Charging infrastructure for electric vehicles in city logistics

Getting zero emission trucks on the road

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CE Delft

Committed to the Environment

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

Buck Consultants International

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Topsector Logistiek

Connekt

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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 CO_2 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.

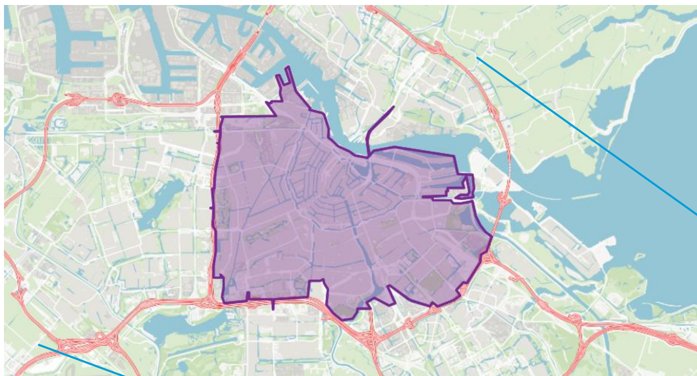
Introduction: Policy context

Important questions:

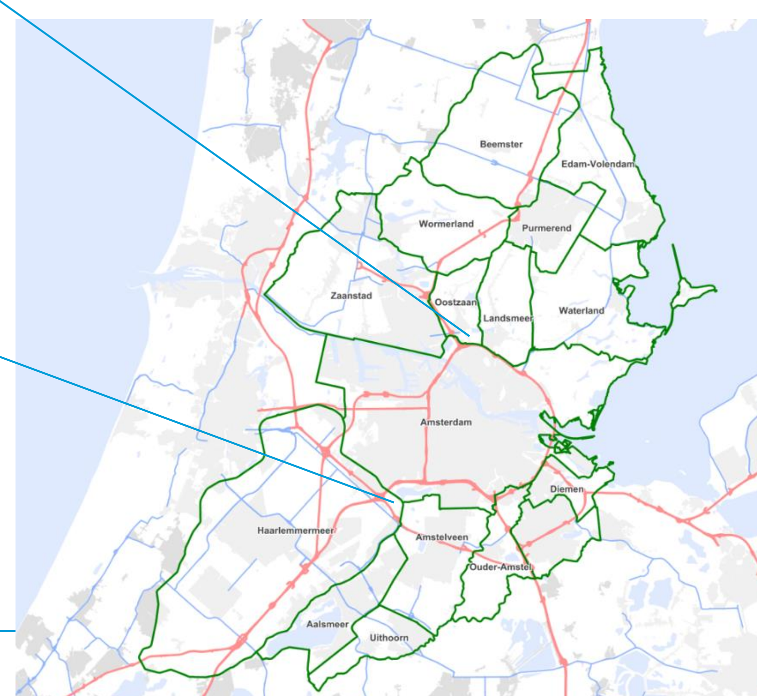
1. At what location are trucks going to charge:
   Depot (Private), Customer site (Private), Third party (Public station)?
   - What is role for fleet owners/ distribution centres?
   - What is role of governments
2. What kind of battery packs and charging power is needed for the trucks?
3. What is the 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 charing for Greater Amsterdam



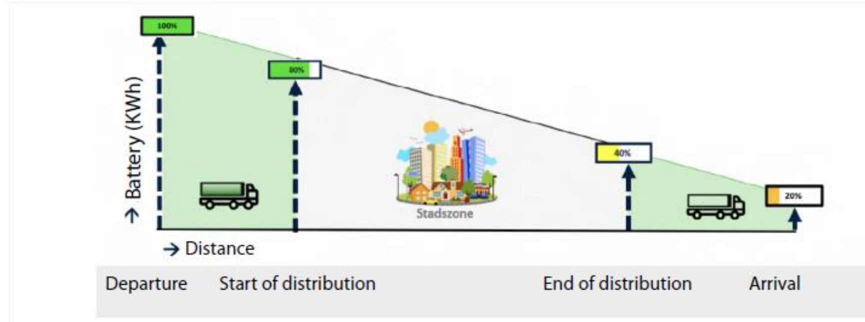
Assumptions

- Logistic profiles remain the same.
- All HGVs will be BEV (no PHEV or H_2)

