FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

Traffic operations and electric road systems

Joram Langbroek
Co-authors: Jubin Jacob, Gerdien Klunder and Joel Franklin
14/06/2017

Introduction

- FABRIC is a European project investigating ERS
- Most parts of the project are technical and investigate issues regarding charging, ICT etc, but there is an assessment part as well
- This presentation covers the traffic operational effects of large-scale development of electric roads
  - Study by KTH (Sweden) and TNO (the Netherlands)

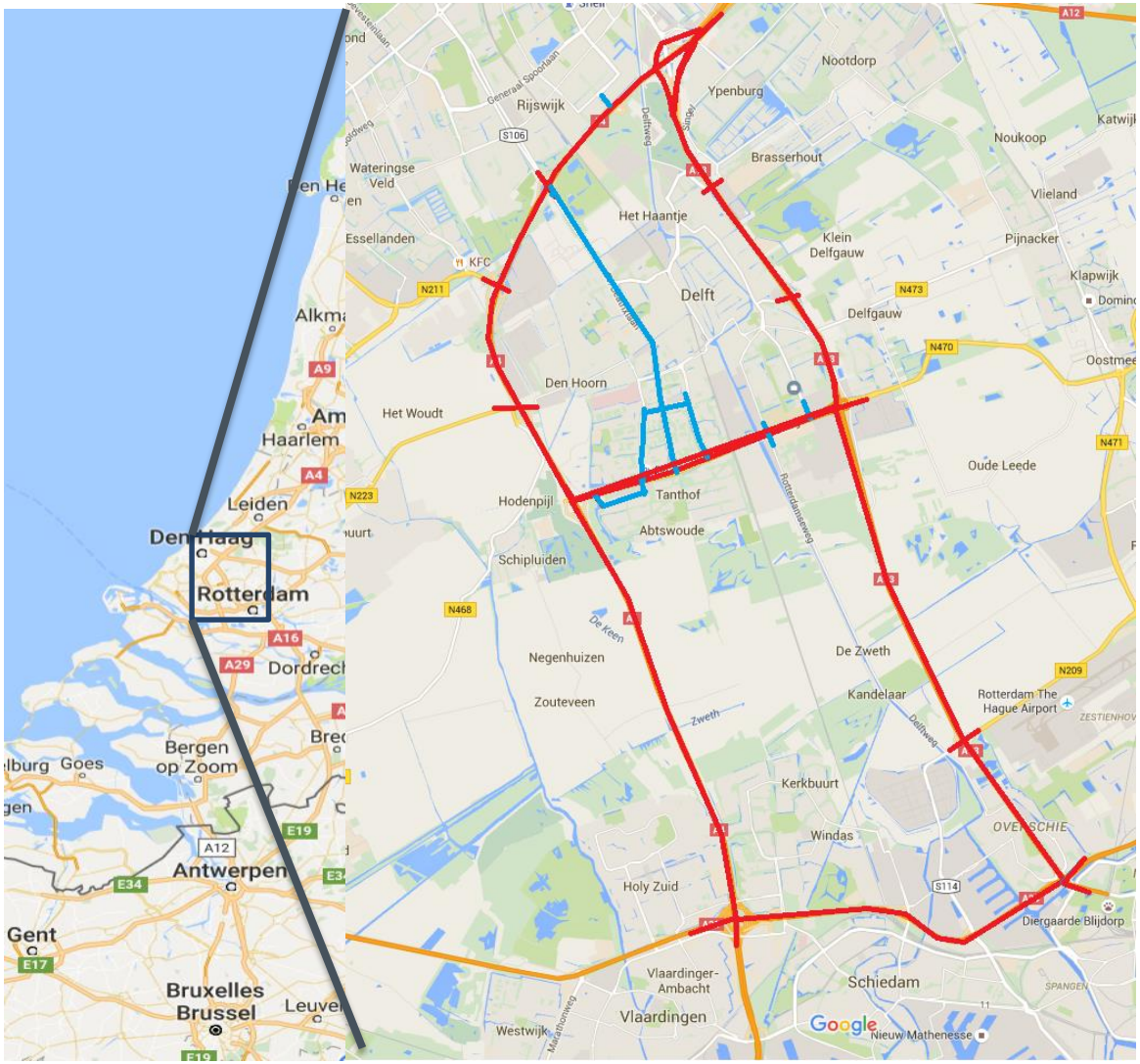
Aims

1. Investigating the physical operations of road way systems
   - Under a staged deployment of on-road charging infrastructure
   - And partial market penetration of compatibly-equipped vehicles into the general fleet
2. Traffic operational as well as emission effects

