Optimised Braking Energy Recovery in Metro and Light Rail Systems

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for Research & Innovation

Overview

- Technologies description
- Methodology
- Ticket to Kyoto experience
  - Reversible substations in the Metro network
- Eliptic Approach
  - Tram Network
- Summary & conslusions

Technologies description

Urban Rail Vehicles: Regenerative Braking & Energy Exchange

Onboard Energy Storage

Wayside Energy Storage

Reversible Substation

Summary of Technologies

	MOBILE STORAGE SYSTEMS	STATIONARY STORAGE SYSTEMS	REVERSIBLE SUBSTATIONS
Overhead line or third rail losses are reduced.	✖	✖	
High efficiency due to lower transformation and storage losses.			✖
Recovered braking energy can supply any equipment (lighting, escalators, etc.).			✖
Vehicles can be operated without overhead lines/ third rail on short sections.	✖		
The systems can be installed without having to modify the vehicles.		✖	✖
Lower safety constraints as not on-board of the vehicle.		✖	✖
Tunnels and stations warming can be avoided by reducing the heat produced by the braking resistors.	✖	✖	✖
Voltage stabilisation and peak-shaving opportunities.	✖	✖	

Methodology

Evaluation of Potential

- Measurements
  - Vehicles power flows and energy consumption
    - Braking resistors energy = Maximum energy savings potential
    - Auxiliaries
    - Traction
    - Energy sent back to the network
  - Substations
    - Energy consumption and power profile
    - OCV and internal impedance

Evaluation of Potential (II)

- **Simulations**
  - Modelling the network and vehicles “as it is”
  - Validation of the model with measurements
  - Introduction of energy recovery technologies