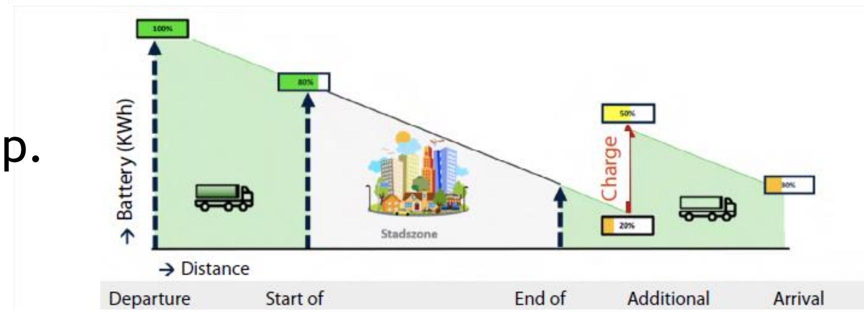
1: Optimal charging behaviour

Cost optimisation model: scenarios

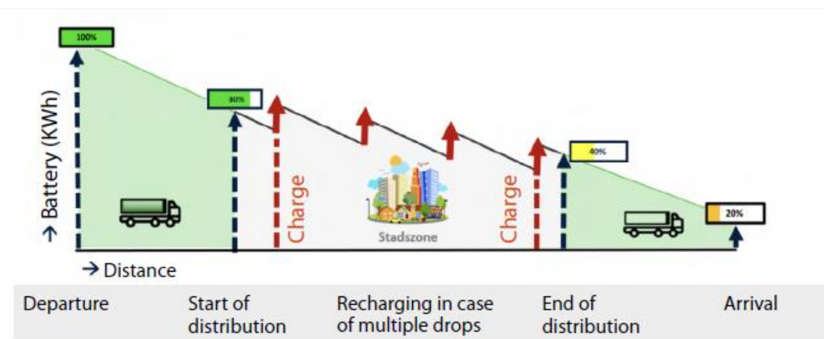
Scenario 1: No recharging



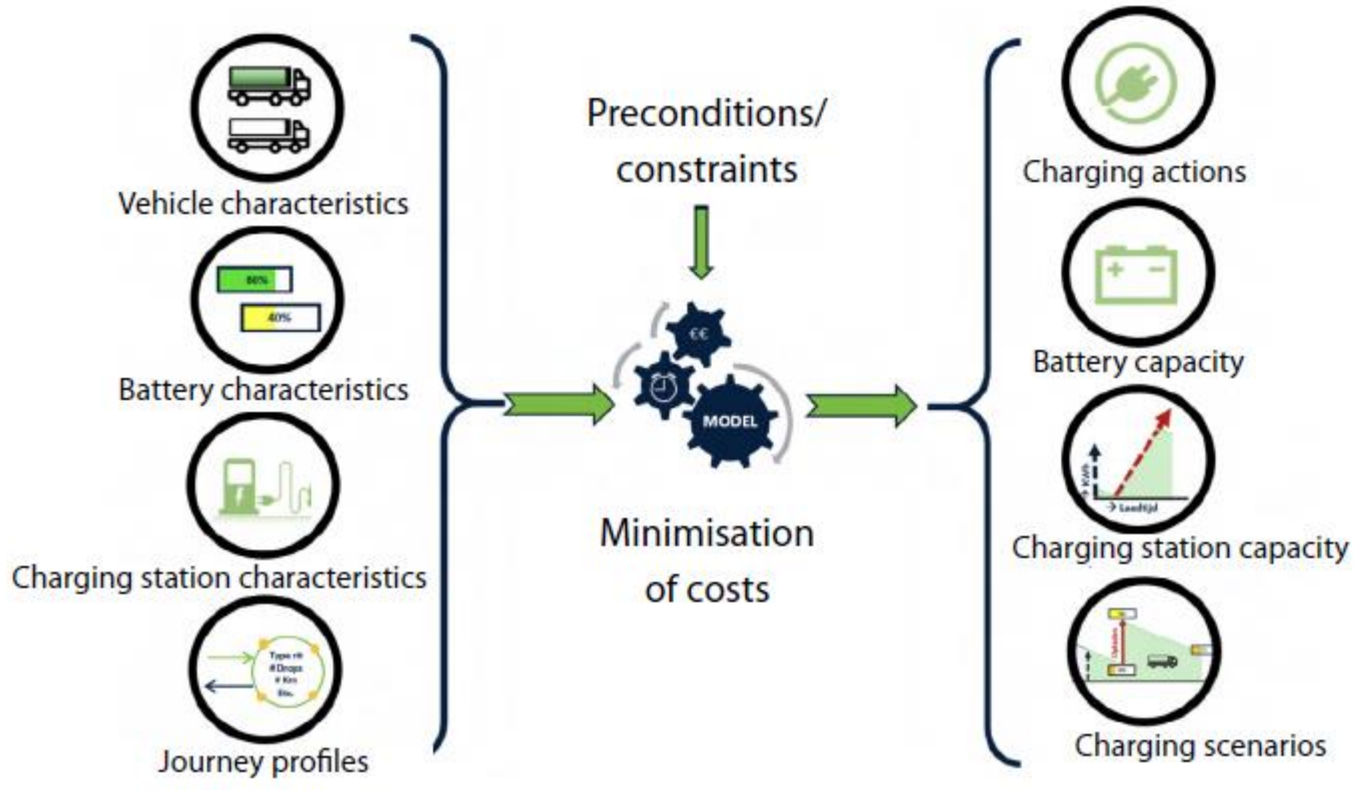
Scenario 2: Additional charging stop.



Scenario 3: Charging at the customer (delivery address/stop address).