Case study

- Case study selection criteria
  - Parallel road structure
  - Parallel routes not too far apart
  - Inside of a metropolitan area with at least some level of congestion

Case study area



Scenario development: concepts

1. Number of on-road chargeable vehicles → Pressure on the e-road
2. Pressure on the e-road → Infrastructure development
3. Infrastructure development → Number of on-road chargeable vehicles
4. Infrastructure development → Route choice
5. Pricing of on-road charging → Use of e-roads
6. The effects of the deployment of non-compatible electric vehicles → Benefits of e-roads

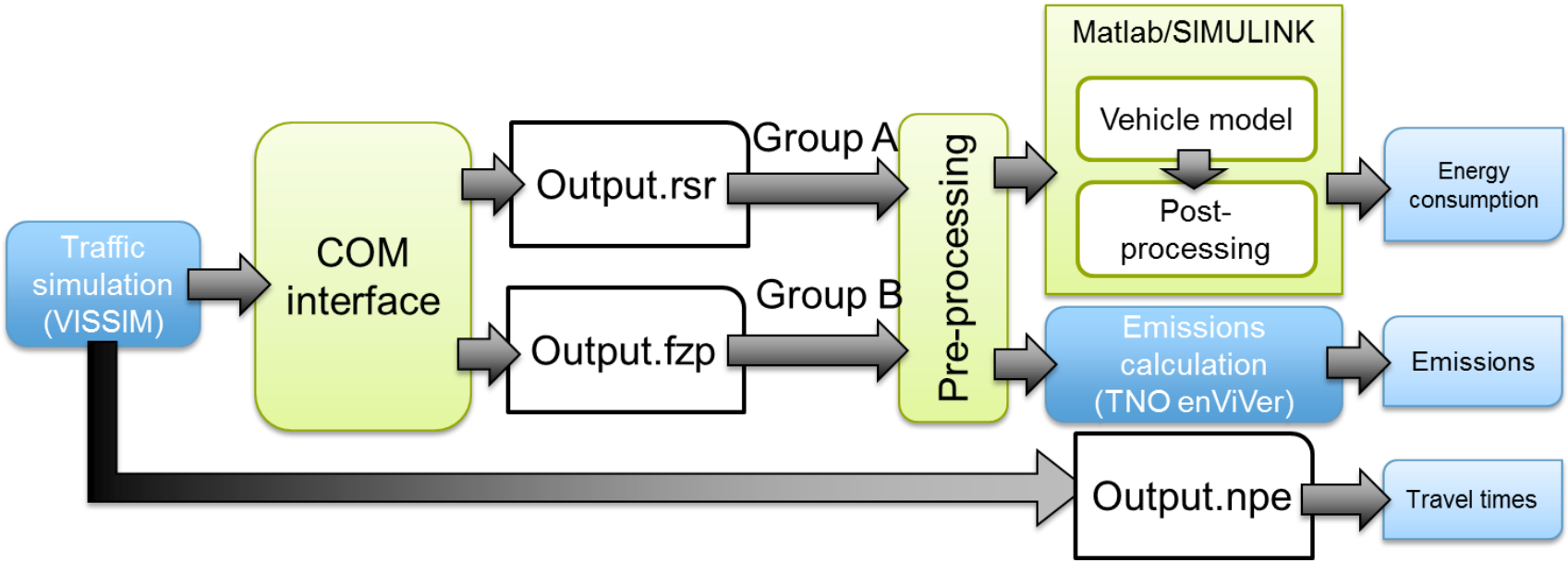
Scenario development: dimensions

1. Uptake of on-road chargeable EVs: full speed, high speed or half speed (6%/4.5%/3%-point increase per year)
2. Infrastructure: BAU (no e-roads), A4 half e-road, A4 + A13 half e-road
3. State of charge: uniform distribution / skewed towards fully charged EVs
4. Autonomous deployment of EVs: optimistic (5->20%) and pessimistic (24->84%) scenario

