Impacts of charging methods and mechanisms of zero-emission buses on costs and level of service

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Automation

Elektrification

Information

Sharification
Elektrification / Zero-emission

- 98% ZE-buses in China
- 2025: All new buses in NL: zero-emission
- 2030+: All buses in NL zero-emission
- Most promising: Hydrogen and electricity
Progress in the Netherlands

- > 5,000 bussen in NL

2016
1% electric

2018
5% electric
Charging types

- Battery charging
  - 2.3.1 Battery swapping
  - In-vehicle battery
    - 2.3.2 Slow
      - Plug-in
      - Pantograph
      - Induction
    - 2.3.3 Fast (OC)
      - 2.3.3.1 Static
        - Plug-in
        - Pantograph
        - Induction
      - 2.3.3.2 Dynamic (IMC)
        - On-vehicle pantograph
        - Induction
Impacts of public transport

Framework of 5 E’s

- Effective mobility
- Efficient city
- Environment
- Economy
- Equity

Zero emission
Focus on environment
What about mobility?

Van Oort et al. 2017
Challenges electric buses

- High investment costs
- Limited radius
- Several charging choices: type, location(s), strategies
Research objective

• Impacts of charging choices on costs and Level of Service
• Supporting trade offs during planning and design

• Focus: bus station
3-step Approach
Goal: Assessment framework

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>1  Disruptions</td>
</tr>
<tr>
<td></td>
<td>2  Delayed departure times</td>
</tr>
<tr>
<td></td>
<td>3  Dispersion in departure times</td>
</tr>
<tr>
<td>LoS</td>
<td>4  Operational delayed vehicle costs</td>
</tr>
<tr>
<td></td>
<td>5  Operational energy/fuel consumption costs</td>
</tr>
<tr>
<td></td>
<td>6  Vehicle investment costs</td>
</tr>
<tr>
<td></td>
<td>7  Charging infrastructure investment costs</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
</tr>
</tbody>
</table>
Modelling approach

1. Calculation charging characteristics, number of buses
   *Charging choices, season, network, timetable, ...*

2. Micro simulation bus station (SimBus)
   *AVL data, design parameters, charging details, ...*

3. Assessment framework
   *Passenger countings, cost-parameters, ...*
Case Schiphol (North)
The world largest opportunity & depot charge network

13 MW
Charging Infrastructure

23 pieces Heliox Opportunity charge
450kW
2-4 min

86 pieces Heliox Depot charge
30kW
At night

100 busses VDL Electric Citea SFLA busses
Schunk roofmounted pantograph

AMSTERDAM AREA

Amstelland-Meerlanden

Amsterdam Airport

Depot charge + Opportunity charge
Depot Amstelveen

Opportunity charge
Schiphol Parking P30

Opportunity charge
Schiphol Parking North

Zero emissions

Passenger heliox
www.heliox.nl
Results 1/2

a. Electric city vehicles

- Delayed departure: €12,000, €10,000, €8,000, €6,000, €4,000, €2,000, €6
- Dispersion in departure time
- Disruptions (%)
- Charging infra investment
- Delayed vehicle costs
- Vehicle investment
- Energy/fuel consumption costs

- OC Induction
- OC Pantograph
- Slow depot charging
- Base case
Results 2/2

b. Electric R-net vehicles

- Delayed departure
  - € 12,000
  - € 10,000
  - € 8,000
  - € 6,000
  - € 4,000
  - € 2,000
  - € 0
  - € -2,000
  - € -4,000
  - € -6,000

- Dispersion in departure time
- Disruptions (%)

- Charging infra investment
- Vehicle investment
- Energy/fuel consumption costs

- Delayed vehicle costs

- OC Induction
- OC Pantograph
- Slow depot charging
- Base case

Challenge the future
Adjusting the timetable: new balance

“Two coffee breaks!

That never happened before on a conventional bus”

‘Twéé pauzes! Dat is me in een dieselbus nog nooit overkomen’

*Elektrische bussen*
Sinds zondag rijdt op Schiphol de grootste elektrische busvloot van Europa. Het is een logistiek karwei: meerdere malen per dag moeten ze worden opgeladen.

Joost Pijpker © 2 april 2018
Decision support

Electric operations

Availability of IMC infrastructure

Yes

No

BRT and (long distance) regional lines

City and (short distance) regional lines

Line type

Costs

Trade-off: costs / LoS

LoS

Suitable locations for OC stations

Yes

No

Depot close to bus station

Trade-off: costs / LoS

LoS

OC at bus station

Frequently use of charging systems and/or short conventional dwell times

Yes

No

More and/or higher power, more expensive charging systems

Less and/or lower power, less expensive charging systems

Depot charging

Consider IMC
Conclusions

- The shift to zero emission bus transport is involved with higher costs and passenger disturbances.

- Benefits of electric operations, including vehicle propulsion cost savings up to 70 percent, are not able to compensate the high investments.

- Our model supports planning choices of charging locations and strategies - extending and updating

- (Slow) depot charging offers opportunities for operations on short distance lines.

- Timetable adjustments needed to maintain LoS: new balance
Questions / Contact

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