    → Find the suitable technology and possible solutions
- **Business Case**

  Investment

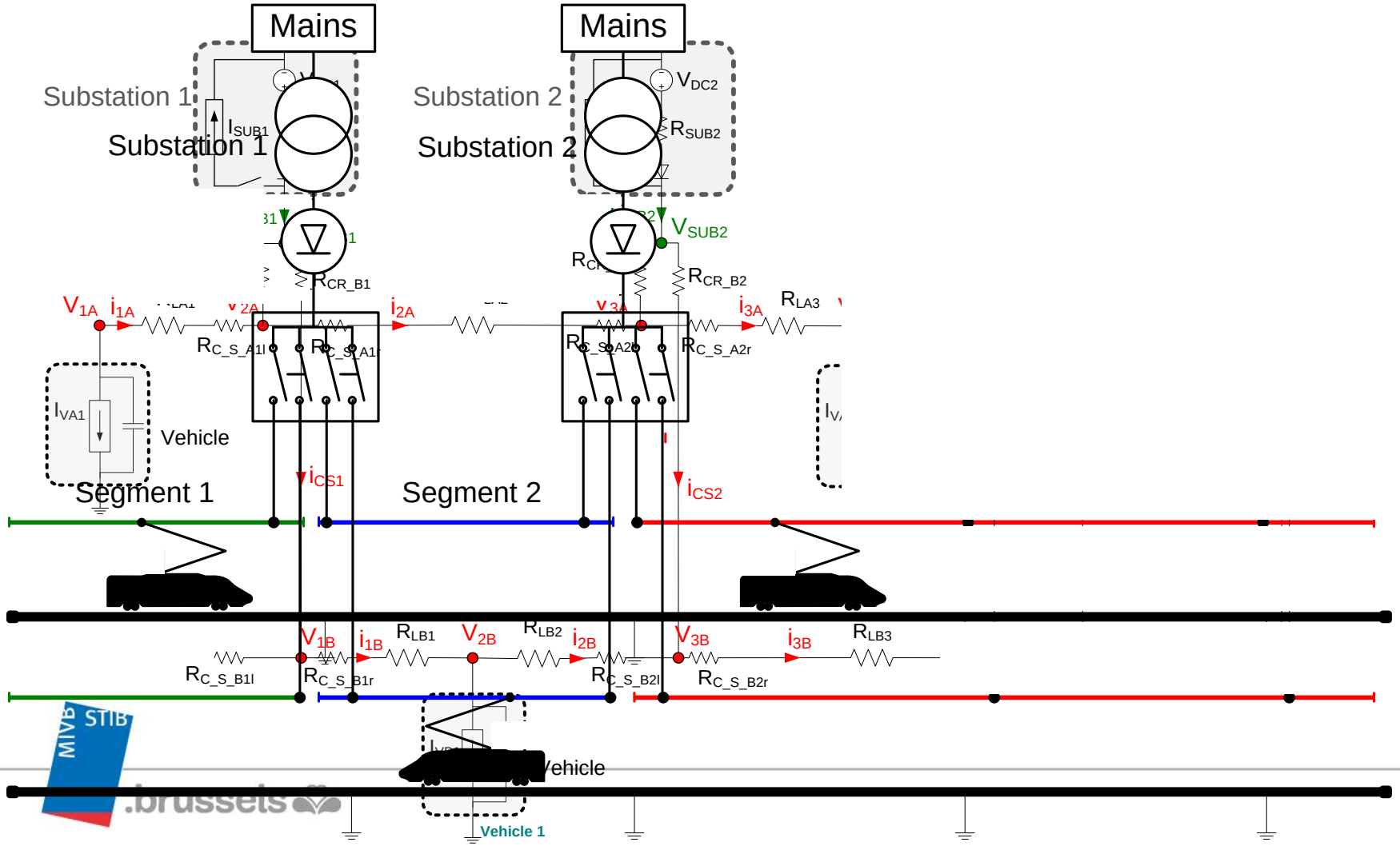
  Maintenance/year

  Energy savings/year

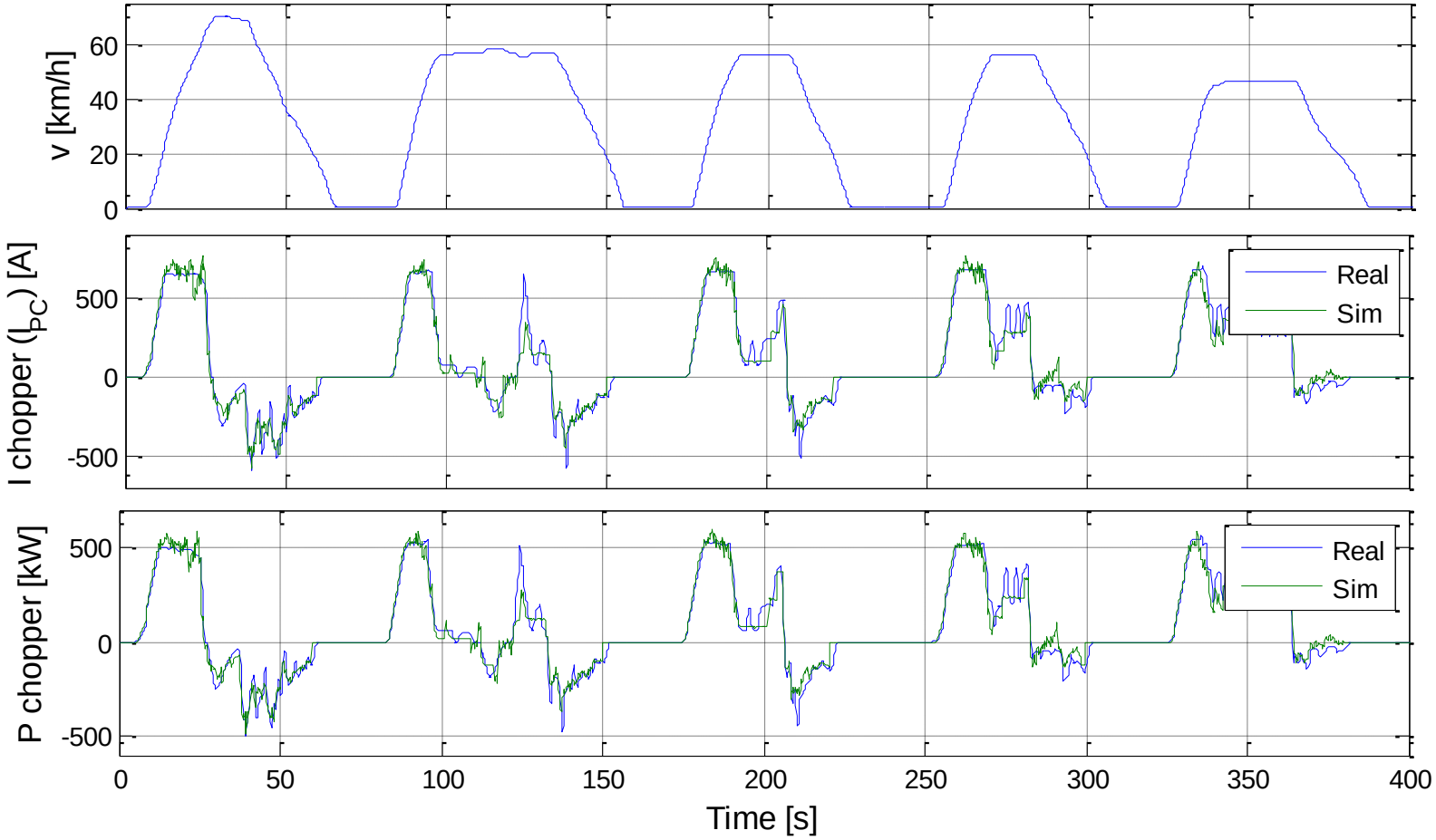
  Other costs/benefits (Installation, CO_2, etc)