Scenario development

Scenario	Time period	Infrastructure	Market share chargeable vehicles	Distribution state-of-battery
Scenario 1	1	Na	0 %	Na
Scenario 2	1	A4 half e-road	24 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 3	1	A4 half e-road	18 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 4	1	A4 half e-road	12 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 5	2	Na	0 %	Na
Scenario 6	2	A4 + half A13 e-road	84 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 7	2	A4 + half A13 e-road	63 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 8	2	A4 + half A13 e-road	42 %	Low/medium/high: 33⅓ / 33⅓ / 33⅓
Scenario 9	2	A4 + half A13 e-road	42 %	Low: 10%, Medium: 20%, High: 70%

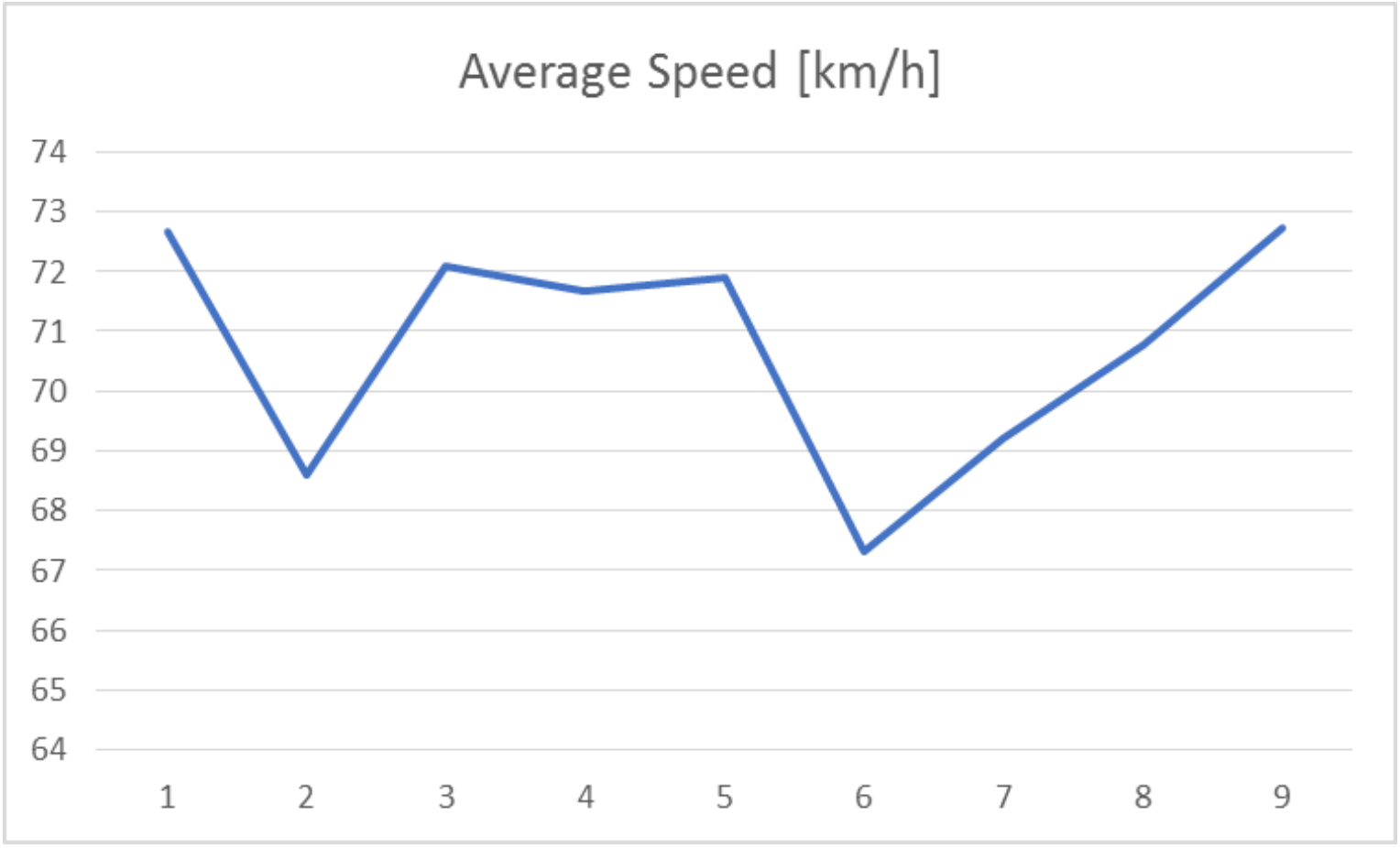
Simulation toolchains (TNO)



