Charging Options for E-bus

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Basics of E-Bus

Types

Batteries

Charging
Batteries

- Specific Energy
- Specific Power
- Safety
- Lifespan
- Operating temperature
- Cost/kWh

Exhibit 2. There Are Tradeoffs Among the Five Principal Lithium-Ion Battery Technologies

Source: BCG research.
Note: The farther the colored shape extends along a given axis, the better the performance along that dimension.
LTO permits the highest charging power of all technologies, however, owing to its comparatively low energy density, it has the lowest capacity. LTO is only applicable in opportunity-charging systems.

NMC enables the largest capacity as well as high charging power and therefore lends itself both to AC and DC.

LFP is only feasible in slow-charging situations.

Charging

Technologies

• **Conductive**

• **Inductive**

• **Battery Swapping**

Equipment

- **AC Charging**
- **DC Charging**

**Charging Equipment**

- **Slow Charging**: charging power of less than 50 kW (20 – 50 kW), is typically done at depots, done overnight
- **Fast Charging**: charging power of 50-150 kW is done at Terminals and major points accessible by the buses in the city, and is prevalent more during the day-time, when the bus operations are at high levels.
### Comparison between Depot Charging Only vs Depot Charging + Opportunity Charging

<table>
<thead>
<tr>
<th>Depot Charging Only/Slow Charging</th>
<th>Depot Charging + Opportunity Charging</th>
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<tbody>
<tr>
<td>• May need extra fleet to cover along high demand corridors</td>
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<tr>
<td>• Less cost of charging infrastructure</td>
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<tr>
<td>• High upfront cost due to large battery</td>
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<tr>
<td>• Adherence to service schedules with lesser fleet size</td>
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<tr>
<td>• Need additional charging infrastructure. Cost may go up.</td>
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<tr>
<td>• Lower battery size can be used resulting in lower bus cost</td>
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</tbody>
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Charging Interfaces

- Plug in
- Automated
- Induction
Charging Standards

- The Japanese CHAdeMO standard,
- The European Combined Charging Standard (CCS), which is also applied in North America, and
- The Chinese GB/T standard or protocol.
Smart charging systems are software-based solutions that allow its users to achieve certain objectives such as capping the peak power demand by intelligently controlling and phasing the charging cycles of buses over time.
Thank you!

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