The Deployment of Battery Electric Buses: Benefits, Challenges and Methods

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IFP School ECAV
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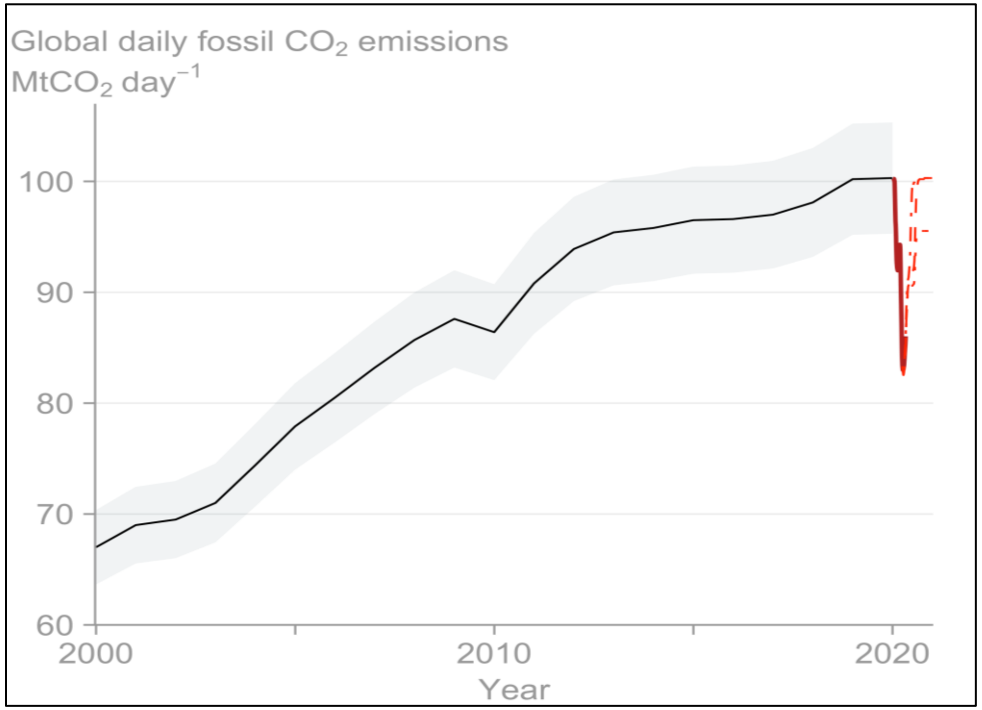
Introduction

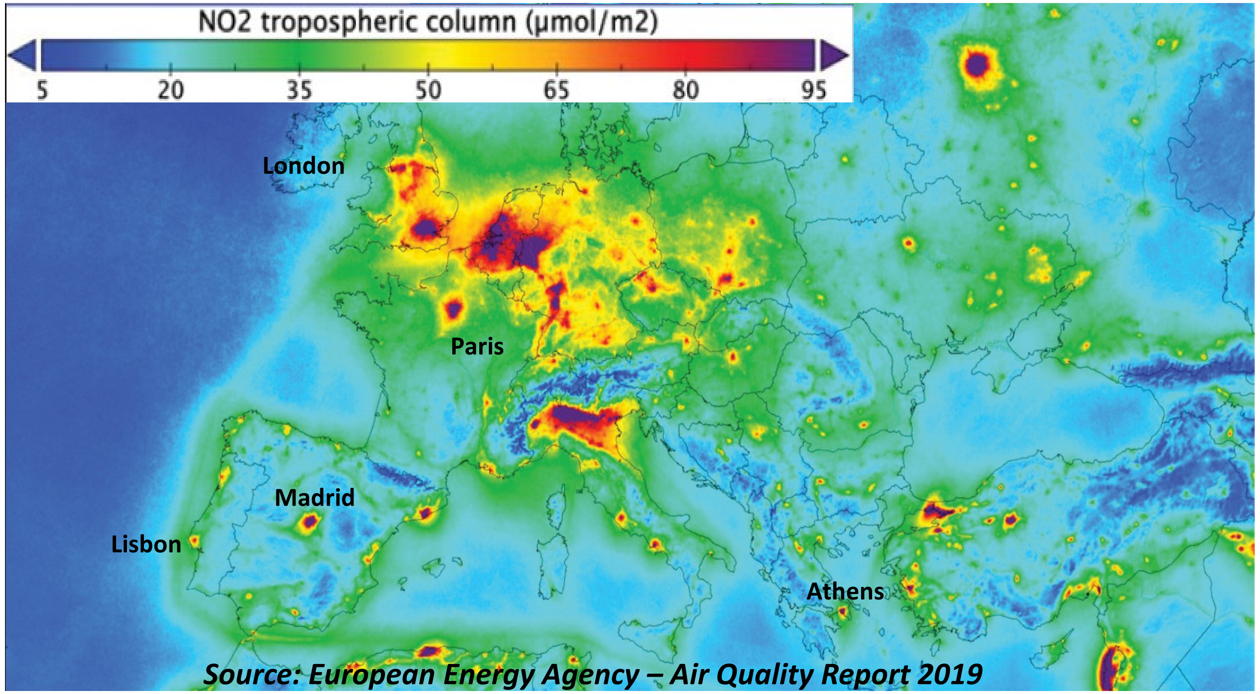
❑ Continuous increase in CO2 emissions

- Increase in global energy demand



❑ Air Quality concerns in European cities

- Diesel Vehicles ~ 40 % of NOx emissions.