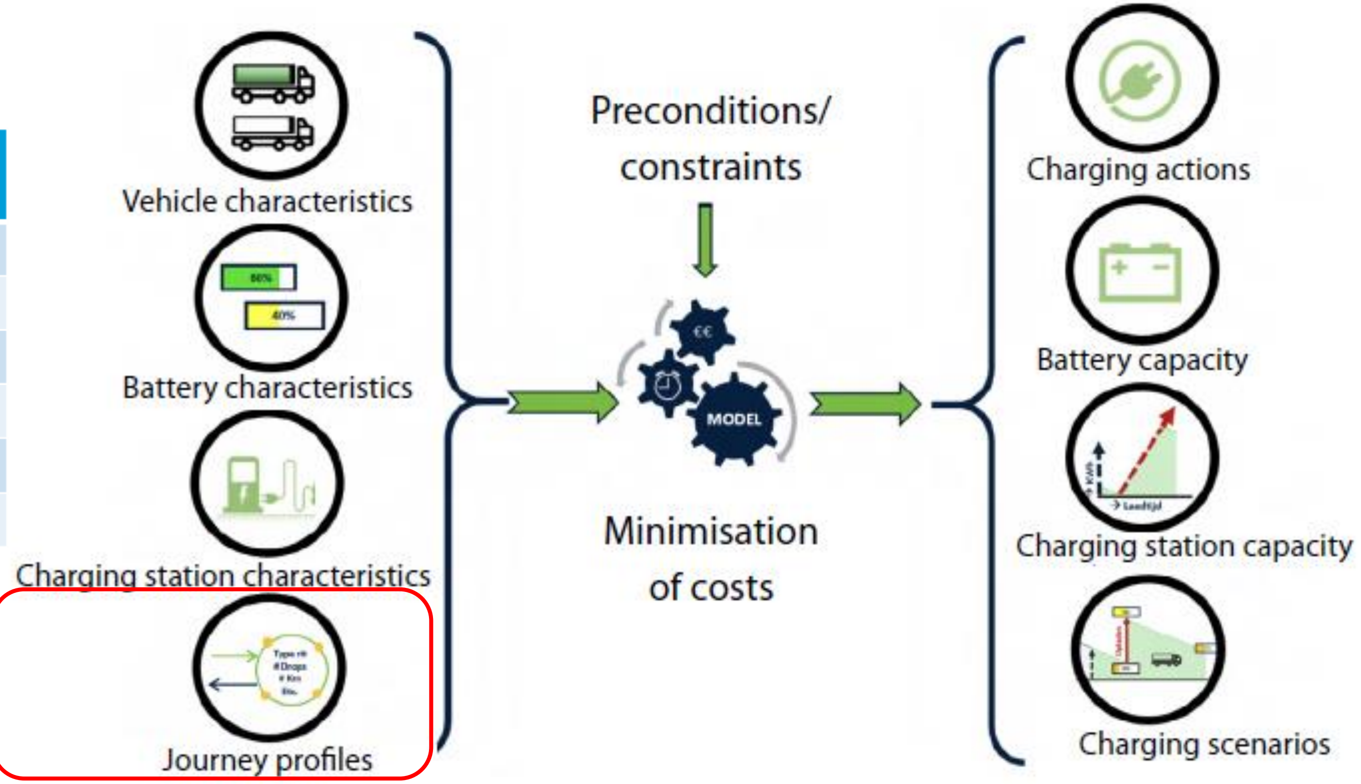


Method: Cost optimisation model



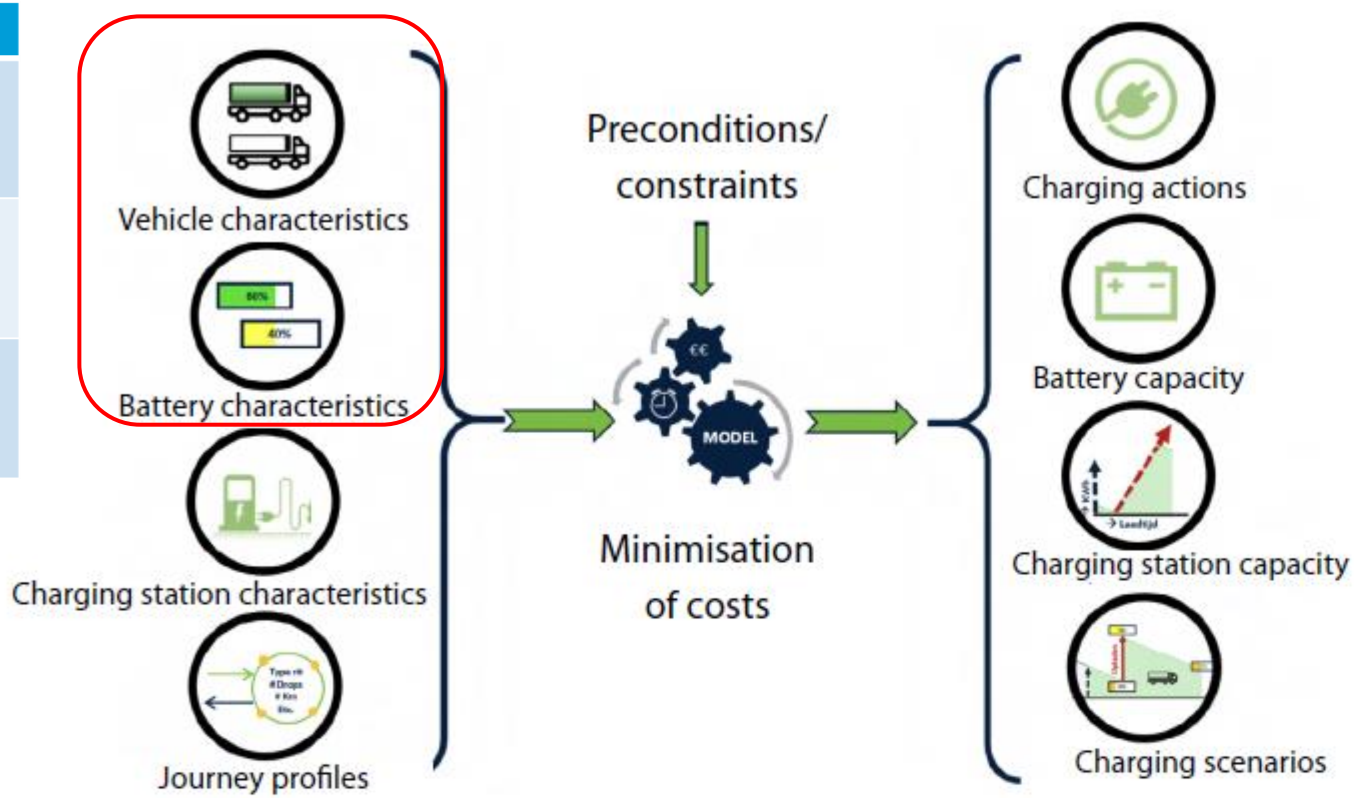
Method: Cost optimisation model

Sectors in city logistics (HGV)
Waste collection
Construction
Facility services
Catering/ hospitality
Retail (Food)
Retail (non-Food)



