C40 CITIES FINANCE FACILITY

Charging Options for E-bus

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Supporting Zero-Emission Bus Webinar Series
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Basics of E-Bus

Types

Batteries

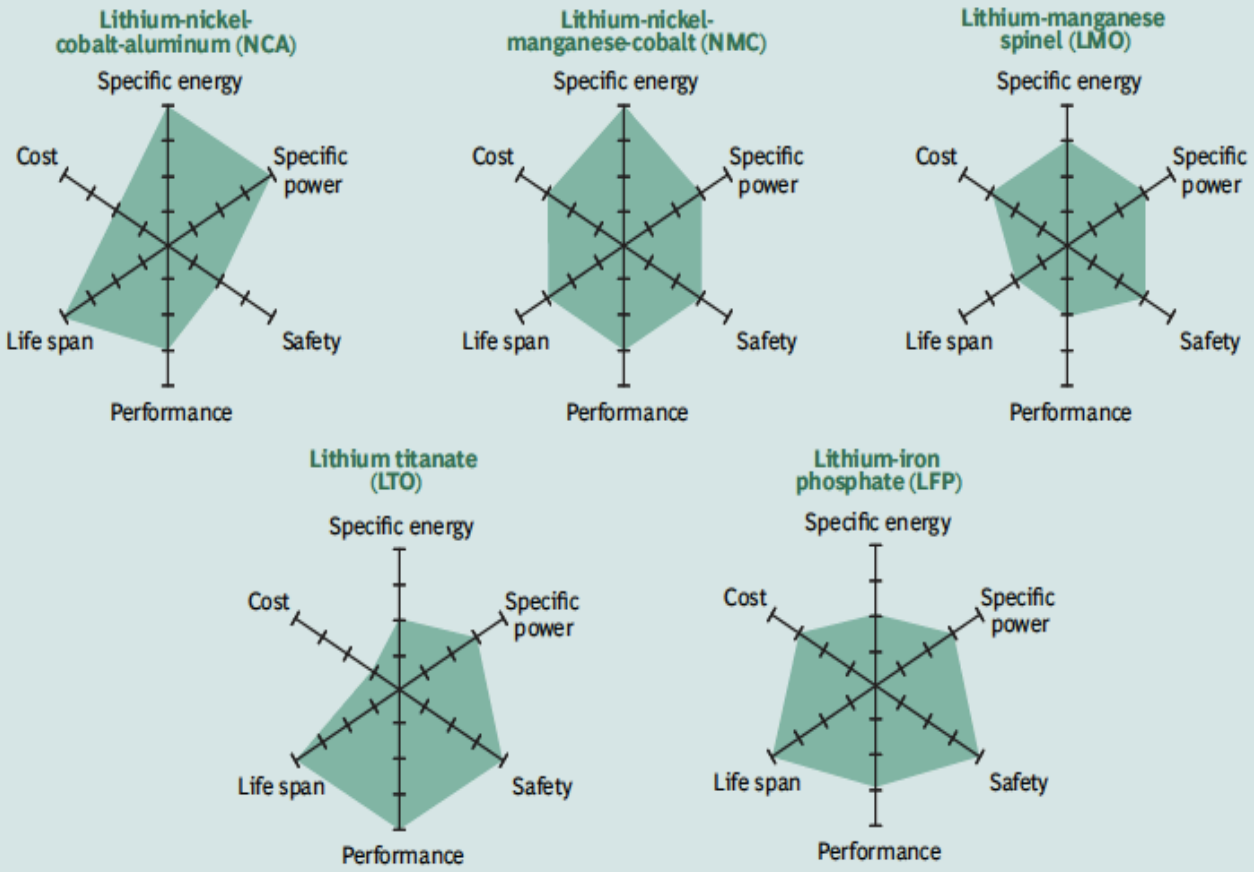
Charging

Batteries

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.