❑ Public Transport ~ 6% of GHG emissions

❑ Cities are banning Diesel Vehicles:

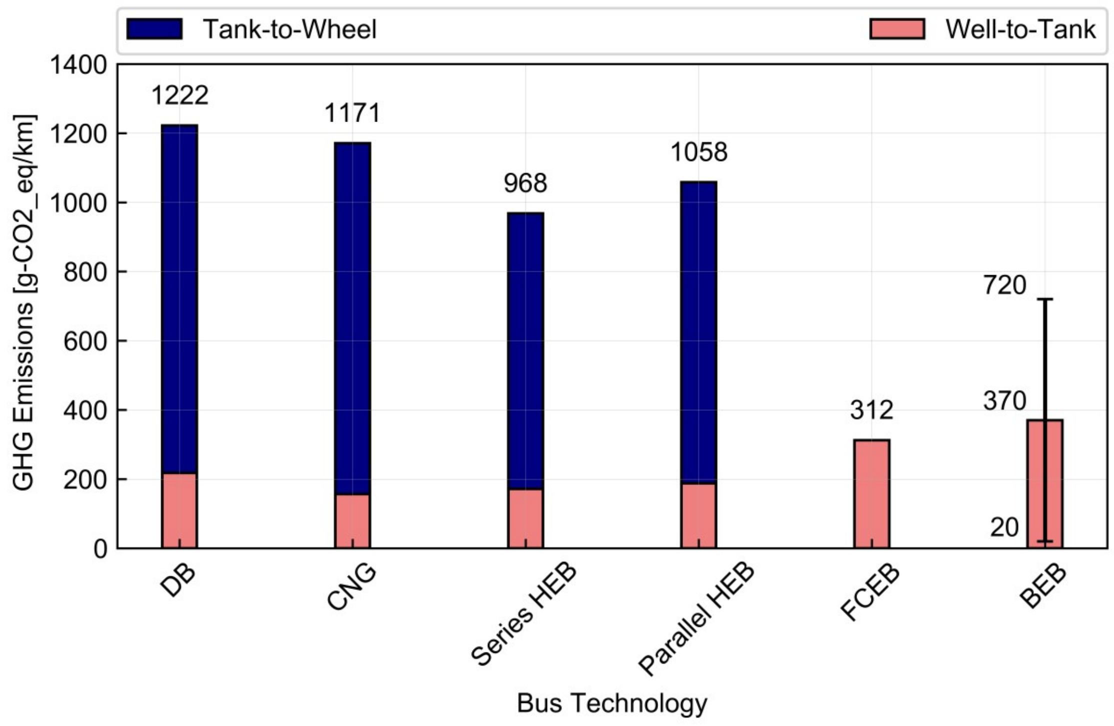
Battery Electric Buses

Outline

Benefits of Battery Electric Buses

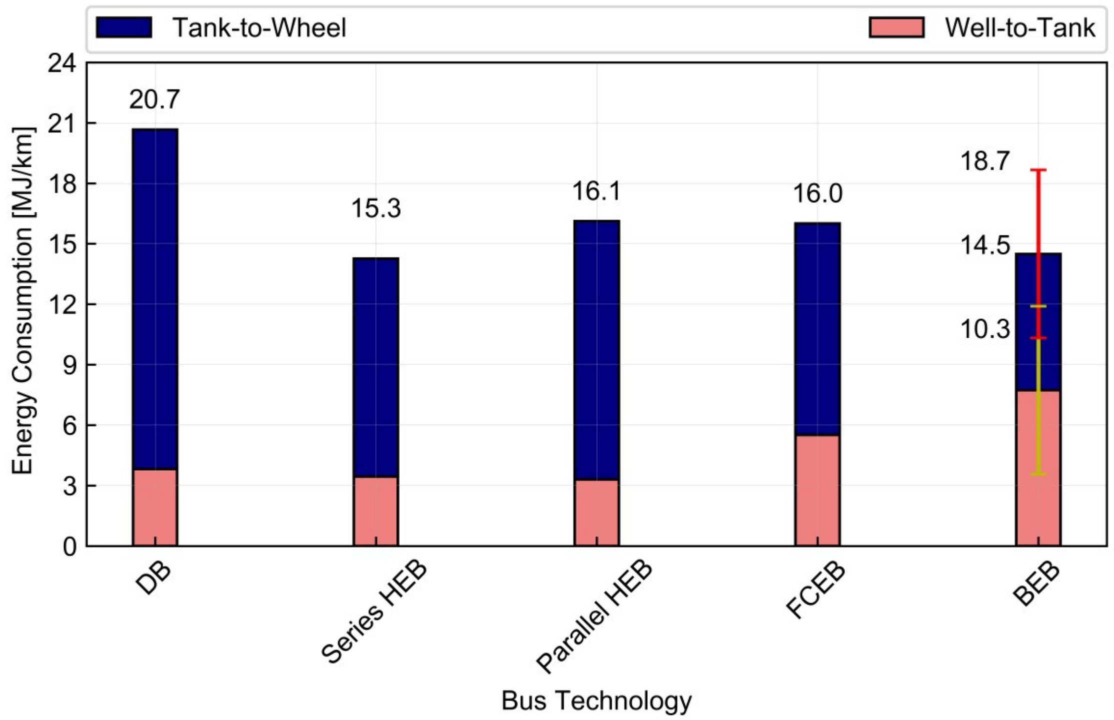
❑ Environmental Performance

- 41 – 98% reduction depending on electricity generation mix



❑ Energy Consumption

- 10 – 50% reduction thanks to powertrain high efficiency



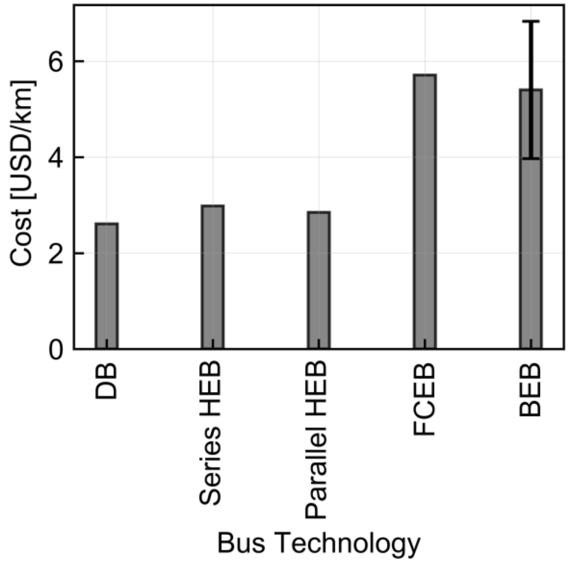
❑ Superior energy and environmental performance over diesel buses and other alternative bus technologies

Outline

