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

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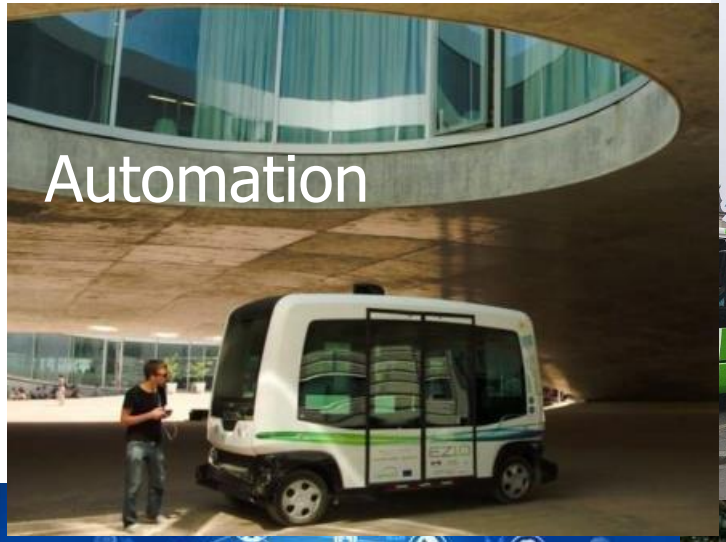