Economic Indicator:
ROI
Payback Time
…

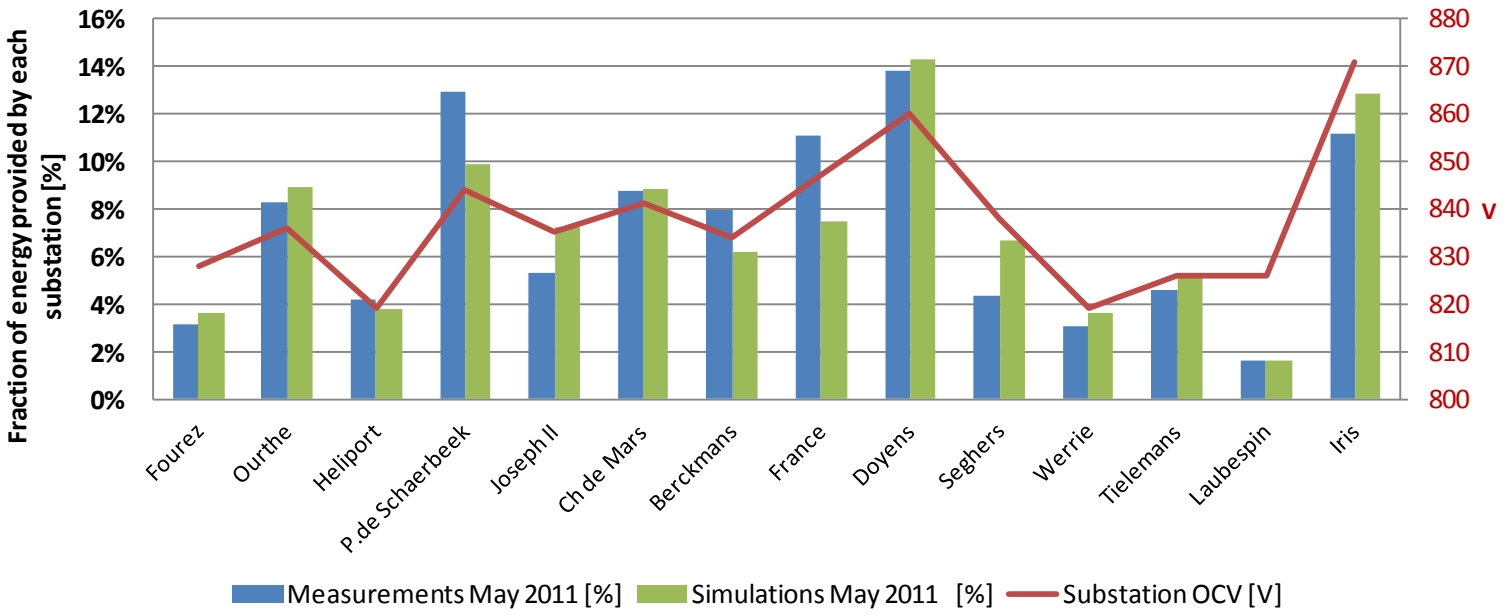
Simulations : Network Model

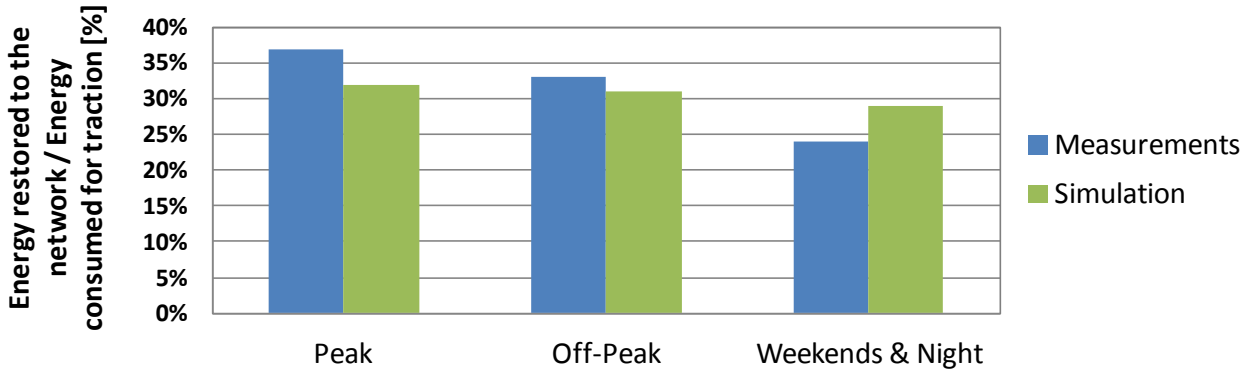


Simulations: Validation

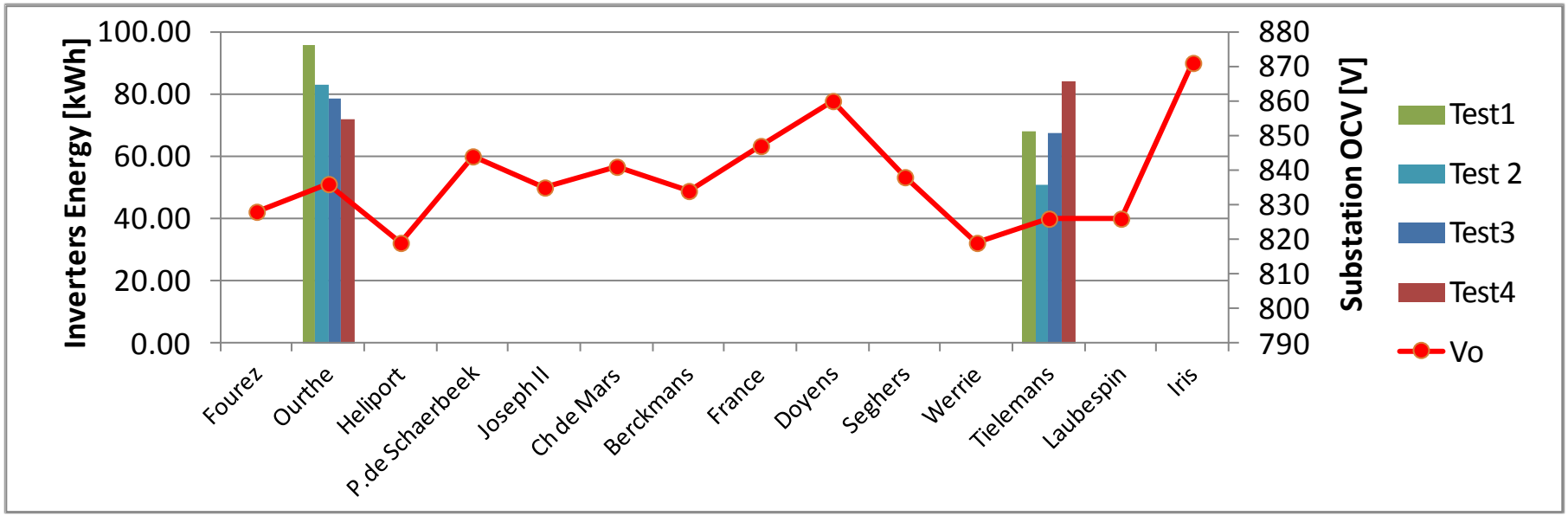


Simulations: Validation (II)