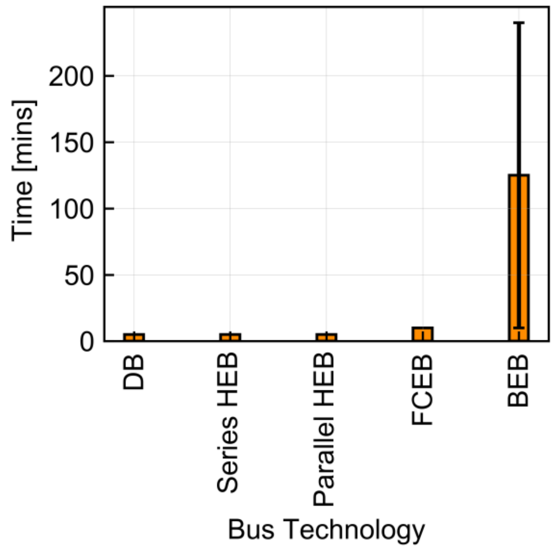
- ❑ Introduction
- ❑ Benefits of Battery Electric Buses
- ❑ **Challenges Facing Battery Electric Buses**
- ❑ Method
- ❑ Results and Discussions
- ❑ Conclusion

Challenges Facing Battery Electric Buses

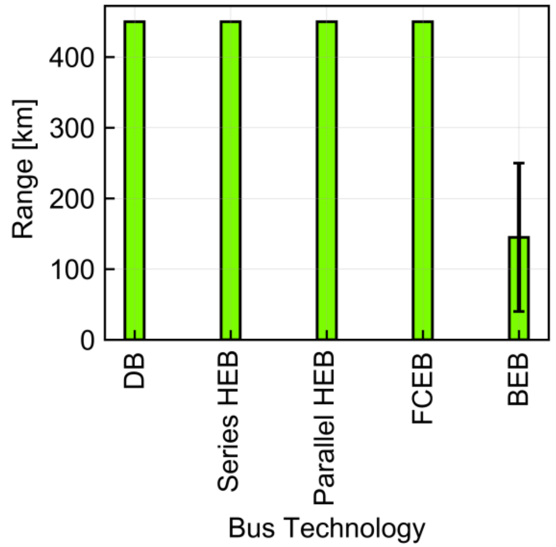
- **Economic Performance**



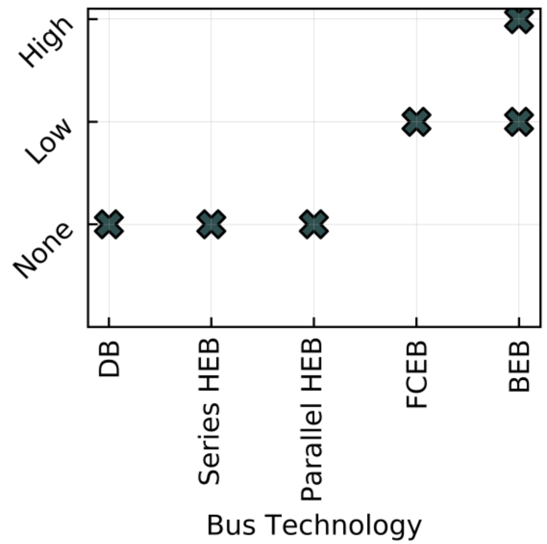
- **Refueling Time**



- **Driving Range**



- **Infrastructure Needed**



- Despite their superior environmental performance and highly efficient operation, BEB are subject to many challenges limiting their massive market penetration