Outputs of the simulation

1. Travel times
2. Emissions
   - CO_2
   - PM10
   - NO_x
3. Energy use

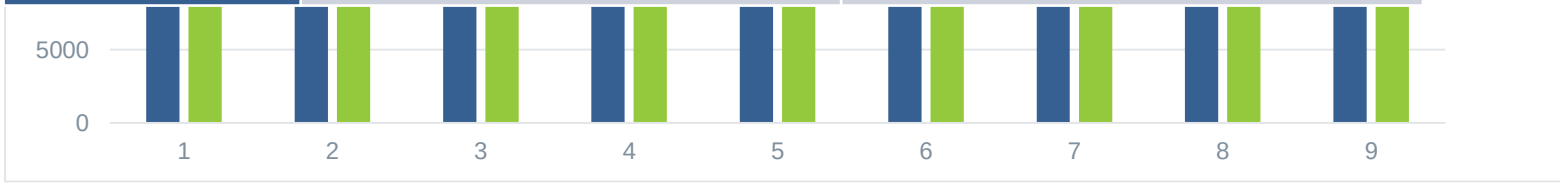
Results: travel times



Emissions

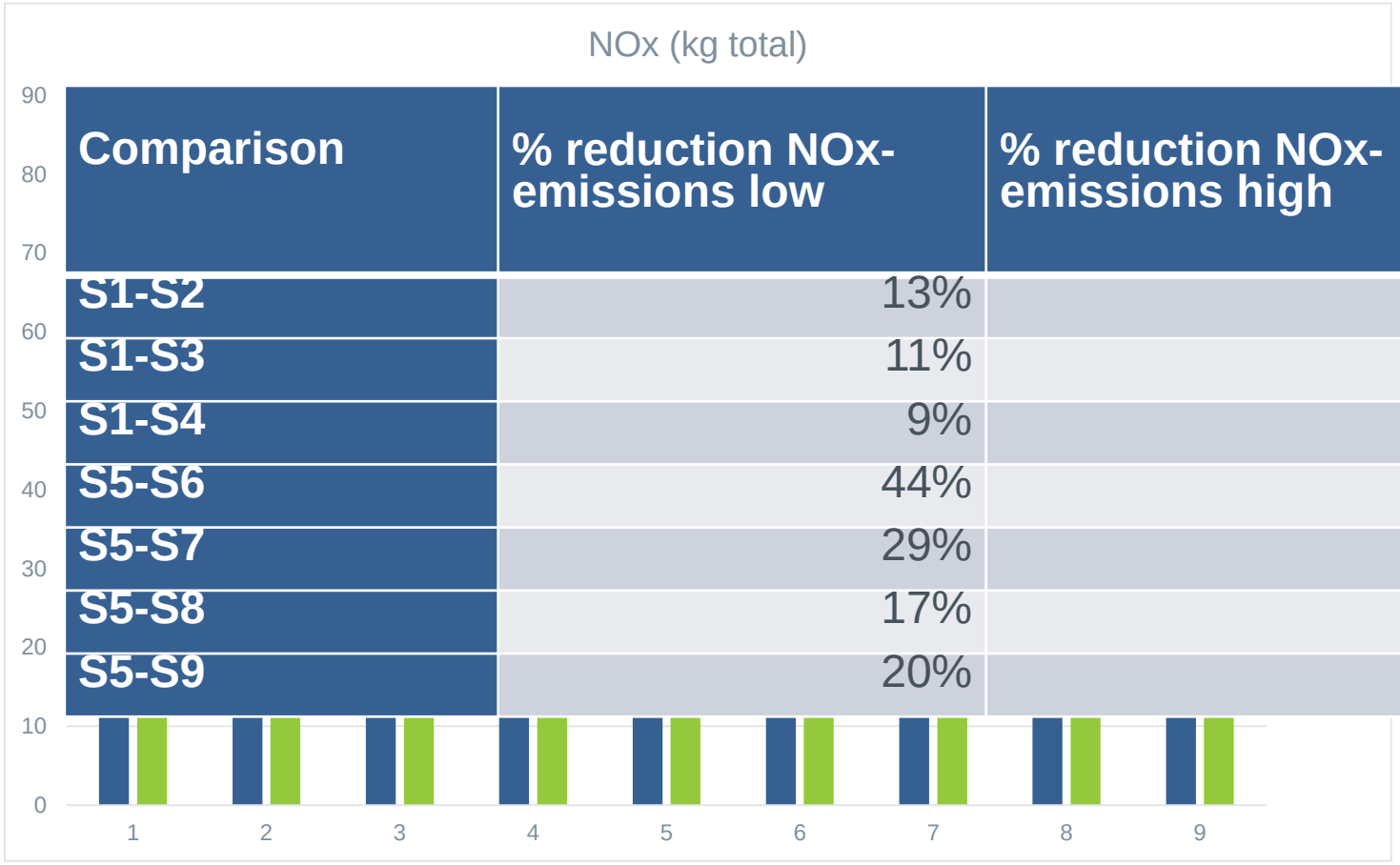
1. CO_2

Comparison	% reduction CO_2-emissions low	% reduction CO_2-emissions high
S1-S2	11%	12%
S1-S3	9%	8%
S1-S4	8%	4%
S5-S6	39%	13%
S5-S7	25%	6%
S5-S8	17%	6%
S5-S9	19%	7%