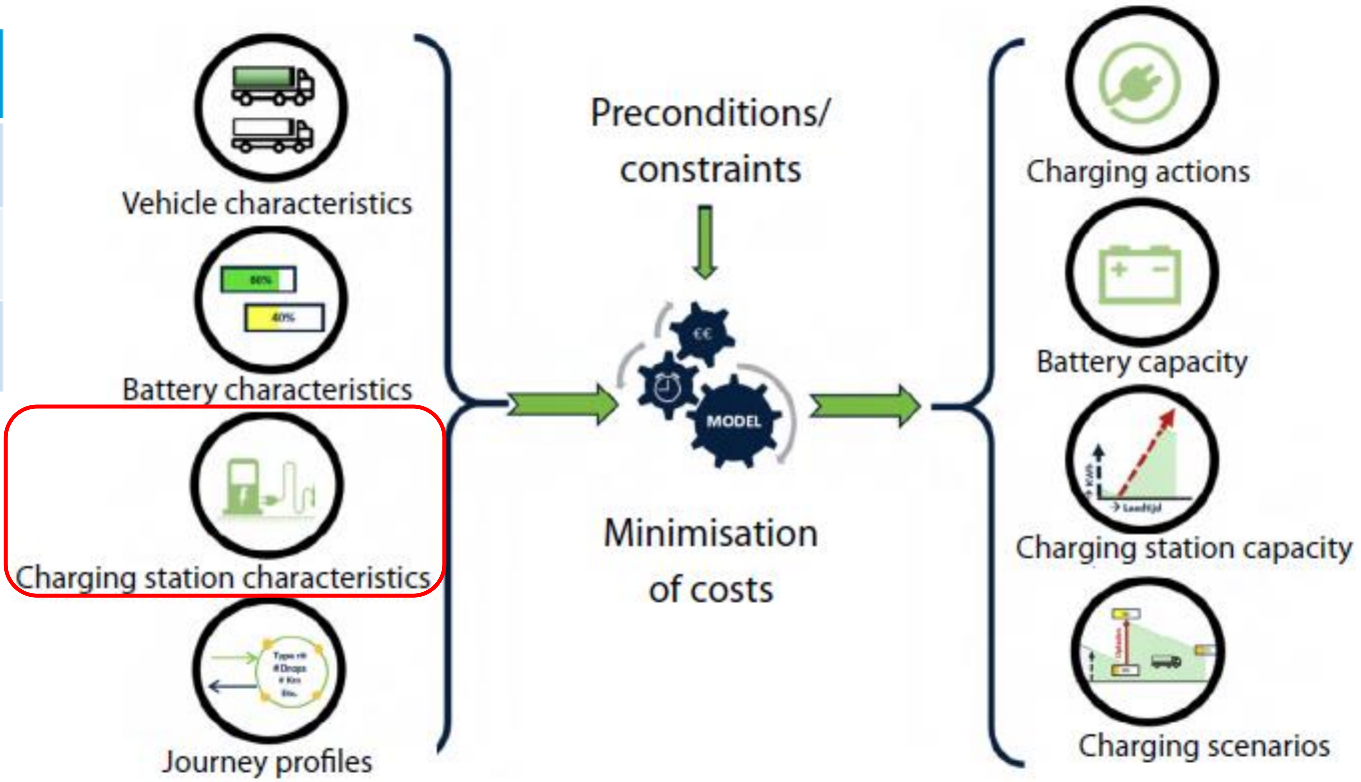
Method: Cost optimisation model

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



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

Sectors in city logistics (HGV)	Fast charging at public station	At depot/ distribution centre	At customer site
Waste collection	15%	85%	0%
Construction	5%	80%	15%
Facility logistics	5%	85%	10%
Catering/ hospitality	5%	85%	10%
Retail (Food)	5%	75%	20%
Retail (non-Food)	10%	60%	30%

Results: charging behaviour trucks

Share (%) of kWh charged per charging station type

Charging station	Fast charging at public station	At depot/ distribution centre	At customer site
FC50 – private 50 kW		5%	2%
HPC 150 –private -150kW		80%	87%
HPC 150 – public -150kW	-	-	-
HPC 350 – private -350 kW		15%	11%
HPC 350 –public -350 kW	100%		

Results: charging behaviour trucks

Optimal battery package (% trip profiles studied)

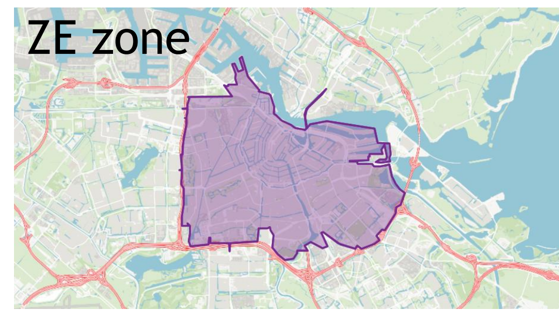
Battery size	Small box truck	Large box truck	Truck trailer
Small	19% (80 kWh)	60% (120 kWh)	6% (170 kWh)
Medium	35% (20 kWh)	21% (200 kWh)	14% (240 kWh)
Large	47% (160 kWh)	19% (240 kWh)	81% (320 kWh)

Part 2: Applying results to case Amsterdam

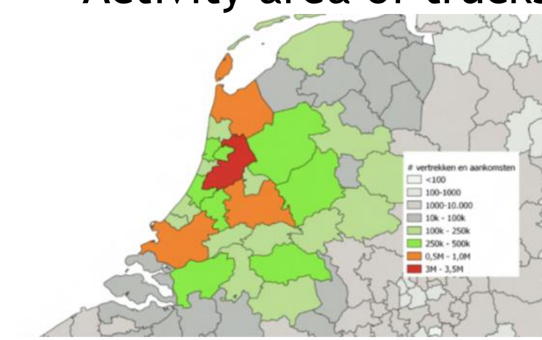
Statistics from annual survey (CBS)

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

	To/ from EZ Amsterdam		All activities	
	# trips / year (x1000)	Distance (mln km)	# trips/ year (x1000)	Distance (mln km)
Truck-trailer	378	26	2,694	204
Box trucks	403	19	1,474	81
Other	150	5	907	40
Total	**931**	**50**	**5,076**	**325**