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Method: Outline

Step 1

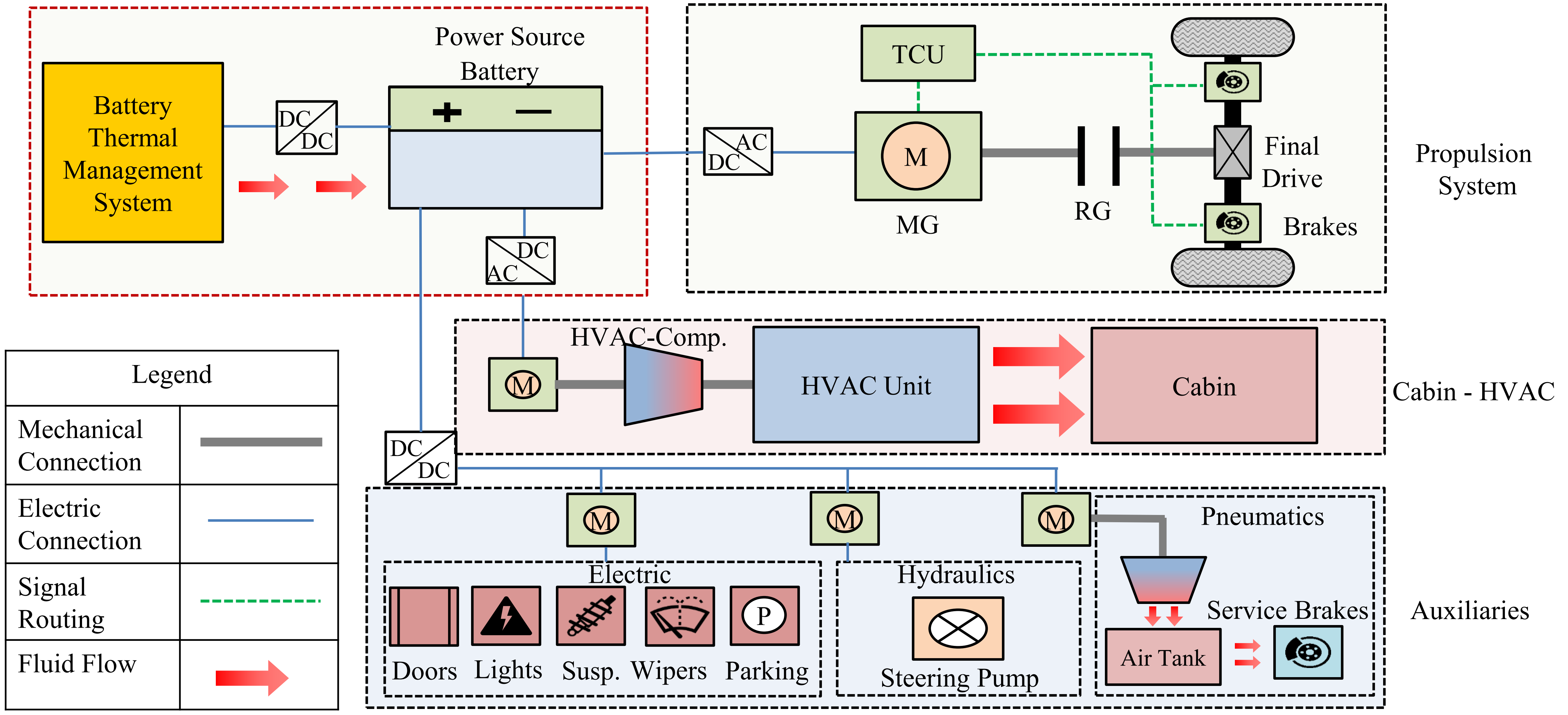
Energy Model and Analysis

→

Step 2

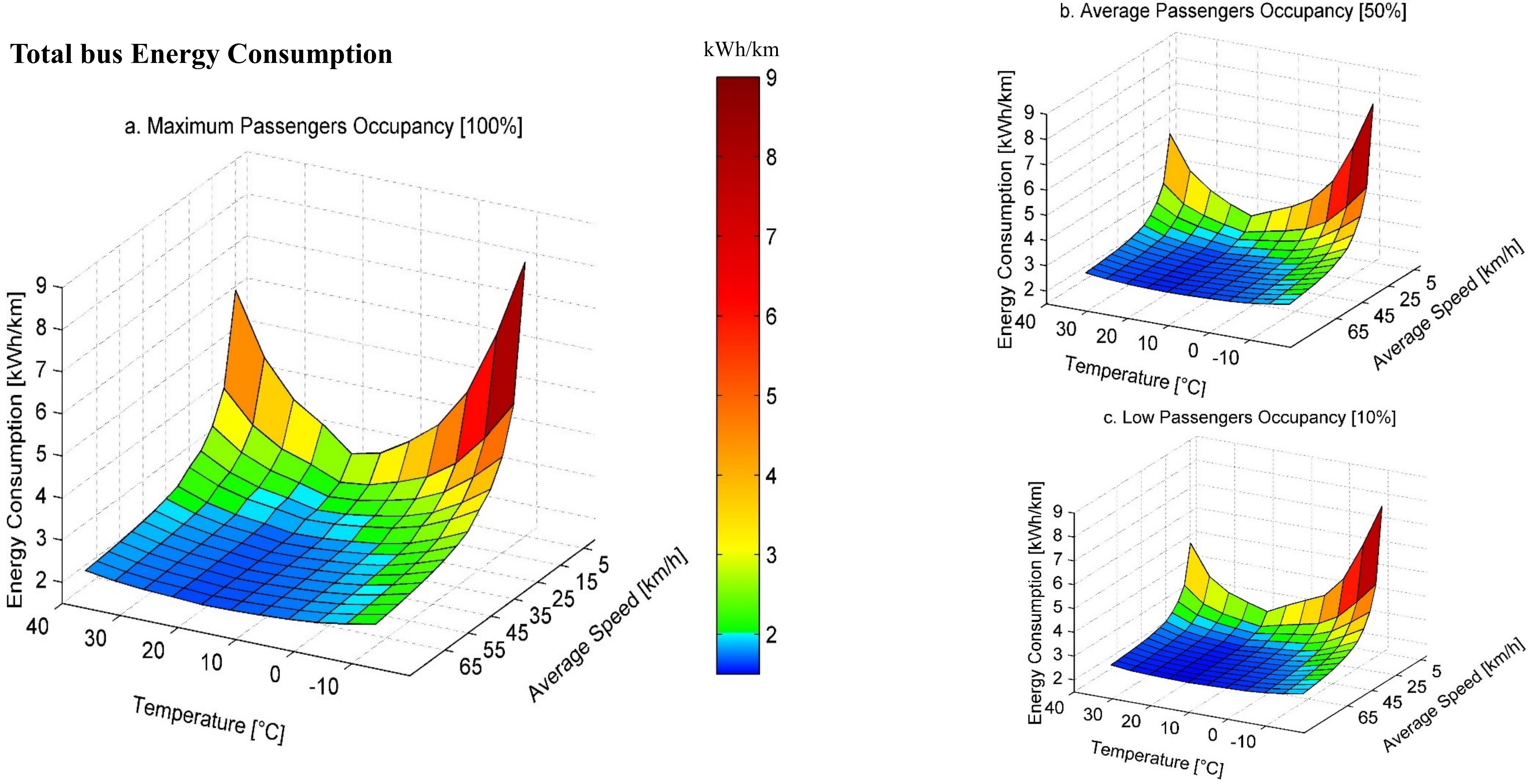
Techno-Economic Analysis

Step 1: Energy Modeling and Analysis

