Charging infrastructure for electric vehicles in city logistics

Getting zero emission trucks on the road
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CE Delft

- Independent environmental research and consultancy since 1978
- Transport, energy and resources
- Know-how on economics, technology and policy issues
- 60 employees, based in Delft, the Netherlands
- Not-for-profit

Clients

- Industries (Small and medium size enterprises, transport, energy and trade associations)
- Governments (European Commission, European Parliament, regional and local governments)
- NGOs
Charging infrastructure for electric vehicles in city logistics
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Introduction: Policy context

Paris agreement -> Dutch Climate Agreement

Dutch Climate agreement

- In 2025: ZERO emission zone in 30-40 cities in the Netherlands (1 Mton CO₂ reduction)
- Regulation in zones:
  - Only ZE/ PHEV Vans can enter ZE zones
  - Only ZE/ PHEV HGVs can enter ZE zones, with exemptions for existing HGVs at January 2025:
    ◦ Articulated Truck-trailer Euro VI, age < 8 years
    ◦ Box lorries Euro VI, age < 5 years
- Larger cities are developing plans that will be presented this year.
Introduction: Policy context

Important questions:

1. At what location are trucks going to charge:
   - Depot (Private), Customer site (Private), Third party (Public station)?
   - What is role for fleet owners/ distribution centres?
   - What is role of governments

2. What kind of battery packs and charging power is needed for the trucks?

3. What is the geographical spread in energy/ power demand?

4. What is the impact of the energy demand on the electricity network?
Introduction: Scope of study

- Case study on ZE zone in Amsterdam (current environmental zone)

- Effects on charging for Greater Amsterdam

Assumptions

- Logistic profiles remain the same.
- All HGVs will be BEV (no PHEV or H₂)
1: Optimal charging behaviour

Cost optimisation model: scenarios

Scenario 1: No recharging

Scenario 2: Additional charging stop.

Scenario 3: Charging at the customer (delivery address/stop address).
Method: Cost optimisation model
Method: Cost optimisation model
Method: Cost optimisation model

HGVs in analysis
- Small box truck (12t)
  Battery: 80, 120, 160 kWh
- Large box truck (19t)
  Battery: 120, 200, 240 kWh
- Truck trailer (37t)
  Battery: 170, 240, 320 kWh

Preconditions/constraints

Minimisation of costs

Vehicle characteristics

Battery characteristics

Charging station characteristics

Journey profiles

Charging actions

Battery capacity

Charging station capacity

Charging scenarios
Method: Cost optimisation model

Charging solution (Private and public)
- FC 50: 50 kW
- DC Fast charger
- HPC150
- DC super fast charger
- HPC350
- DC ultra fast charger
Results: charging behaviour trucks:

% of kWh charges per location type

<table>
<thead>
<tr>
<th>Sectors in city logistics (HGV)</th>
<th>Fast charging at public station</th>
<th>At depot/distribution centre</th>
<th>At customer site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste collection</td>
<td>15%</td>
<td>85%</td>
<td>0%</td>
</tr>
<tr>
<td>Construction</td>
<td>5%</td>
<td>80%</td>
<td>15%</td>
</tr>
<tr>
<td>Facility logistics</td>
<td>5%</td>
<td>85%</td>
<td>10%</td>
</tr>
<tr>
<td>Catering/ hospitality</td>
<td>5%</td>
<td>85%</td>
<td>10%</td>
</tr>
<tr>
<td>Retail (Food)</td>
<td>5%</td>
<td>75%</td>
<td>20%</td>
</tr>
<tr>
<td>Retail (non-Food)</td>
<td>10%</td>
<td>60%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Results: charging behaviour trucks

<table>
<thead>
<tr>
<th>Charging station</th>
<th>Fast charging at public station</th>
<th>At depot/distribution centre</th>
<th>At customer site</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC50 - private 50 kW</td>
<td>5%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>HPC 150 - private -150kW</td>
<td>80%</td>
<td>87%</td>
<td></td>
</tr>
<tr>
<td>HPC 150 - public -150kW</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HPC 350 - private -350 kW</td>
<td>15%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>HPC 350 - public -350 kW</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results: charging behaviour trucks