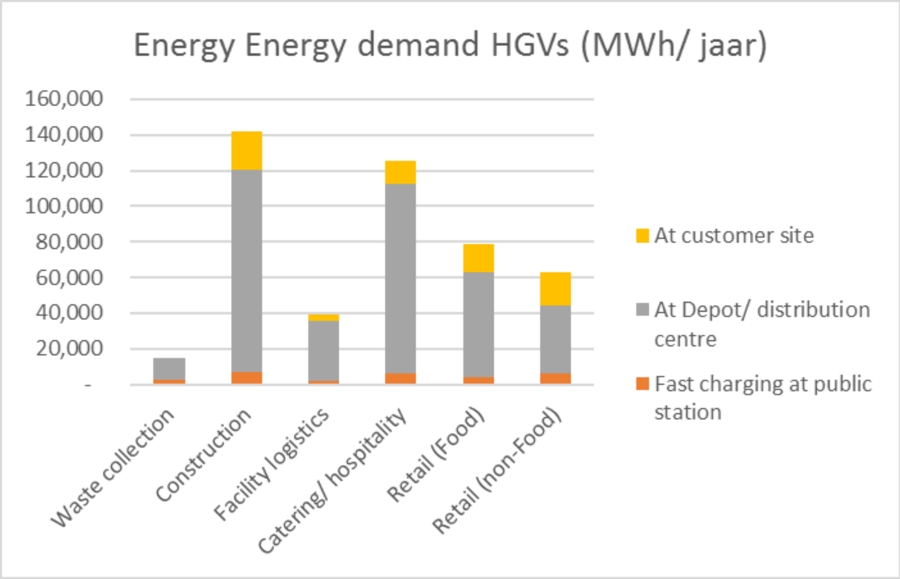


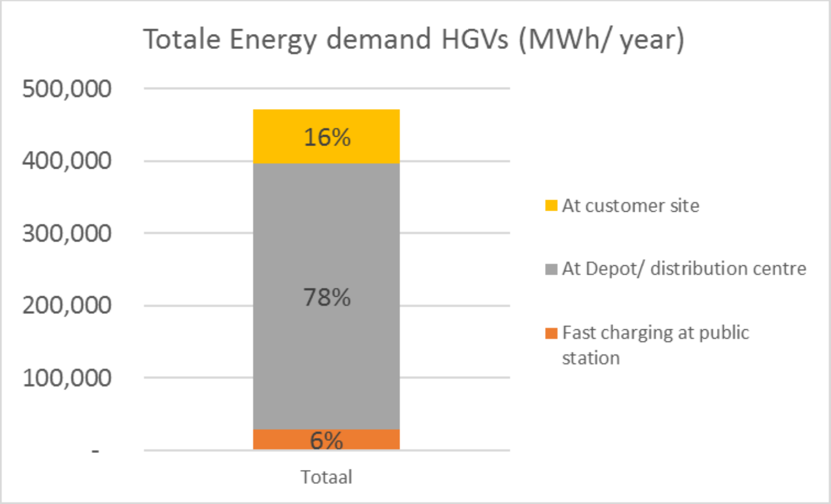
Activity area of trucks



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

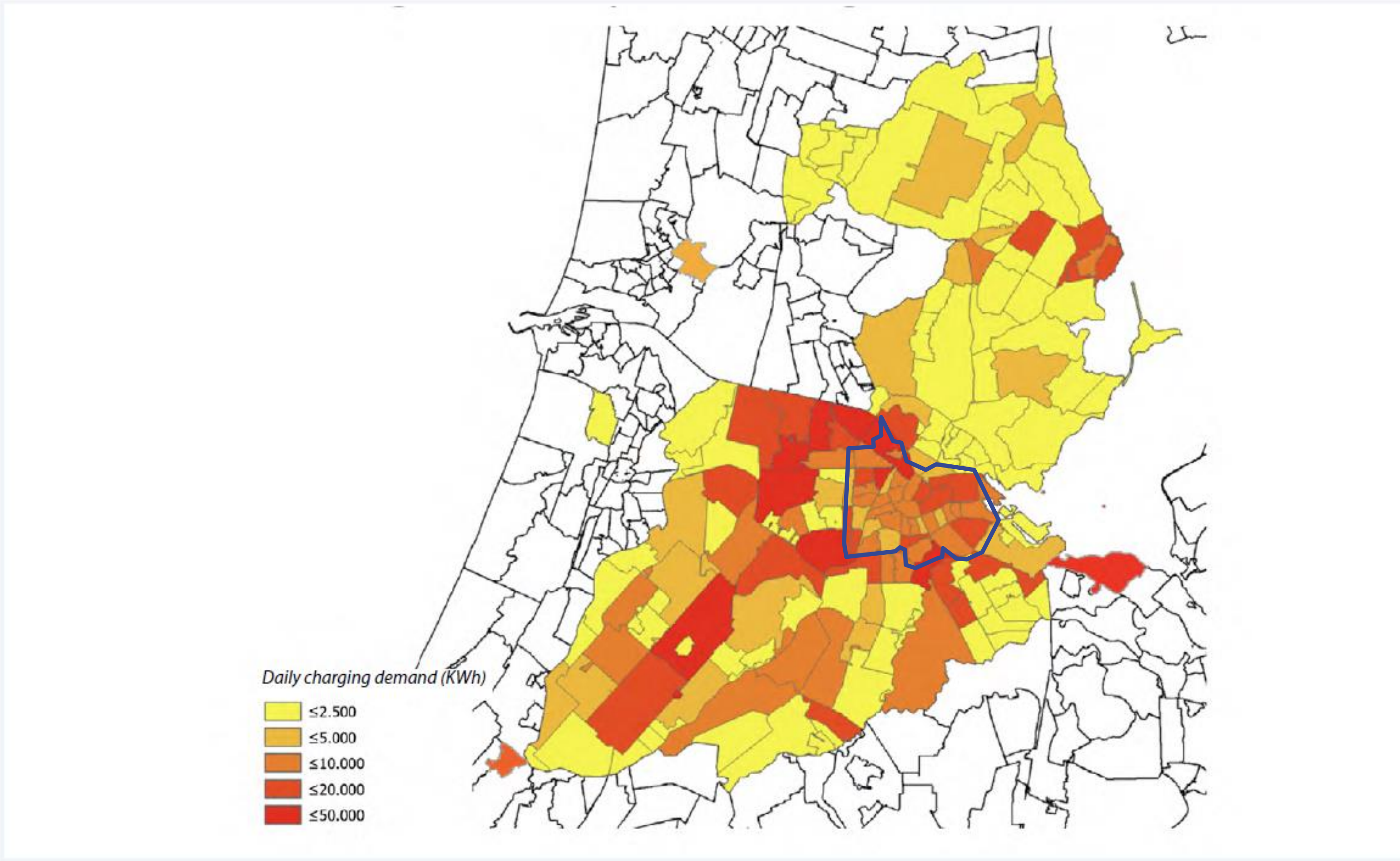
Method

- 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)