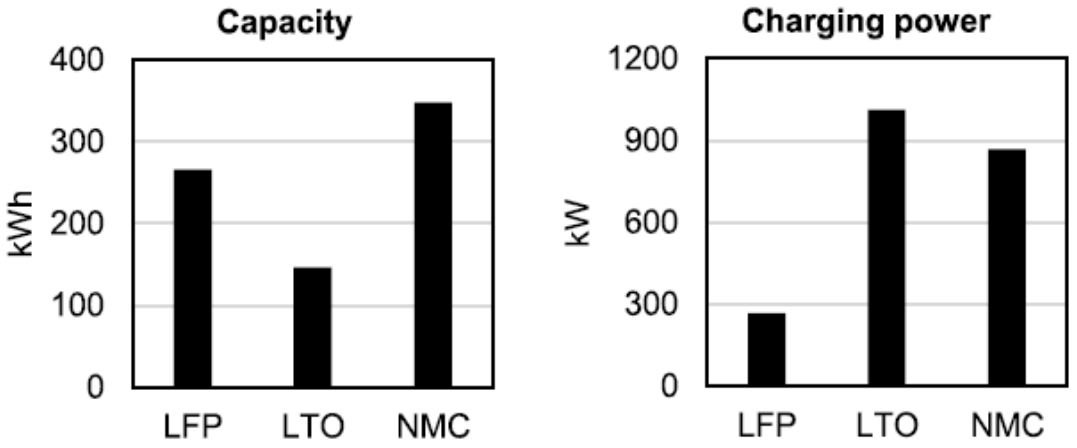
Batteries

Batteries

LFP

LTO

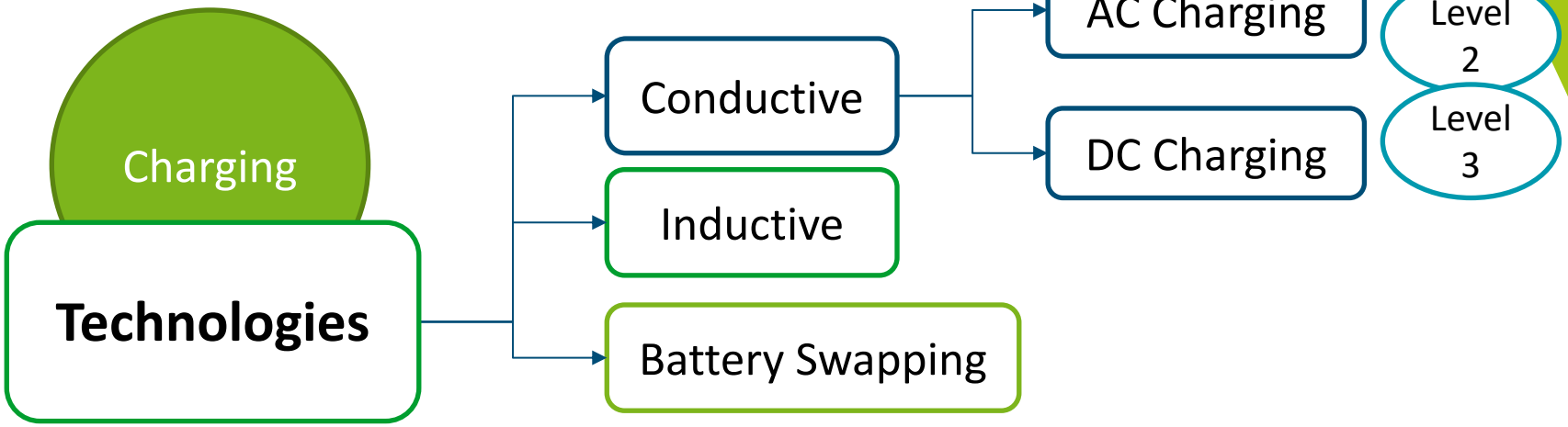
NMC



Source: Göhlich, Dietmar & Fay, Tu-Anh & Jefferies, Dominic & Lauth, Enrico & Kunith, Alexander & Zhang, Xudong. (2018). Design of urban electric bus systems. Design Science. 4. 10.1017/dsj.2018.10.

- 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



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.

Charging

Comparison between Depot Charging Only vs Depot Charging + Opportunity Charging

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

Charging

Charging

Interfaces

- Plug in

- Automated

- Induction

Charging

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 System

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.

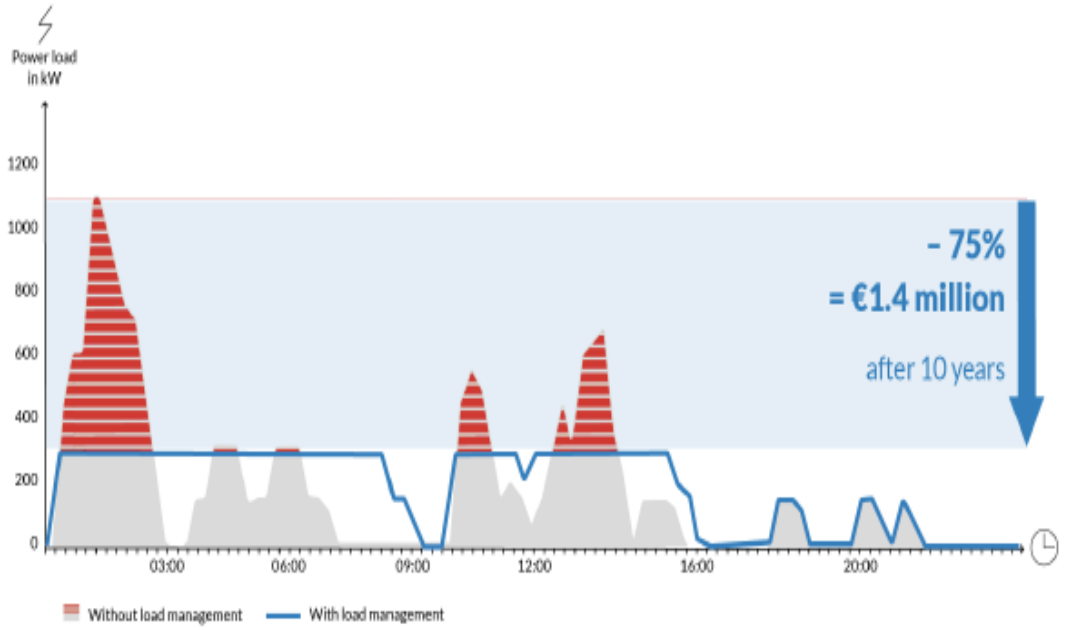


Fig. 2: Comparison of the network load with and without load management for 15 electric buses. Savings calculated over 10 years.

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Thank you!

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