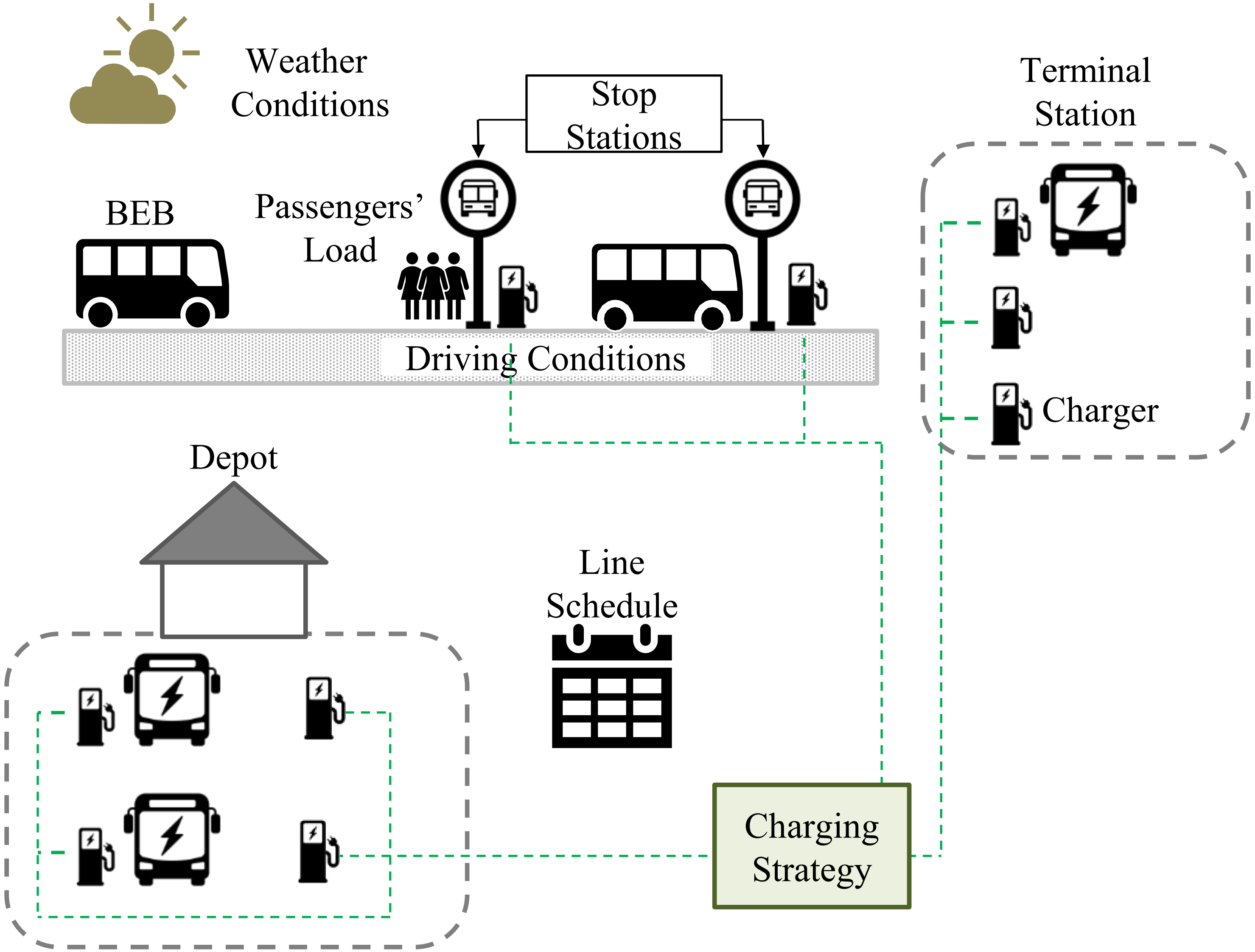


Step 1: Energy Modeling and Analysis

- **Total bus Energy Consumption**



Step 2: Techno-Economic Analysis



Total Cost of Ownership

- Battery Costs
- Energy Costs
- Demand Charge
- Infrastructure Costs
- Battery Replacement Costs