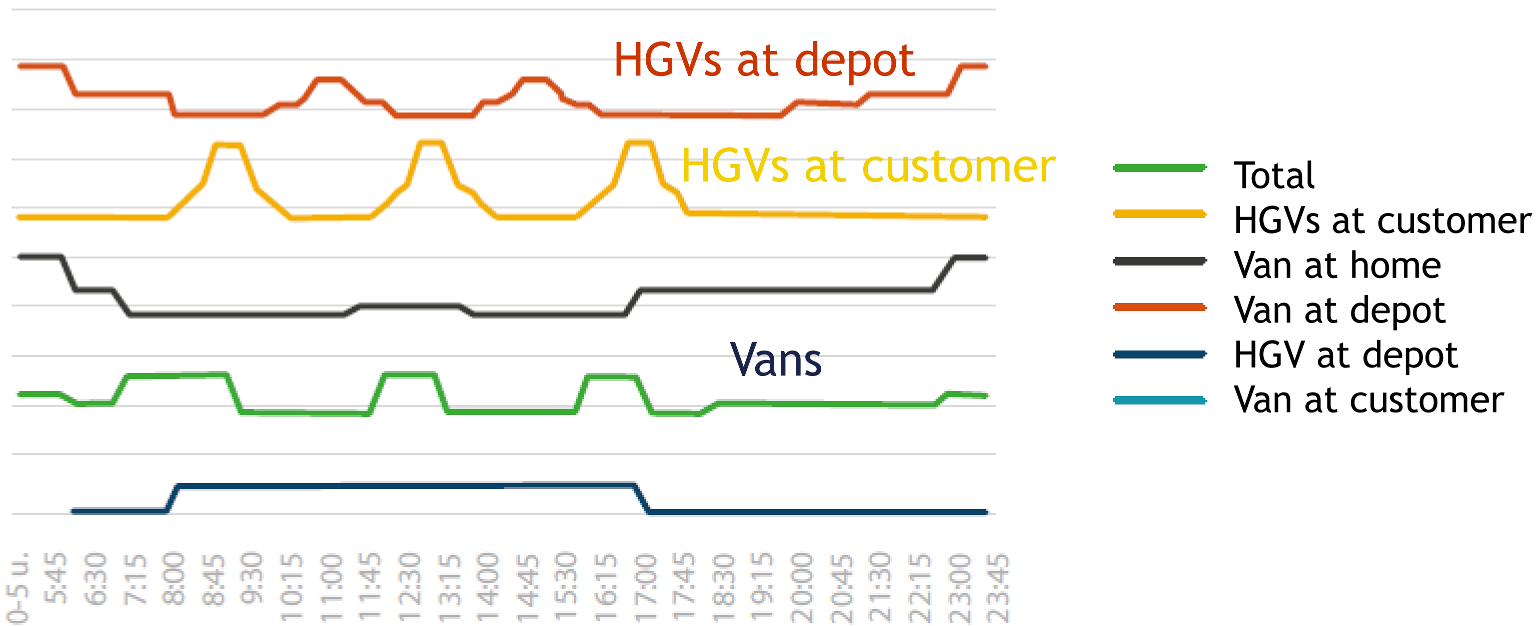
Results: Geographical energy demand (HGVs and vans)



