ASSURED Open Workshop
Planning & Operation electric buses

Marc Vanhoutte
Bus Fleet Director
Transdev group

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Operation with articulated BEB

Parameters

34 bus routes = 34 buses + 3 technical reserve = 37 buses

Estimated energy consumption: 1,6 kWh/km

Daily km load: 300 km with high passenger transport capacity

Commercial speed: 20 – 27 km/h

Defining the size of the battery pack

Energy needed: 300 km's daily with 1,6 kWh/km = **480 kWh**

We need to calculate with battery fading, assume that 20% battery fading is acceptable (remaining 80% of initial SOC).

The battery pack will need to be 80% SOC = 480 kWh

100% SOC = 480/0,8 = **600 kWh**

We cannot use the batteries till 0% SOC, assume that we need to discharge at the max till 15% SOC

15% of 600 kWh = 90 kWh. We need a battery pack with **690 kWh** capacity

Operation with articulated BEB

Conclusions

LFP and NMC batteries have a weight of around 40 Wh/kg

690 kWh would mean a weight of 4.900 kg without housing.

This is not acceptable because of the need of a high passenger capacity.

Battery pack size available – opportunity charging e-bus

Battery pack proposed with a capacity of **180 kWh**

The battery pack weight is 1280 kg or a saving of around 3600 kg.

The available energy at 80% SOC = **144 kWh**

We cannot use the batteries till 0% SOC, assume that we need to discharge at the max till 15% SOC

15% of 144 kWh = 22 kWh.

The operational availability of the pack = **122 kWh**

Range on one charge = 75 – 80 km

Charging articulated BEB

Charging strategy

Battery technology: **NMC**

Authorized charging speed: **1,5 C**

Allowed charging capacity: 180 kWh x 1,5 C = **270 kW** charger capacity

Chargers chosen for fast charging: **Heliox 300 kW**

The BMS (Battery Management System) will limit the charging power towards 270 kW.

Maximum charging time: **40 min.** (when charging the full capacity of 144 kW when batteries are new)

Minimum charging time: **13 min.** (after one hour of operation)

Daily charging sessions: **3 to 4** depending on total km-load

Max. daily operation on one charge: **3 hours**

Charging articulated BEB

Charging equipment

Chargers for fast charging

Fast charging doesn't have to happen for all buses at the same time.

The buses that are starting the operation during the morning are coming back after only one hour of operation (nevertheless they started the operation fully charged).

The charging planning learns us that 10 fast chargers are enough.

Grid capacity needed = 2,7 MW or 3 MVA

For the purpose of exchanging buses for charging, 6 additional buses are needed: total fleet 37 + 6 = 43 electric articulated buses.

Charging articulated BEB

Charging equipment

Chargers for slow charging

NMC battery technology need balancing the battery cells once every day, this is done during the slow charging sessions at night.

There is minimum **4,5 hours** available for slow charging the complete fleet.

Charger chosen: Heliox with a capacity of **30 kW**

Max time needed for charging: 144 kW/30 kW = **4,8 h this** is when the battery capacity has been used completely which is never the case.

Number of chargers: To be able to have them all charged during the night we need one charger per vehicle.

We can also use the fast chargers for slow charging during the night.

We programmed these chargers at **60 kW** so that we can charge 2 buses on each fast charging position, this is covering 20 buses.

We installed 22 slow charging positions so we cover 42 buses for charging during the night.

Operation with articulated BEB

During the day:

Fast charging position for 2 buses. First bus is charged with 270 kW. Second bus is connected to the same charger, but is waiting to start charging from the moment the first bus is fully charged.

During the night:

First bus is charged with 60 kW. Second bus is awaiting to start charging from the moment the first bus is fully charged.

Thank You!

Marc Vanhoutte
Marc.vanhoutte@transdev.com

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