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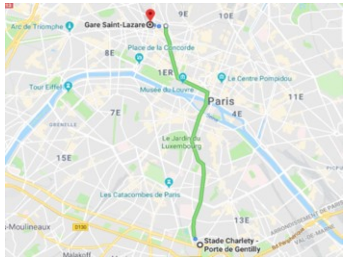
Step 2: Techno-Economic Analysis

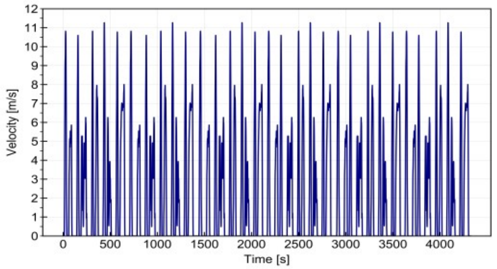
❑ BEB Line Specifications

- Bus line 21 in Paris
- 20 BEBs
- Stade Charlety Paris 13eme to Gare Saint Lazare Paris 8eme



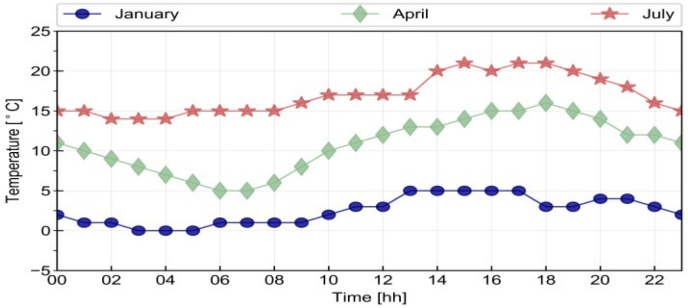
❑ Driving Conditions

- One-way trip is 9.7 km.
- Average duration is 1°, 25'.
- 34 Stop stations / direction
- Depot is One terminal station



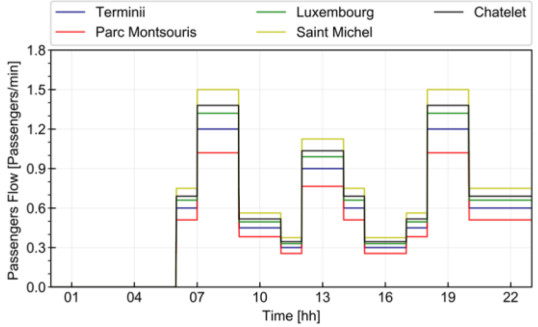
❑ Weather Conditions

- Daily average per month
- 10-year average
- Temperature and solar flux profiles



❑ Passenger's Occupancy

- Passengers' flow data
- Collected over a 3-week period
- June-July 2019



❑ Schedule

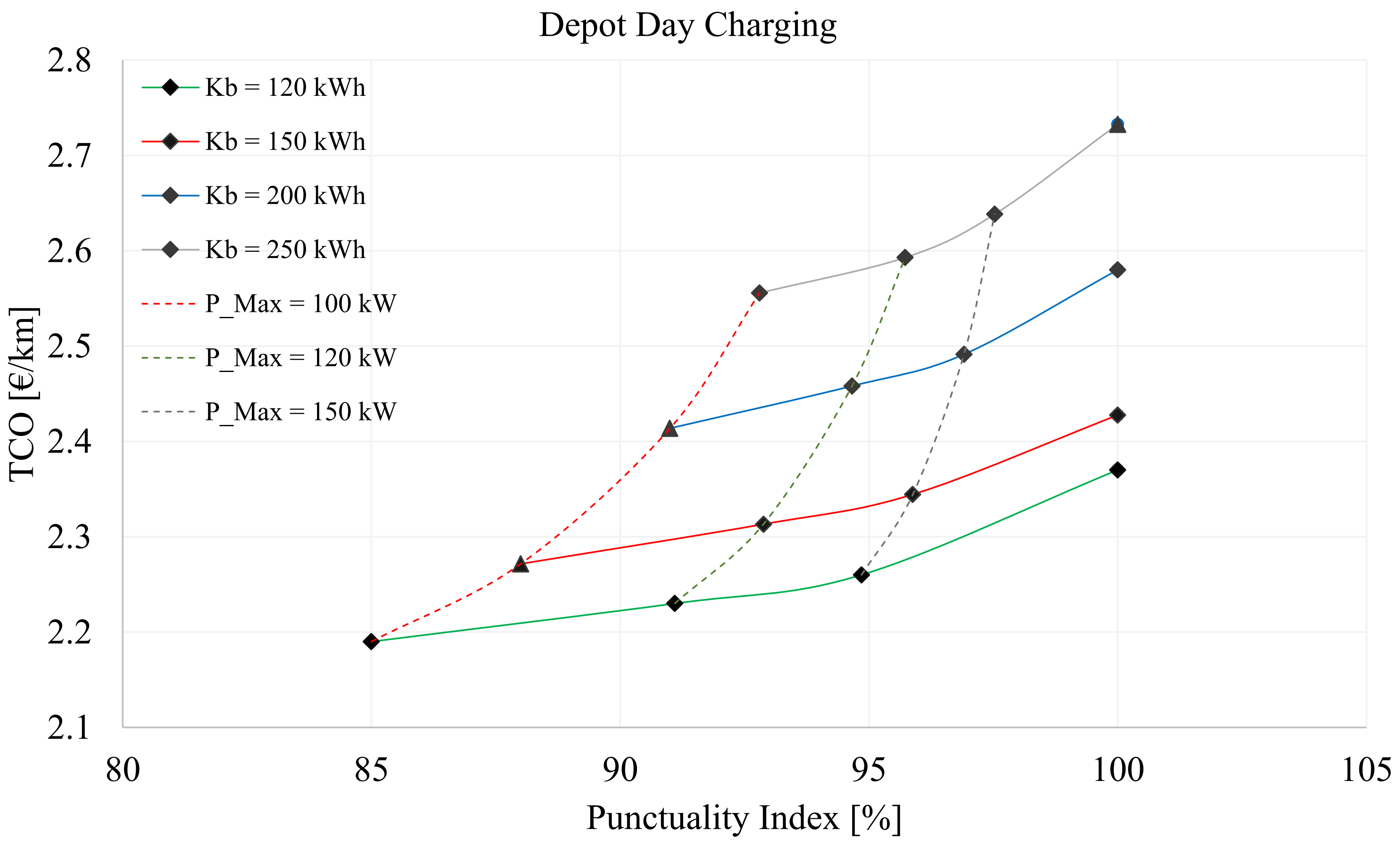
Time [hh: mm]	Bus Frequency [mins]
5:30 - 7:00	15
7:00 - 8:30	8
8:30 -13:15	10
13:15 - 17:45	12
17:45 - 20:00	8
20:00 - 00:30	15