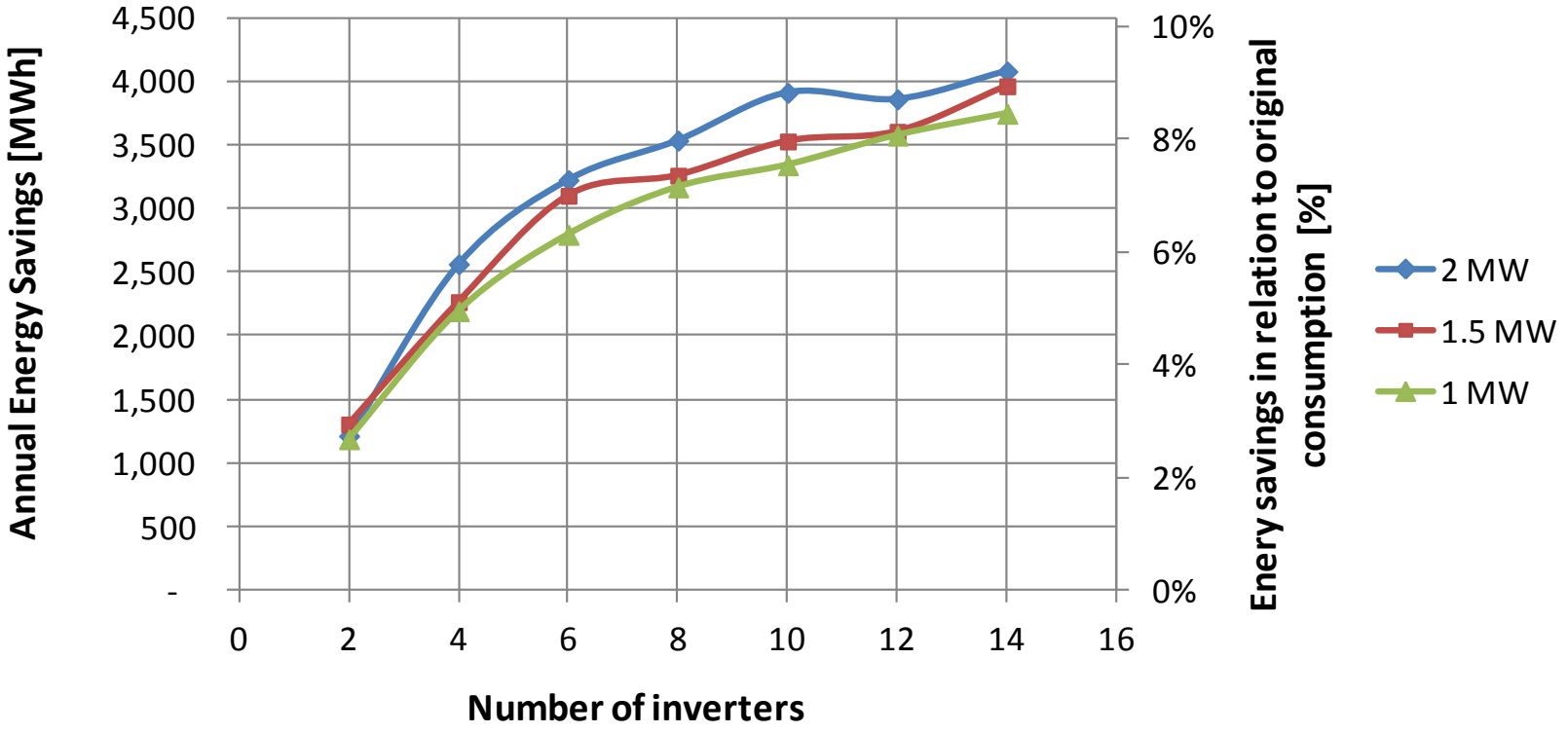




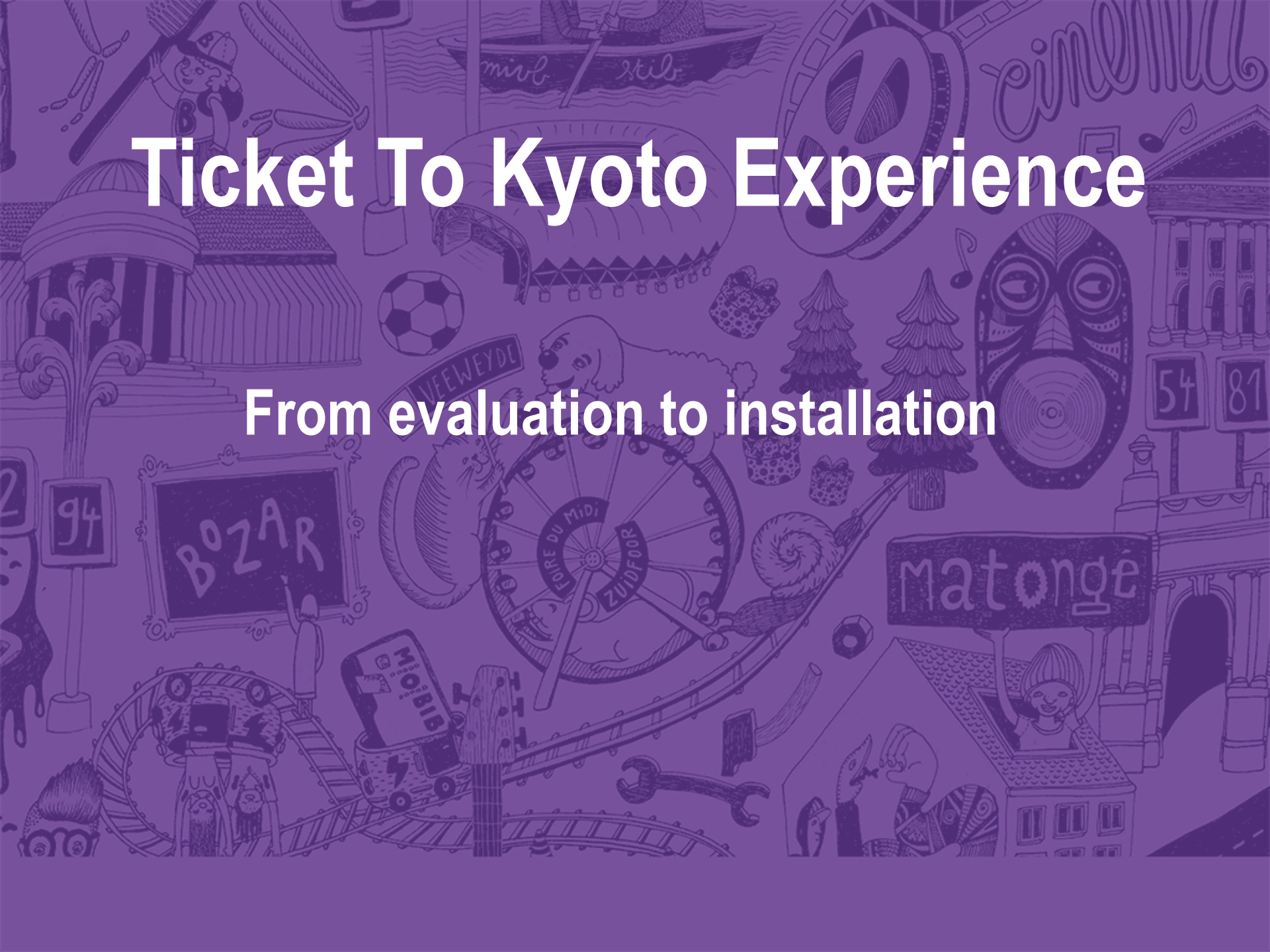
Simulation Results



Simulation Results (II):



Trade-off solution: 6-8 Inverters of 1 to 1.5 MW


Ticket To Kyoto Experience
From evaluation to installation
BOZAR
VEEWEYDE
FOIRE DU MIDI
ZUIDFOOR
MOBIB
matongé
54
81
94

Tender Process

- Tender answered by 8 companies

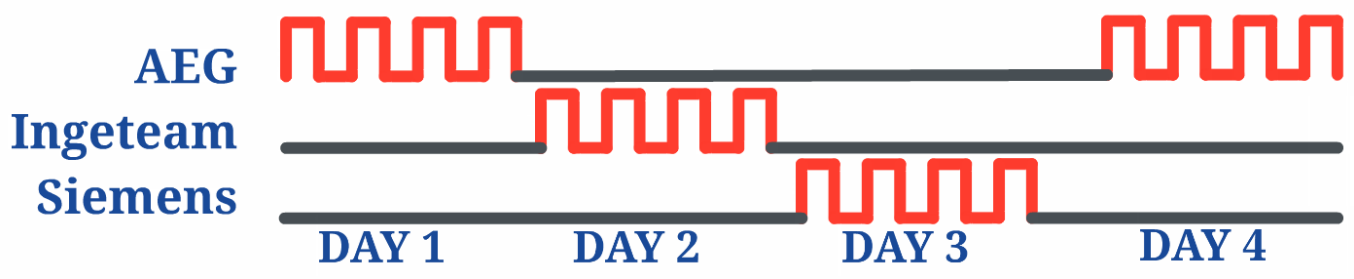