Automation


ABB
ELECTRIC
Elektrification


Information


Bio
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

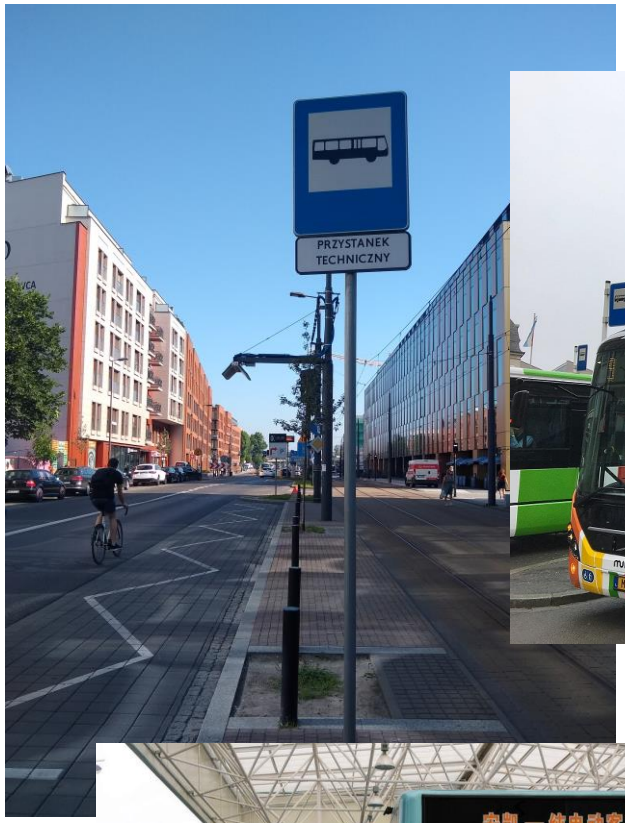

PRZYSTANEK
TECHNICZNY

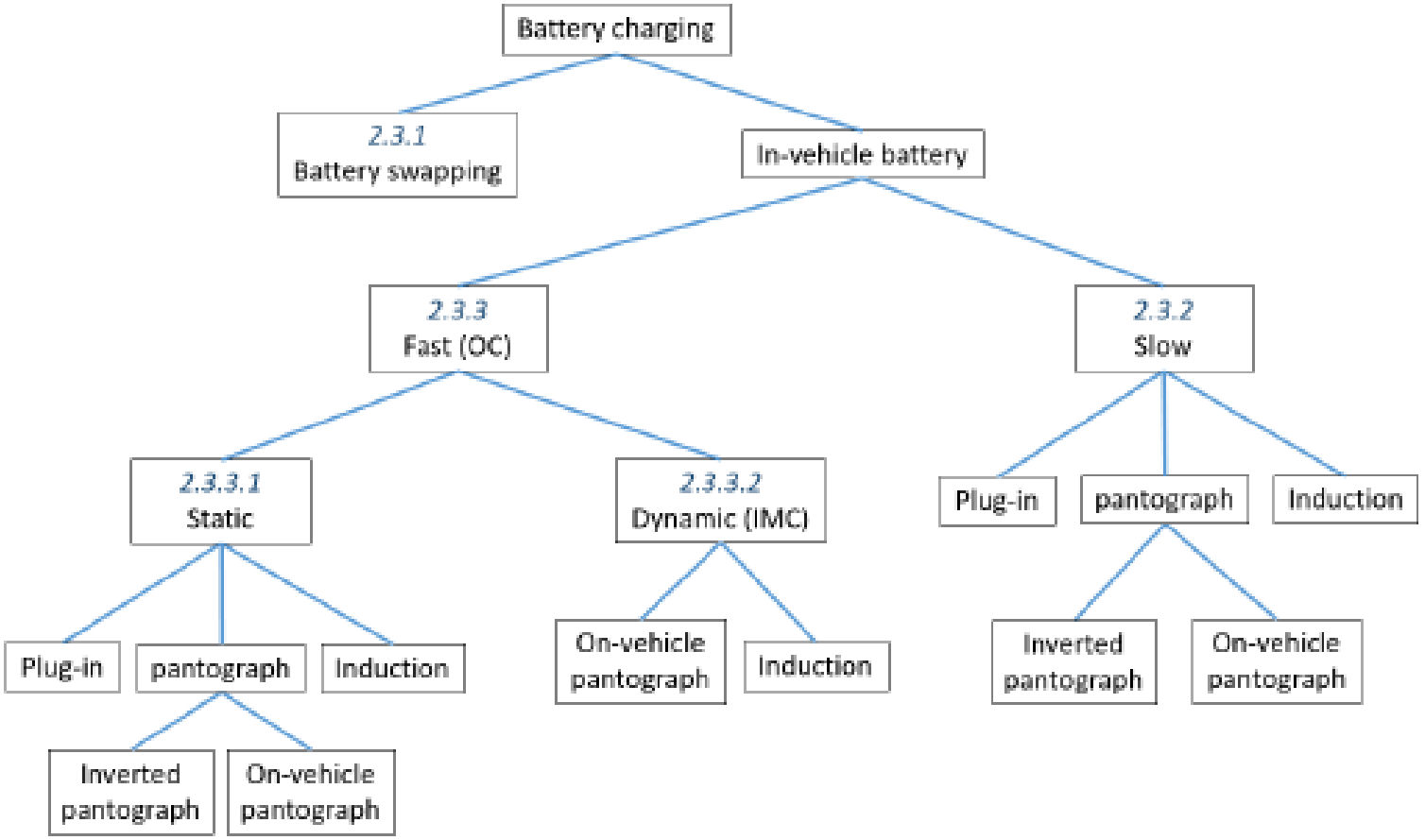

ABB
ELECTRIC


100% ELEKTRISCH
VOLVO


安凯一纯电动客车
零排放
更环保


RIJDENDEBATTERIJ.NL
Abgasfrei unterwegs

Charging types



Impacts of public transport

Framework of 5 E's

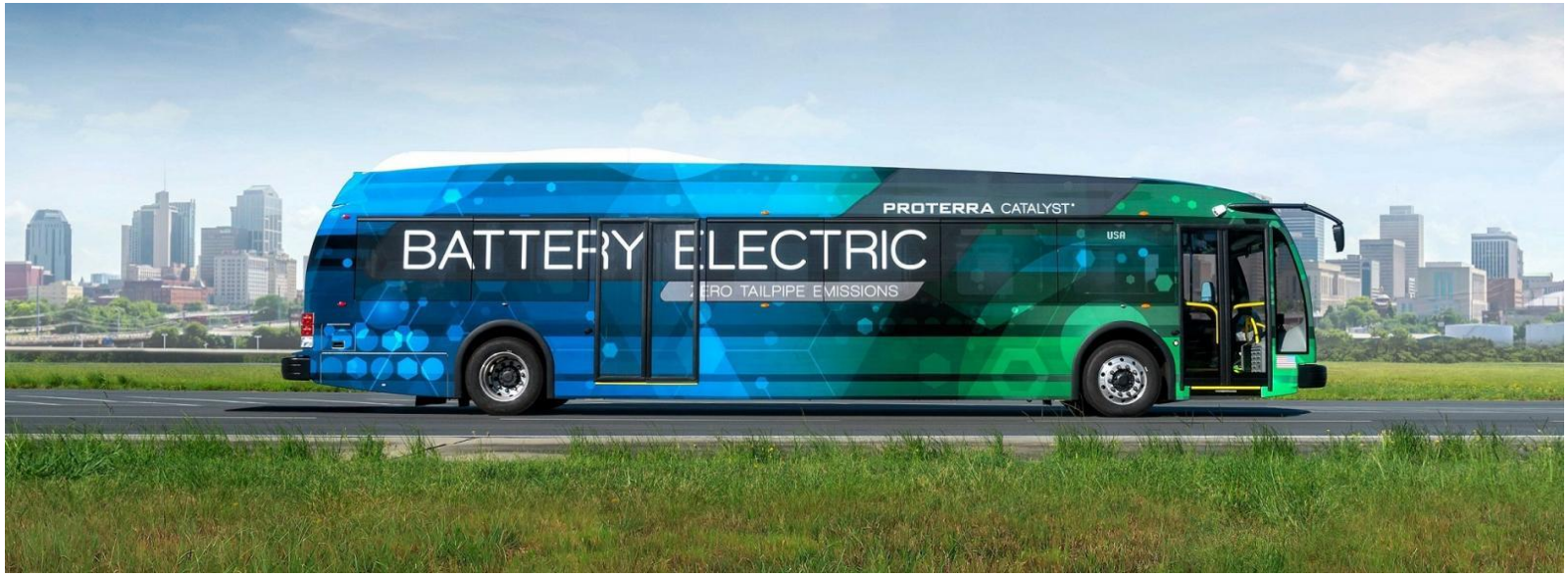
- Effective mobility
- Efficient city
- Environment
- Economy
- Equity

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

Criterion	Variable	
Operations	1	Disruptions
LoS	2	Delayed departure times
	3	Dispersion in departure times
Costs	4	Operational delayed vehicle costs
	5	Operational energy/fuel consumption costs
	6	Vehicle investment costs
	7	Charging infrastructure investment costs

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)