Optimal battery package (% trip profiles studied)

<table>
<thead>
<tr>
<th>Battery size</th>
<th>Small box truck</th>
<th>Large box truck</th>
<th>Truck trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>19% (80 kWh)</td>
<td>60% (120 kWh)</td>
<td>6% (170 kWh)</td>
</tr>
<tr>
<td>Medium</td>
<td>35% (20 kWh)</td>
<td>21% (200 kWh)</td>
<td>14% (240 kWh)</td>
</tr>
<tr>
<td>Large</td>
<td>47% (160 kWh)</td>
<td>19% (240 kWh)</td>
<td>81% (320 kWh)</td>
</tr>
</tbody>
</table>
Part 2: Applying results to case Amsterdam

Statistics from annual survey (CBS)

- 4700 trucks visit the environmental zone of Amsterdam regularly
- 325 million kilometres -> 470 GWh energy demand for Electric trucks

<table>
<thead>
<tr>
<th></th>
<th>To/ from EZ Amsterdam</th>
<th>All activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># trips / year (x1000)</td>
<td>Distance (mln km)</td>
</tr>
<tr>
<td>Truck-trailer</td>
<td>378</td>
<td>26</td>
</tr>
<tr>
<td>Box trucks</td>
<td>403</td>
<td>19</td>
</tr>
<tr>
<td>Other</td>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>931</td>
<td>50</td>
</tr>
</tbody>
</table>
Scaling result for Amsterdam

- Sector in City logistics known for 4700 HGVs (CBS Statics)
  => Energy demand per sector
  => Energy demand per type of location (depot, third party, customer)
Geographical allocation of energy demand

Method

- Depots charging: based on survey information CBS on overnight location trucks (postal code 4 areas)
- Location of customer: Estimated on HGV origin destination relations with Amsterdam (transportation model region Amsterdam)
- Location of fast charging at public station: Traffic intensities on main roads from transportation model.

Result

=> Total Energy demand in Greater Amsterdam from HGVs: 123 GWh (1-2% of total energy demand)
Results: Geographical energy demand (HGVs and vans)
Impact on electricity net: method

- Conversion of Energy demand in maximum power demand with charging profiles
- Per postal code area, maximum power demand has been calculated.

Charging profiles
Impact on electricity grid:
Result Greater Amsterdam
Impact on electricity grid: Result

- Calculation by electricity distribution system operator: 
  *Only little increase in power demand on power grid substations <0,25% for 25 out of 26 stations, only one station (port area) with a 1.5% increase.*

- However: For connections above 2 MW (5 in this case) a direct connection to substation is required.
  - No free field on substation: 1-3 year waiting time
  - Power capacity not sufficient: 3-8 years

- Fleet owners need to consult electricity distribution system operators in time about their situation and plans.
Result: Infrastructure need (HGVs and vans)

Charging point needed:
HGV: 1350
Vans 17,130

Charging stations needed:
HGVs: 418-772
Vans: 9,700-10,600

Majority (1340 of 1350) Charging point are private (depot/ customer)
Conclusion

- Electric HGVs in city logistics will charge mainly at depots and distribution centres at night using 150 kW charging stations.
  => No need for local governments to provide charging infrastructure in city centres

- It seems well possible to perform most of current City logistic operations with electric HGVs

- A zero emission zone in Amsterdam will cause a total energy demand in greater Amsterdam of 120 GWh from Electric HGVs (1-2% of total energy demand).
  => 350 GWh energy demands outside greater-Amsterdam.

- The increase in power demand due to the charging of electric vehicles is limited (<0.25%)

- For large electric truck fleets (~50): Consult the energy network company in time.
Ongoing discussions and work

Discussion in response to report.

- Electric HGVs are not commercially available on large scale - still uncertainty on costs, range: little experience.
- Some logistics parties pioneering with E-trucks are experiencing problems with the range of E-trucks in their operation; there is a big variation in logistical profiles

⇒ Top Sector Logistics will organize expert/ user discussion groups to share experiences on availability and costs of E-trucks and charging infrastructure.

Ongoing research

- Extension of Amsterdam analysis to other cities and possibly group of cities.
- Check of statistical method with camera observations.