AEG TranzCom Ingeteam SIEMENS

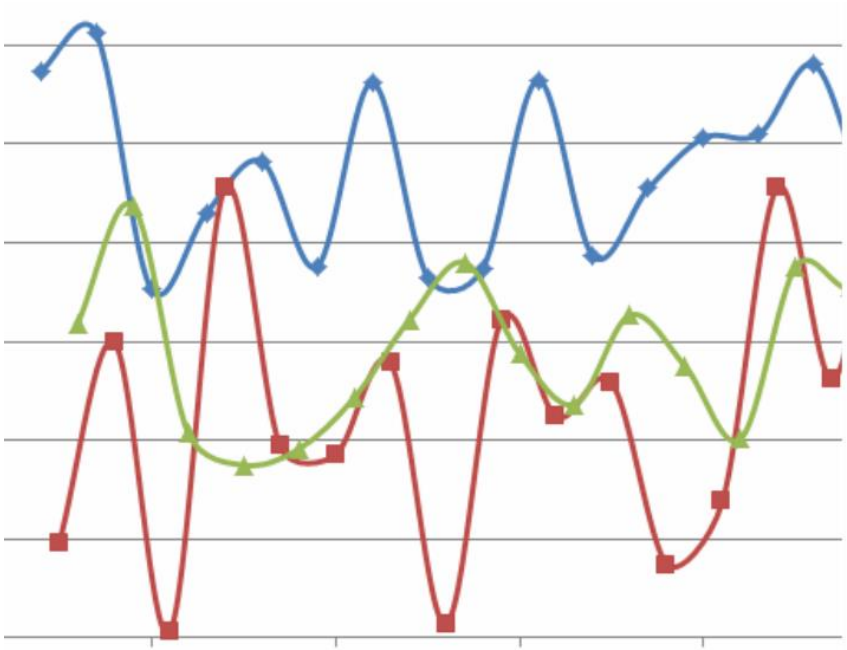
- Each company proposed a solution and estimated the yearly savings
  - Proposals evaluated & challenged by external expert
- After a few corrections, the final proposals from the 3 companies were similar

  → STIB decided to test 3 prototypes in the same conditions

How does a 1,5 MW inverter look?