13 MW Charging Infrastructure

The world largest opportunity & depot charge network

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 — 18 m

AMSTERDAM AREA

Amstelland-Meerlanden

42 pcs Depot charge + 8 pcs Opportunity charge — Depot Amstelveen

4 pcs Opportunity charge — Schiphol Parking P30

4 pcs Opportunity charge — Schiphol Parking North

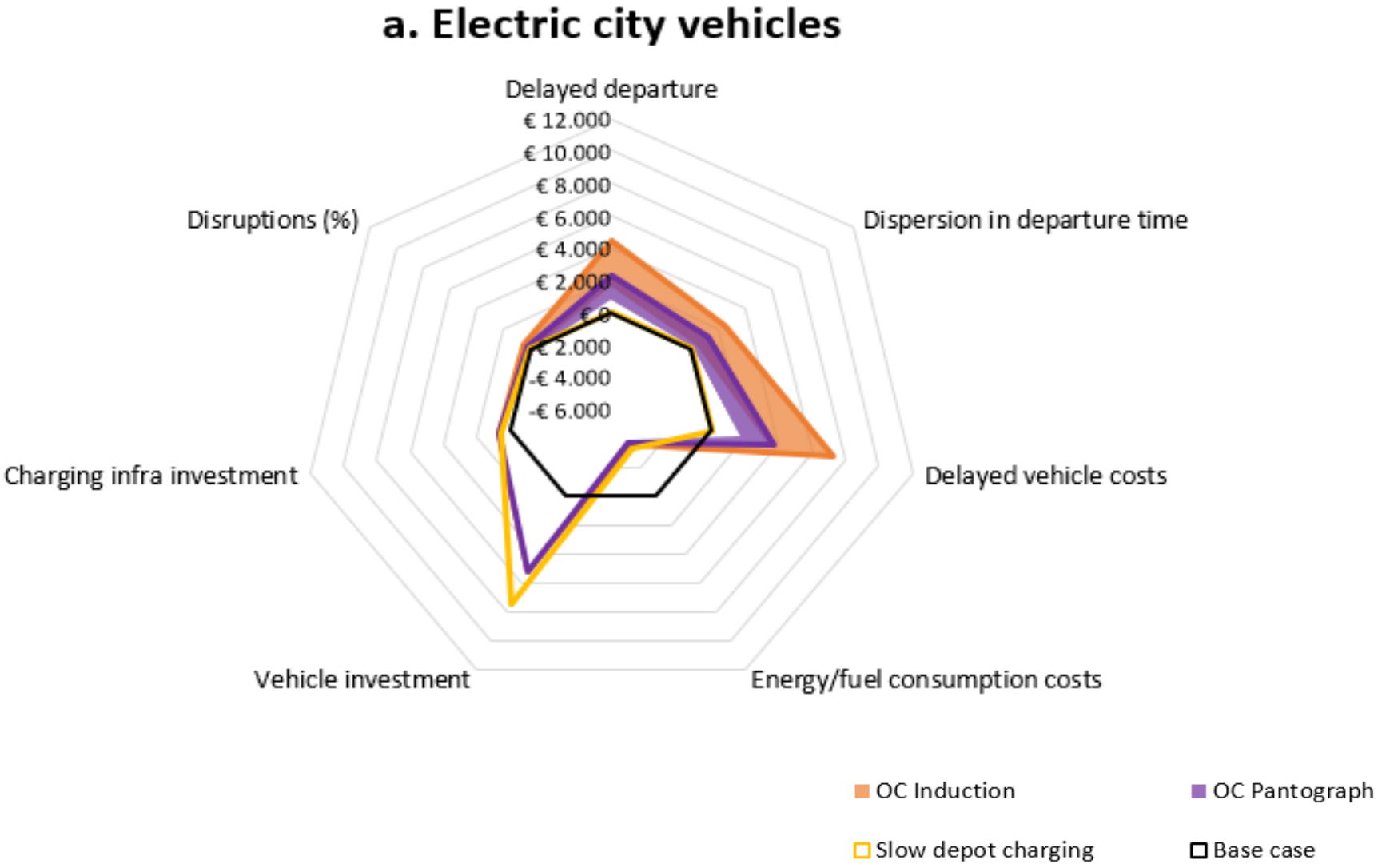
Amsterdam A

Zero emissions

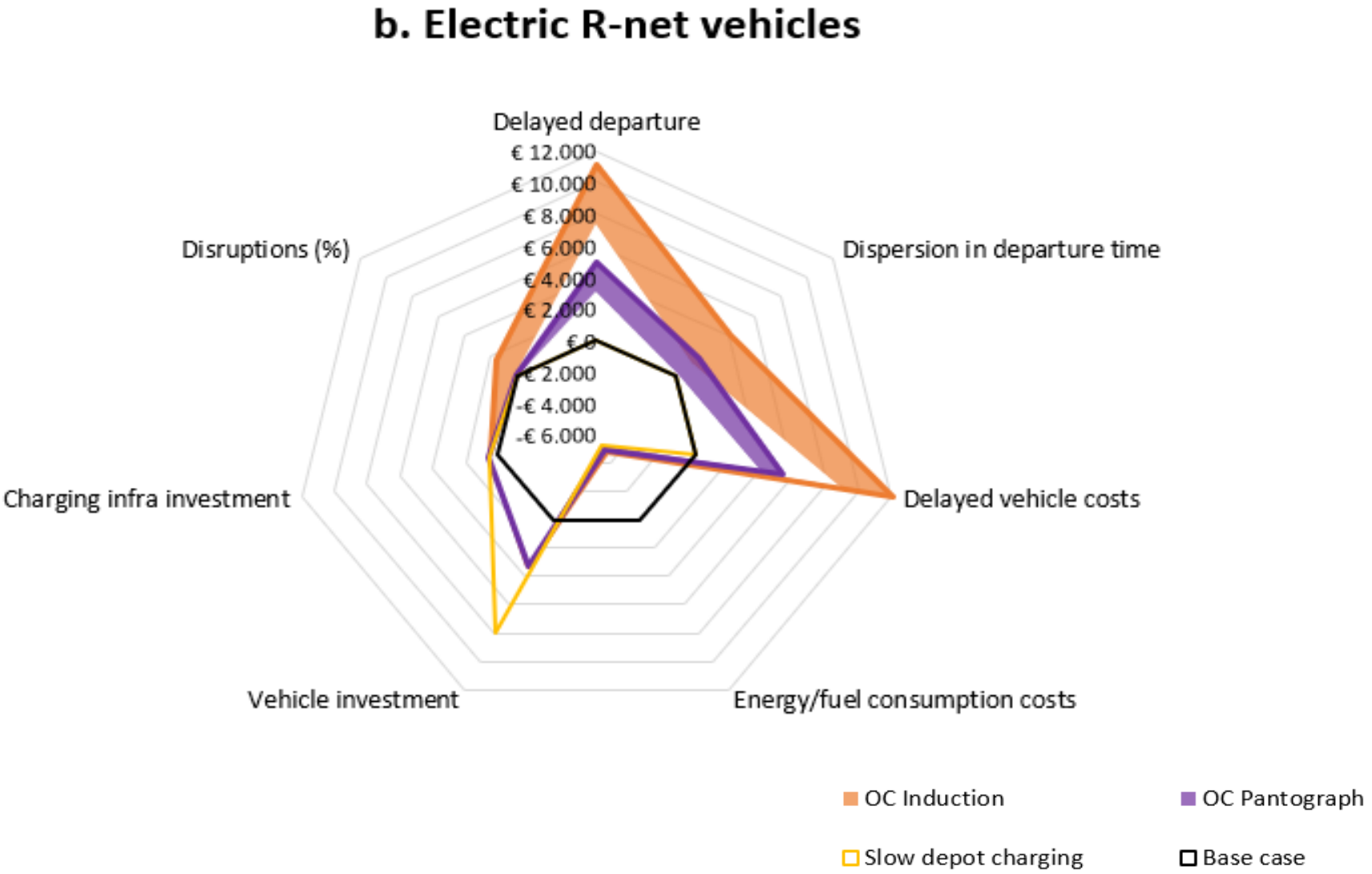
Passenger

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
€ 0
€ 2.000
-€ 4.000
-€ 6.000
Dispersion in departure time
Delayed vehicle costs
Energy/fuel consumption costs
Vehicle investment
Charging infra investment
Disruptions (%)
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
Delayed vehicle costs
Energy/fuel consumption costs
Vehicle investment
Charging infra investment
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OC Pantograph
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Base case

Adjusting the timetable: new balance

“Two coffee breaks!