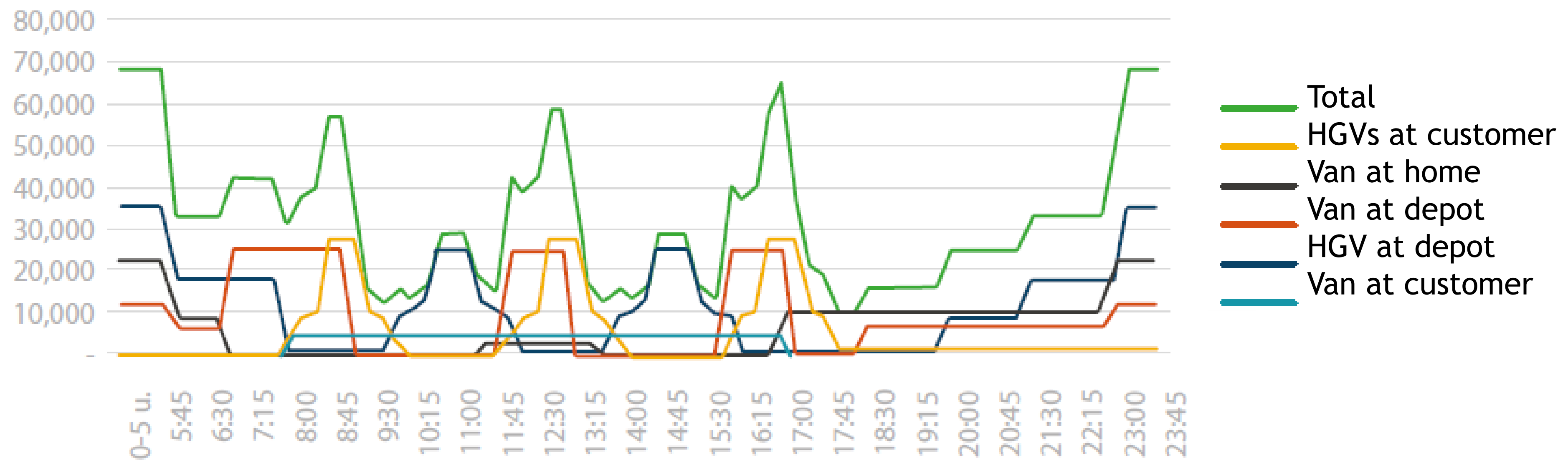
Impact on eletricity net: method

- 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



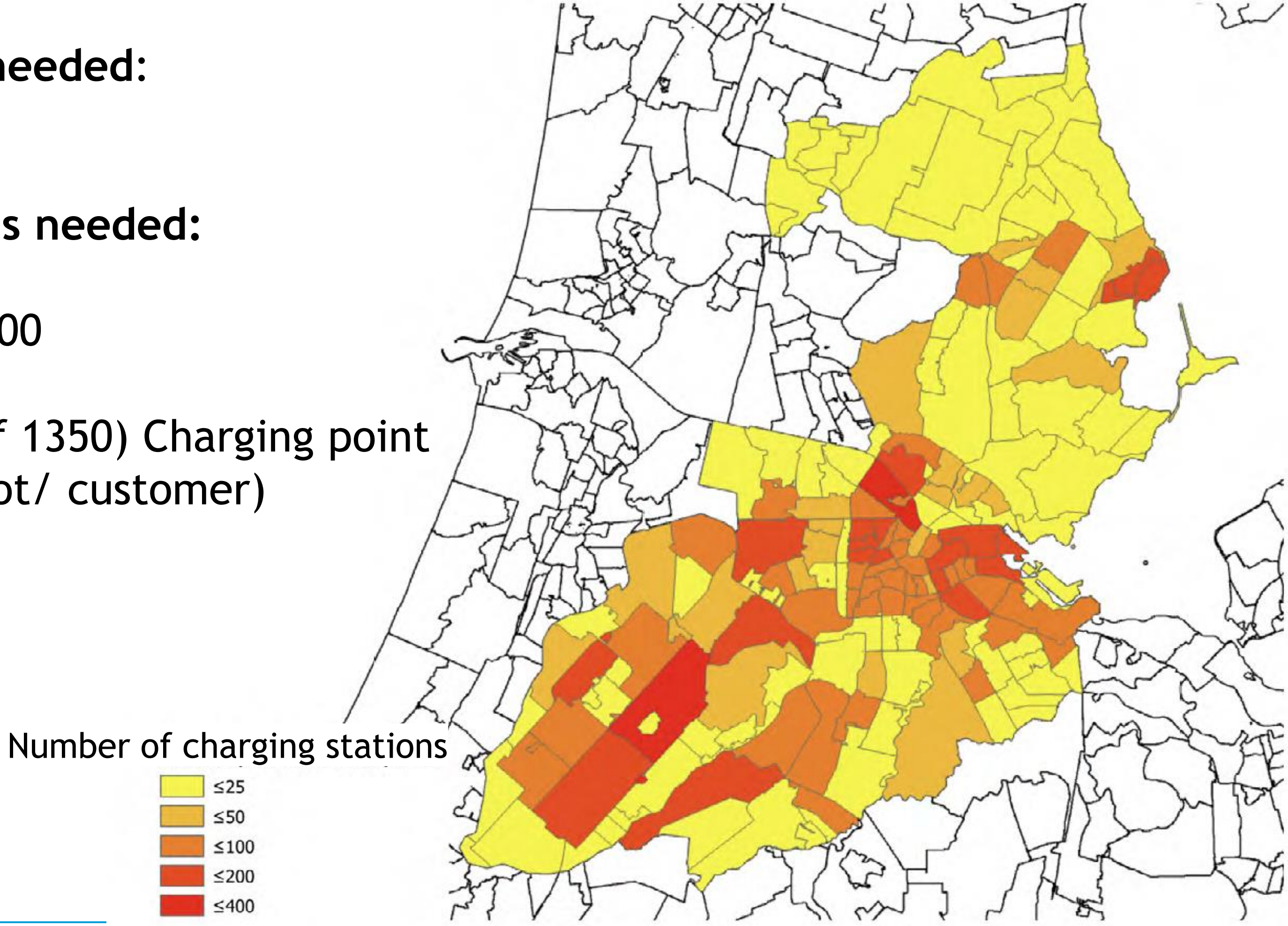
Impact on electricity grid: Result

- 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

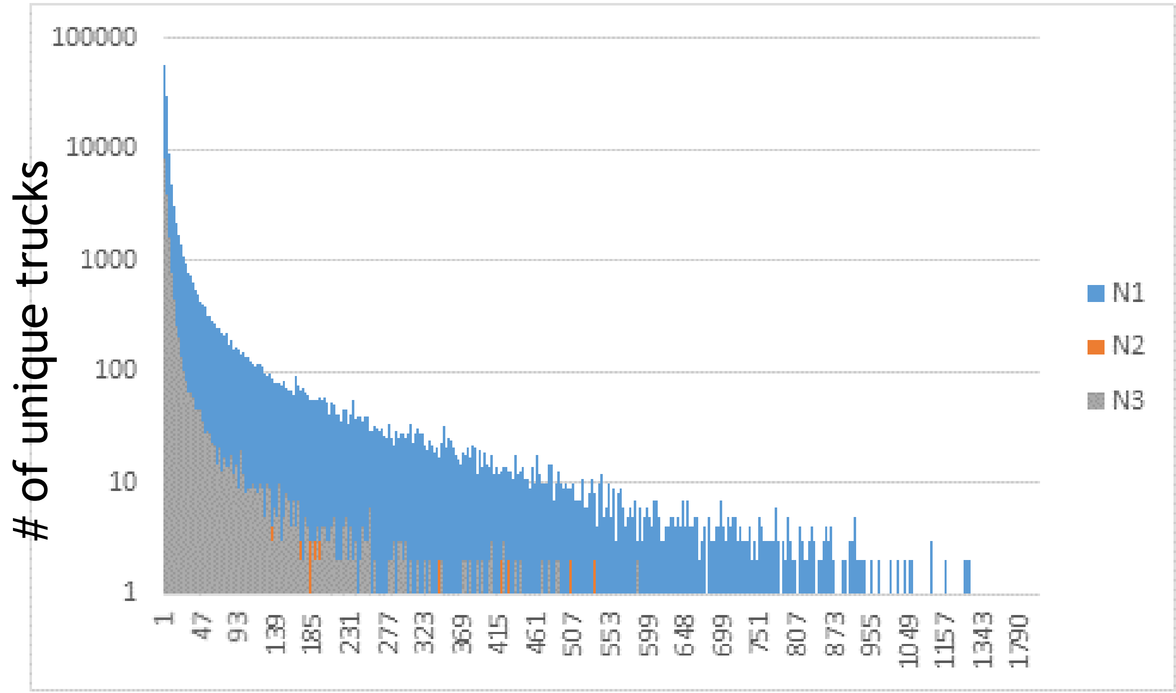
⇒ Top Sector Logistics will organize expert/ user discussion groups to share experiences on availability and costs of E-trucks and charging infrastructure.