Emissions

2. NOx

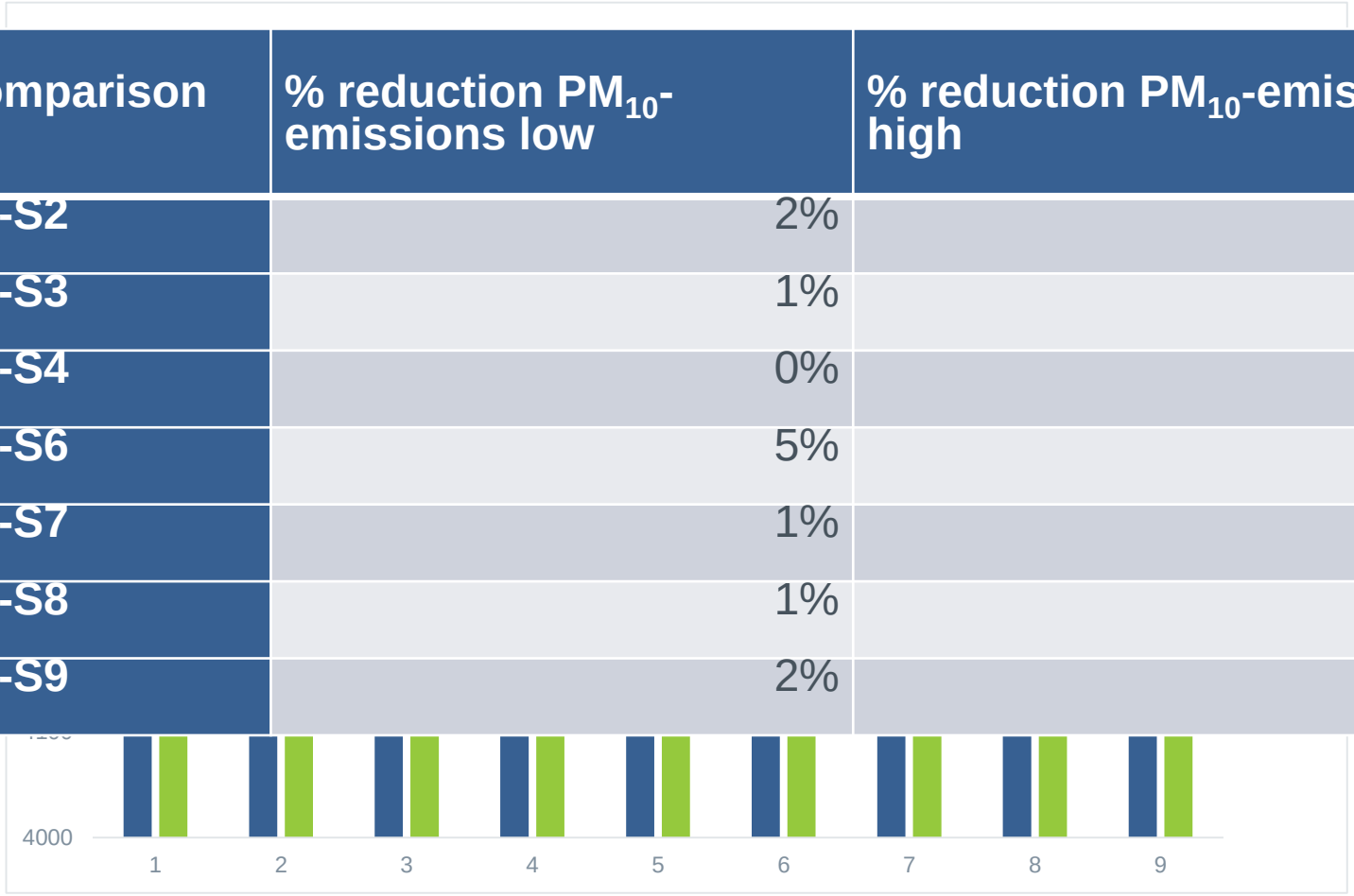


Comparison	% reduction NOx-emissions low	% reduction NOx-emissions high
S1-S2	13%	14%
S1-S3	11%	10%
S1-S4	9%	5%
S5-S6	44%	15%
S5-S7	29%	9%
S5-S8	17%	7%
S5-S9	20%	9%