❑ Cost Model Parametrization

Parameter	Value
Cost of battery pack	580 €/kWh
Electric energy tariff	0.17 €/kWh between 6:00 – 23:00
	0.13 €/kWh between 23:00 – 6:00
Battery max capacity fade	0.2 (20%)
BEB end lifetime	12 years

Results

❑ Trade-off(s) between costs and operability



❑ Maximum allowable charging power decreases:

- Reduction in:

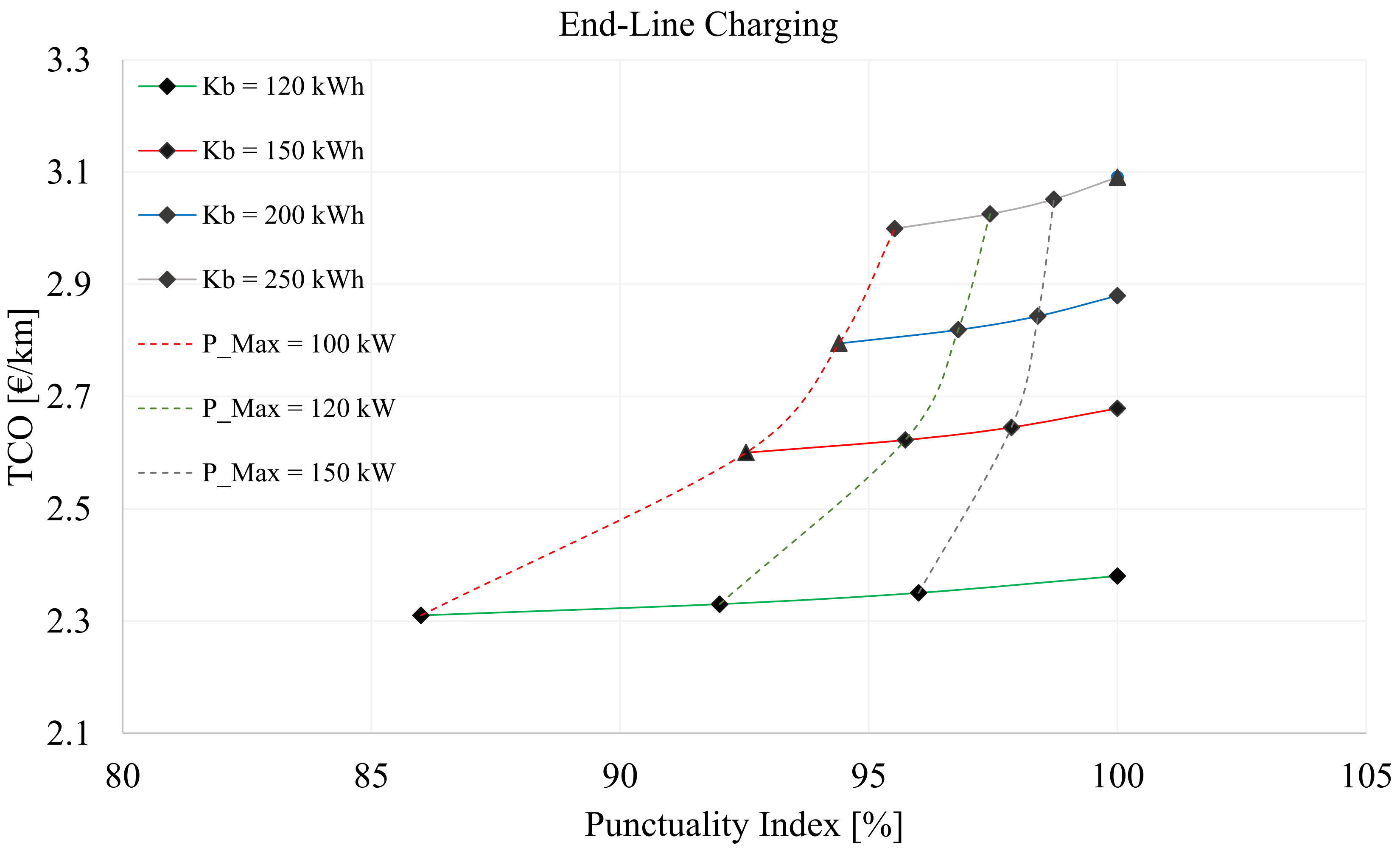
  Infrastructure Costs
  Battery Replacement Costs
  Demand Charge Costs.