Trial Phase

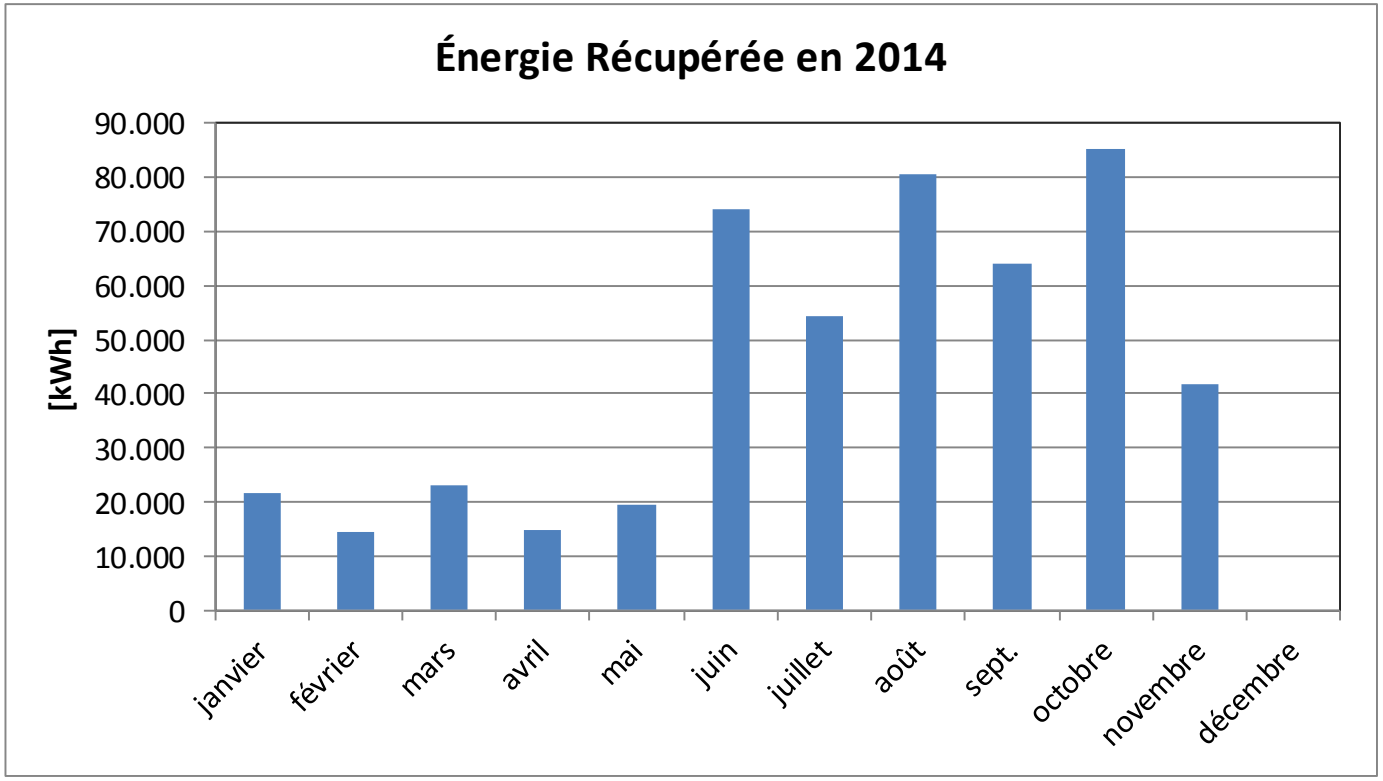




- Estimated Payback Time: 5 years (*)
- Differences in Power Factor
- Trial results in line with estimations