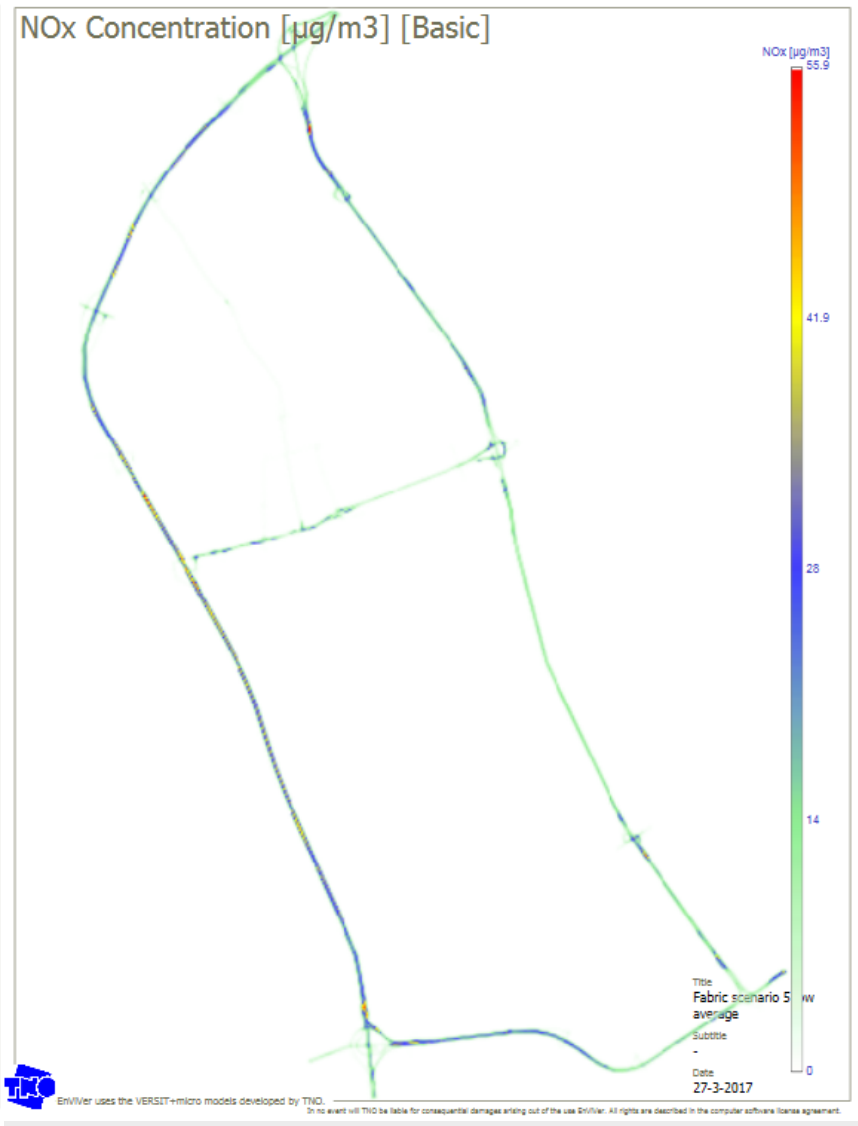
Emissions

3. PM10

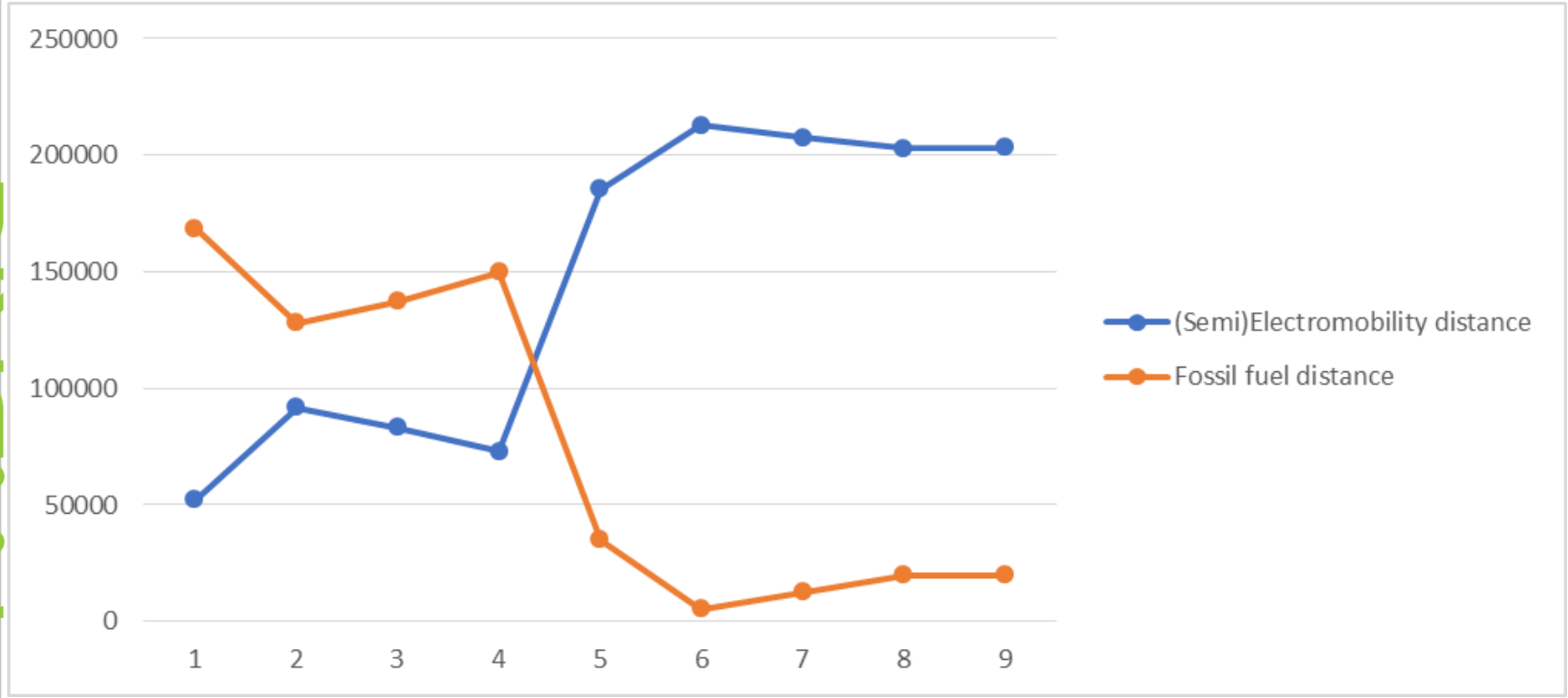
Comparison	% reduction PM_{10}-emissions low	% reduction PM_{10}-emissions high
S1-S2	2%	3%
S1-S3	1%	1%
S1-S4	0%	0%
S5-S6	5%	0%
S5-S7	1%	-3%
S5-S8	1%	-2%
S5-S9	2%	0%



