1

Total for period

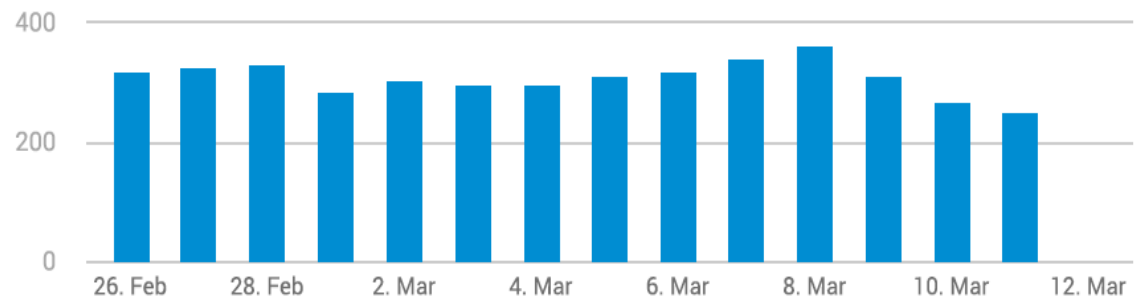
4309 km

Daily Average

307.8 km

Average Speed

25.6 km/h



● Series 1

Total for period

4316 kWh

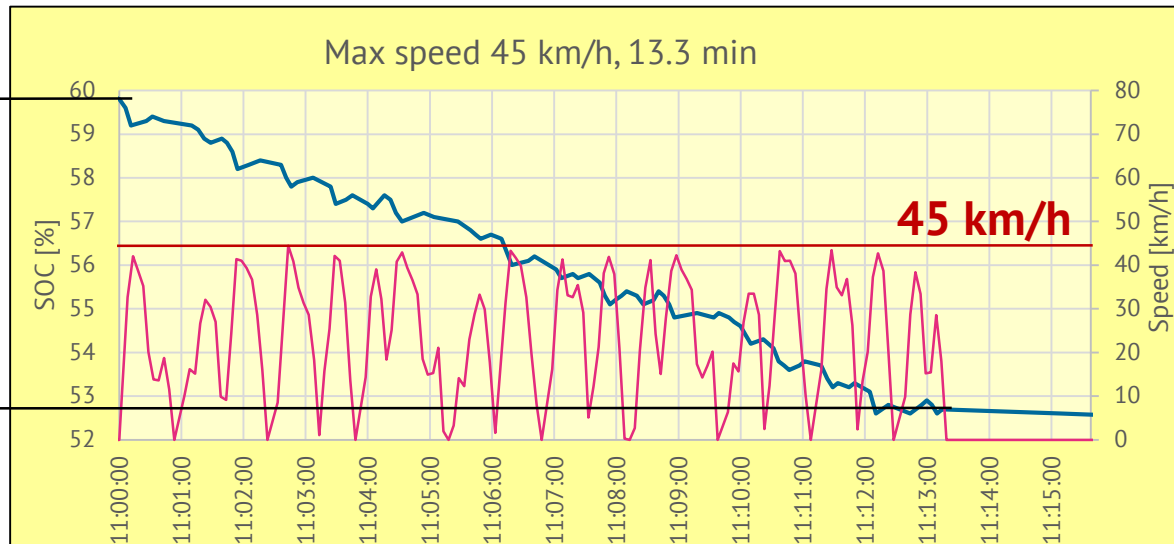
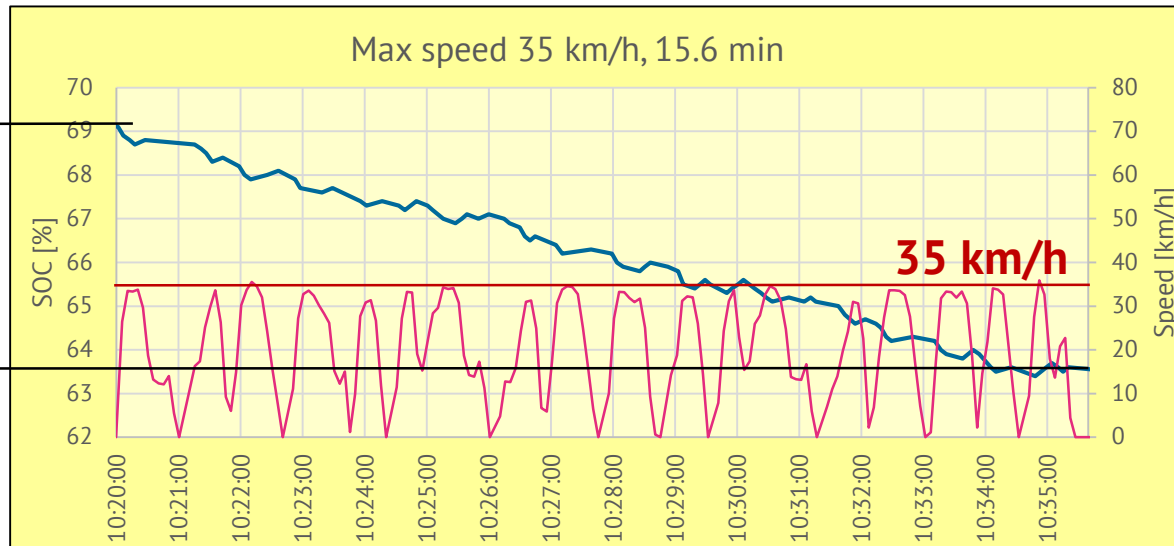
# Linkker 13LE Electric Bus

## Data Collection, line simulation: 5.4 km

$\Delta$ SOC 5.5 %

Consumption  
increase  
~20 %

35 => 45 km/h





# Linkker 13LE Electric Bus Training

- Initial training at beginning of service
  - Drivers (bus operation)
  - Rescue workers (safety)
  - Towing company
- Economical Driving training for drivers (~100) after 1 yr
  - Moderate max speed (~40 km/h)
  - Rapid accelerations
  - Mild and early decelerations
  - Anticipation: Avoiding braking as much as reasonably possible, maintaining the speed gained



# Linkker 13LE Electric Bus

## Experience and Conclusions

- The bus is energy efficient battery-to-wheel ( $\sim 1$  kWh/km)
  - Grid-to-wheel consumption higher than battery-to-wheel
- More quiet than diesels
- Smooth ride (no gear changes)
- Occasionally somewhat lower share of on-time departures than with diesel
- System reliability (bus and re-charging devices) lower than for diesel
  - Reliability increasing