Results 2014

- 3 prototypes in the same substation until May



Installation and relocation of inverters

Eliptic

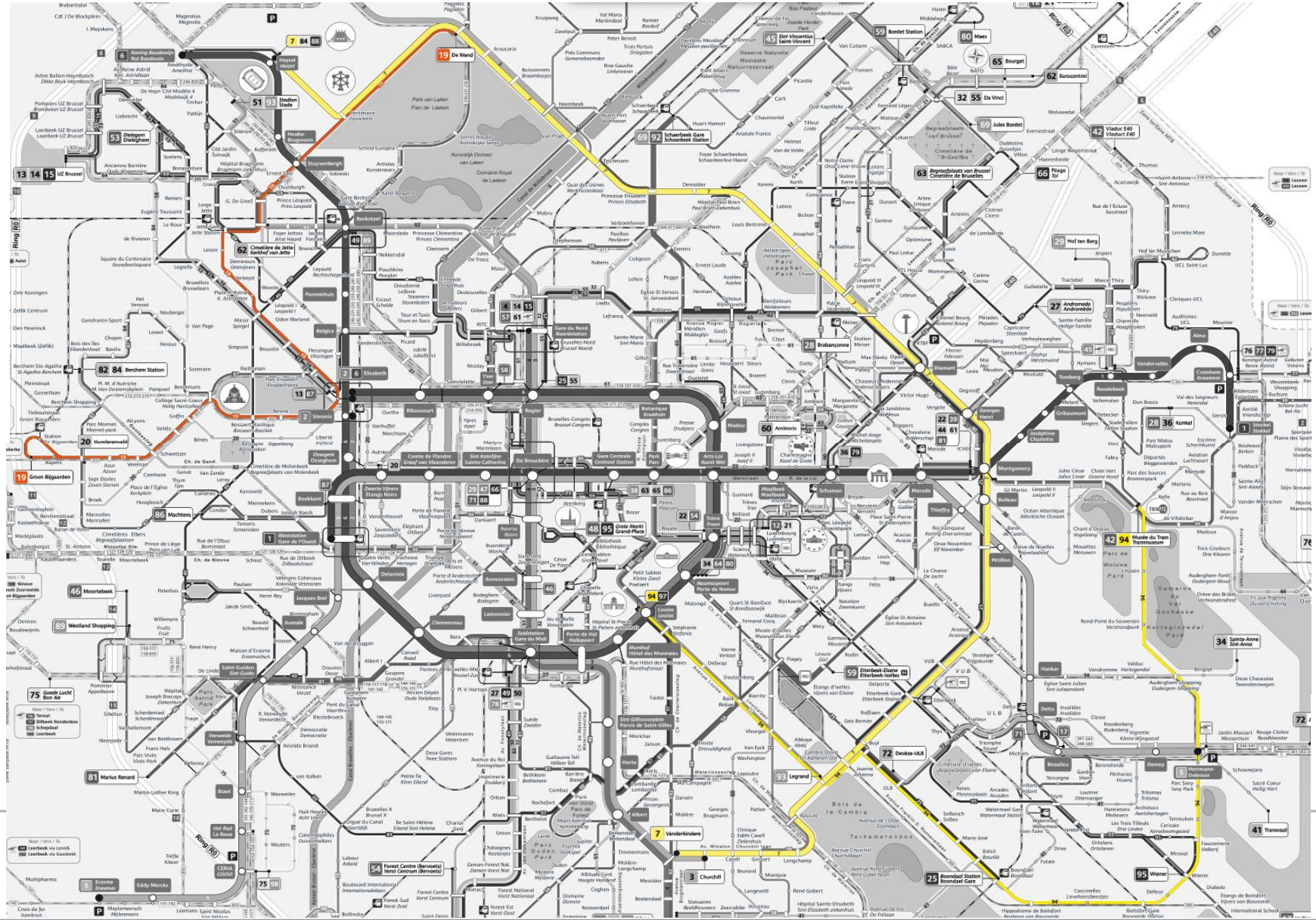
Energy Recovery in the Tram Network

MIVB STIB .brussels

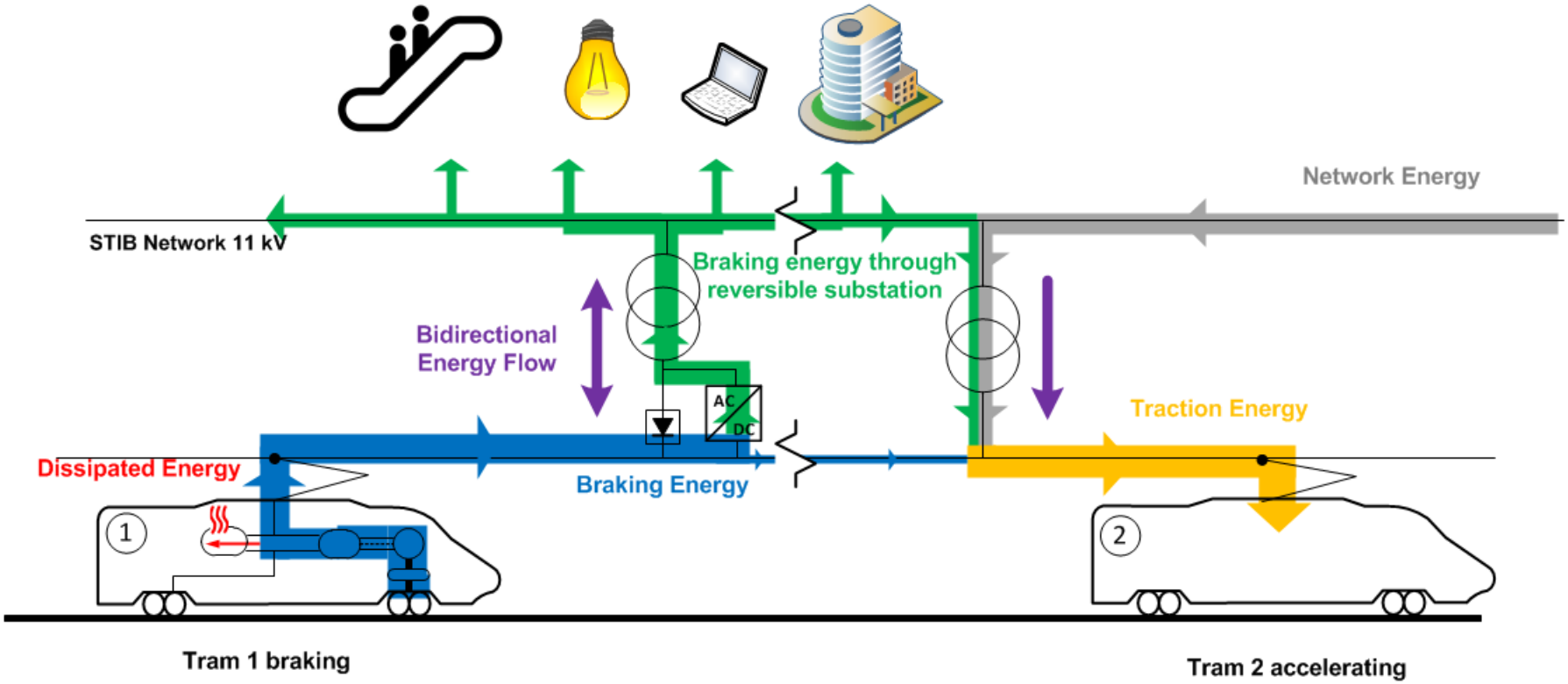
Eliptic Approach

- **Study of Tram Network**
  - Similar approach to the Metro study
  - Higher complexity
    - Interconnected lines
    - Substation feeding different lines
    - Electric feeders and catenary differ in sections
    - Most of the lines are mixed with car traffic
- **Use of feedback from real systems installed in the metro lines**