Ongoing research

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

Background sheets

Rotterdam

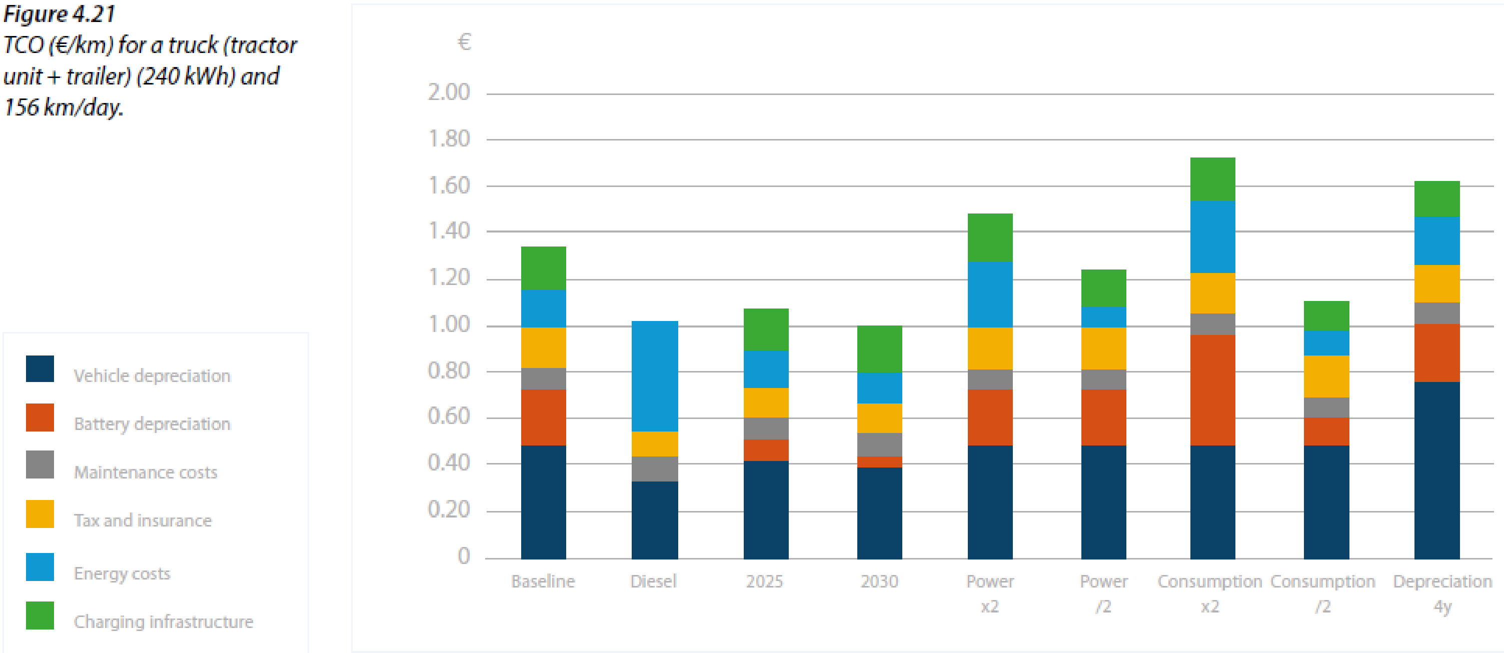


4000 HGVs > 20 time/ year in Rotterdam
28000 HGVs <20 times/ year
9700 HGVs 10,000 times/ year

Annual frequency in Environmental zone Rotterdam

TCO Costs of Electric Trucks vs Diesel

Figure 4.21
TCO (€/km) for a truck (tractor unit + trailer) (240 kWh) and 156 km/day.



Energy consumption HVGs

- Small box truck: 0.77 kWh/km
- Large Box truck 0.91 kWh/km
- Truck-trailer: 1.75 kWh/km

Cost price per kWh (at given annual consumption)

Table 3.12
Overview of the TCO and cost price per kWh for a given annual consumption.

* *The public charging stations have a maximum rate set by the local government (in Amsterdam). The cost price rate is given in brackets.*

		TCO (FIXED AND VARIABLE)	COST PRICE AT GIVEN ANNUAL CONSUMPTION	
INDICATION OF CHARGING STATION TYPE	FIXED COSTS PER YEAR €	VARIABLE COSTS PER KWH €	COST PRICE AT KWH €	TOTAL ANNUAL CONSUMPTION IN KWH
AC3,7 Home	147	0.21	0.22	7,500
AC10 Public*)	982	0.11	0.28 (0.31)	5,000
AC20 Public	1,677	0.11	0.28 (0.45)	5,000
AC20 Private	447	0.13	0.14	30,000
FC50 Public	6,838	0.11	0.37 (0.26)	45,000
FC50 Private	6,370	0.12	0.19	87,500
HPC150 Public	14,625	0.10	0.37 (0.26)	90,000
HPC150 Private	13,146	0.08	0.23	90,000
HPC350 Public	36,575	0.10	0.42 (0.30)	180,000
HPC350 Private	33,429	0.08	0.27	180,000