That never happened before on a conventional bus”

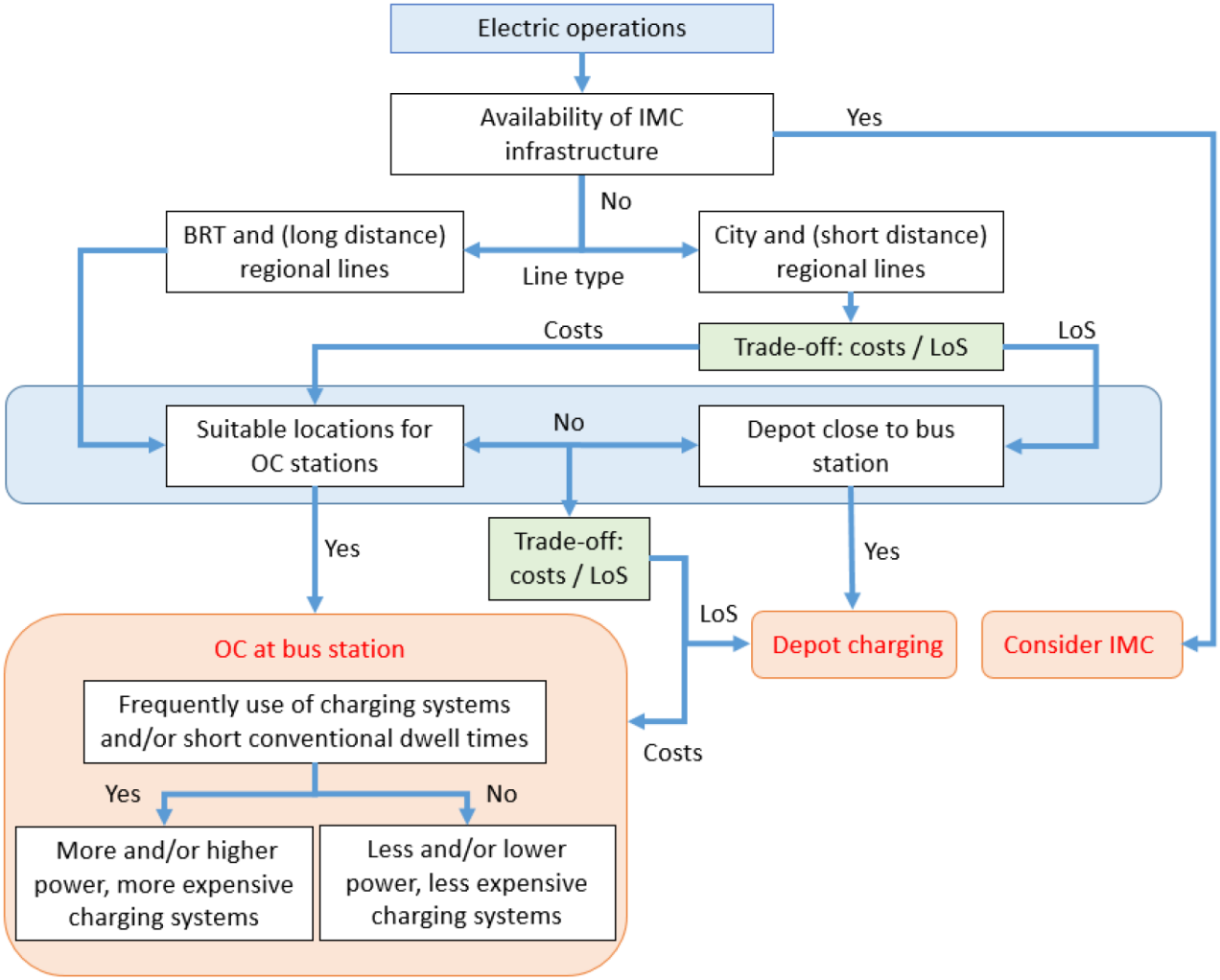
‘Twéé pauzes! Dat is me in een dieselbus nog nooit overkomen’

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



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 support 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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