❑ Battery size increases:

- Additional Battery Costs and Energy Costs
- Increase in Punctuality Index → lower charging frequency

Results

❑ **Trade-off(s) between costs and operability**



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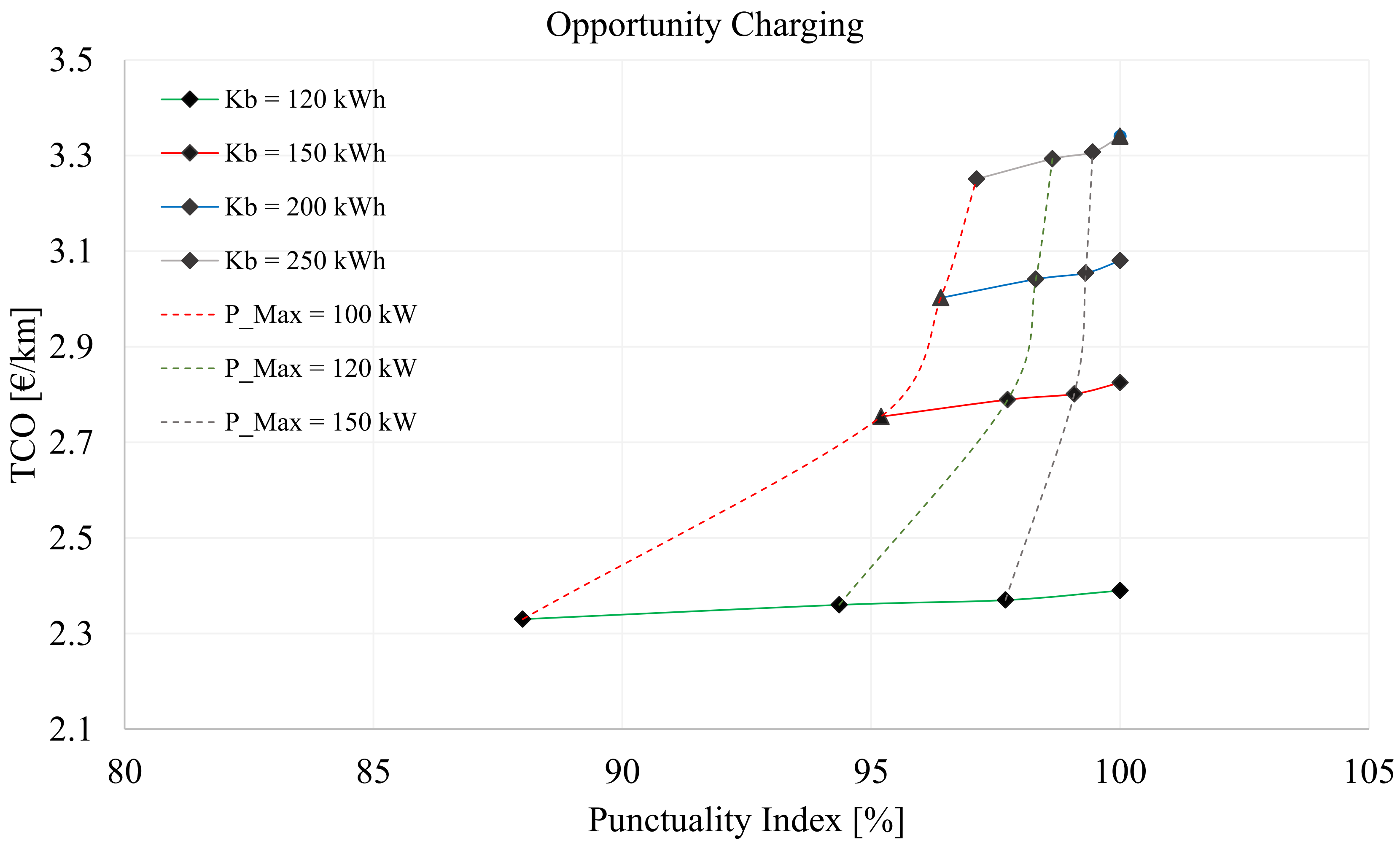

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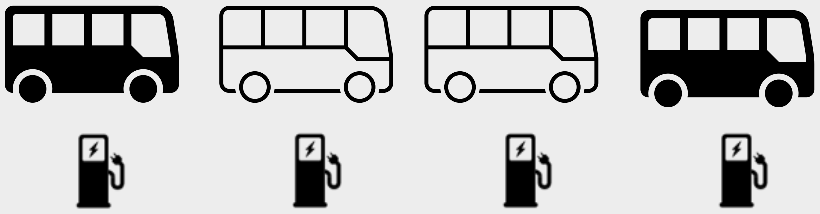
Outline

Conclusions

Deployment of Battery Electric Bus Fleet



Comprehensive Energy Analysis

Techno-Economic Analysis

Optimization of Battery Sizing, Charging Strategy and Infrastructure

- The proposed methodology could be applied to any BEB fleet.

Thank You

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