Tram Network



Reversible Substations Concept

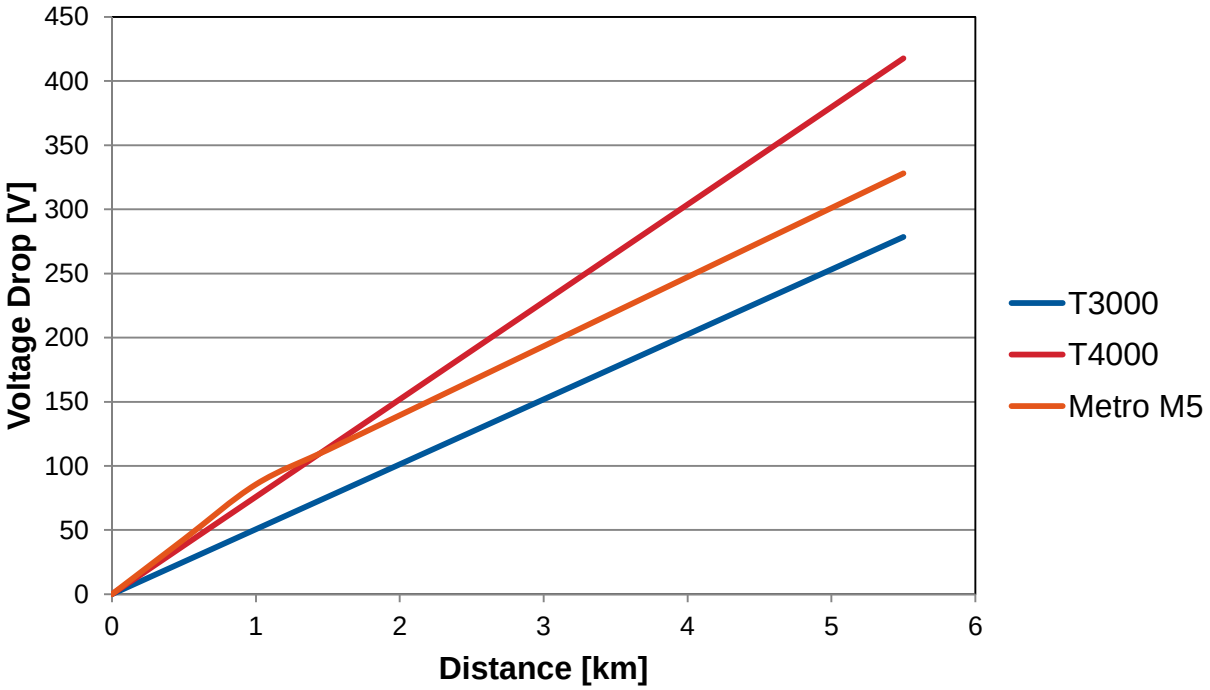


Quick Comparative: Tram vs. Metro

	Metro	Tram
Vehicles' Power	> 2 MW	< 600 kW
Vehicles' Speed	Higher (up to 70 km/h)	Lower (dependant on traffic)
Electric Network	Regular feeders and third rail	Irregular feeders and caternary sections
Auxiliaries' consumption	Low	High (expected)
Stations Nearby	Always	Rarely
Supply Voltage	900 Vdc	700 Vdc
Electric consumers near the substation	Always (station): escalators, lighting, shops	Rarely

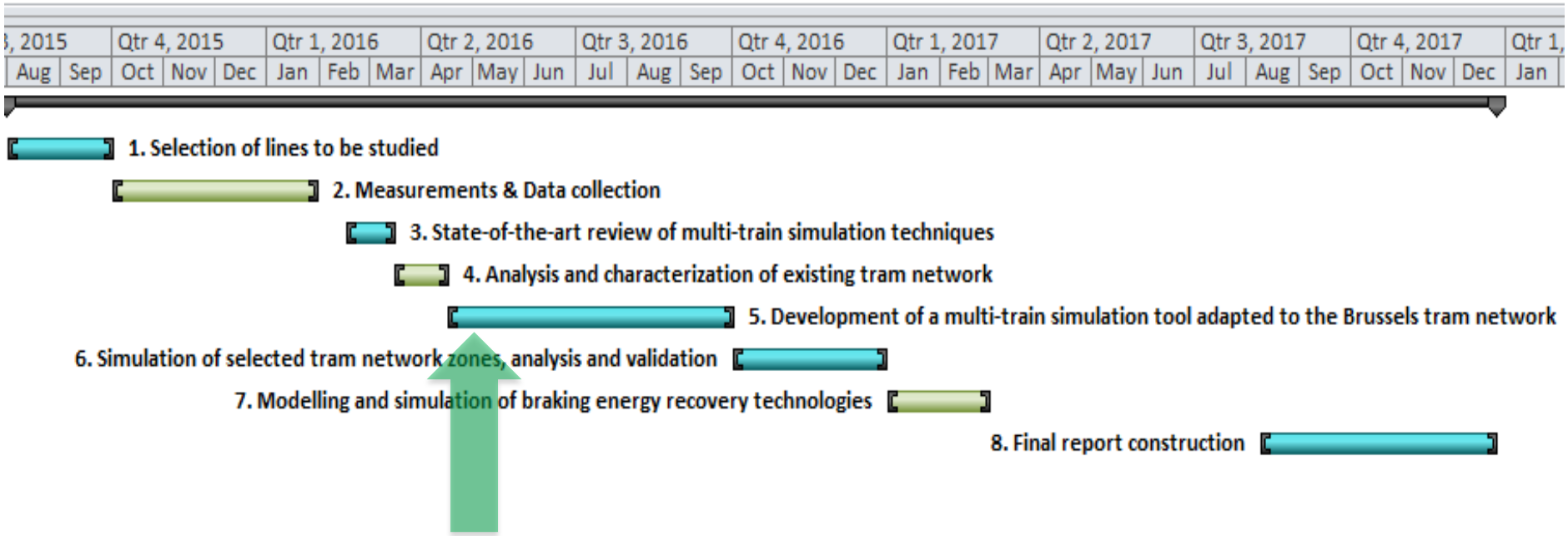
Tram vs. Metro: Voltage drop par km

This parameter influences "How far the braking energy can be sent"



Despite the differences → similar behaviour

Eliptic Timeline



- ✓ Lines Selection
- ✓ State of the art review
- ✓ Analysis of network
- ✓ Comparative Metro vs Tram

- ➢ Network Model (ongoing)
- ➢ Measurements (ongoing)
- ➢ Simulations & Validation
- ➢ Energy Recovery Simulations
- ➢ Business Case
- ➢ Reporting

Summary


VEEWEYDE
FOIRE DU MIDI
ZUIDFOOR
BOZAR
MOBIB
matongé
54
81
94

Summary & Conclusions

- Overview of methodology and Ticket to Kyoto experience
- Lessons learned:
  - Control expertise is crucial
  - The same hardware can have very different results
  - Importance to challenge the supplier proposal by independant consultant
  - Each network is different → Hard to extrapolate results
- Eliptic:
  - Similar methodology will be used
  - Feedback from Ticket to Kyoto will be used