Emissions: localized emissions



Energy consumption

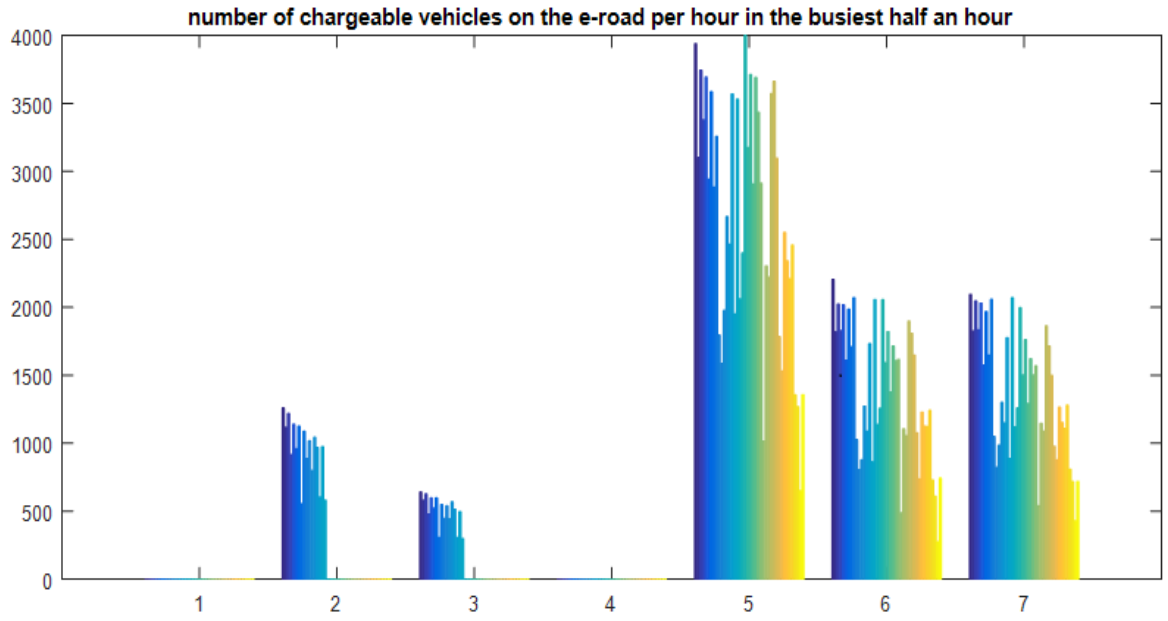


Discussion

1. Traffic operations deteriorate
   - Longer driving distances
   - Different distribution of traffic over the road system
2. Traffic operations less affected in Scenario 9
   - Pricing strategies: make static charging cheaper than dynamic charging
   - Use EVs with relatively high driving range
3. Emissions decrease
   - However, for future vehicles, the effect on problematic locations is limited
   - Effect also limited if there is a high autononomous deployment of electric vehicles

Discussion

4. Location of e-road lanes:
   - Alteration of existing right lane
   - Alteration of existing left lane
   - Adding an additional chargeable lane
   - Providing charging facilities on all lanes



FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

Thank you!

This work was also supported by the European Commission under FABRIC, a collaborative project part of the FP7 for research, technological development and demonstration (Grant Agreement NO 605405). The authors would like to thank all partners within FABRIC for their cooperation and valuable contribution.