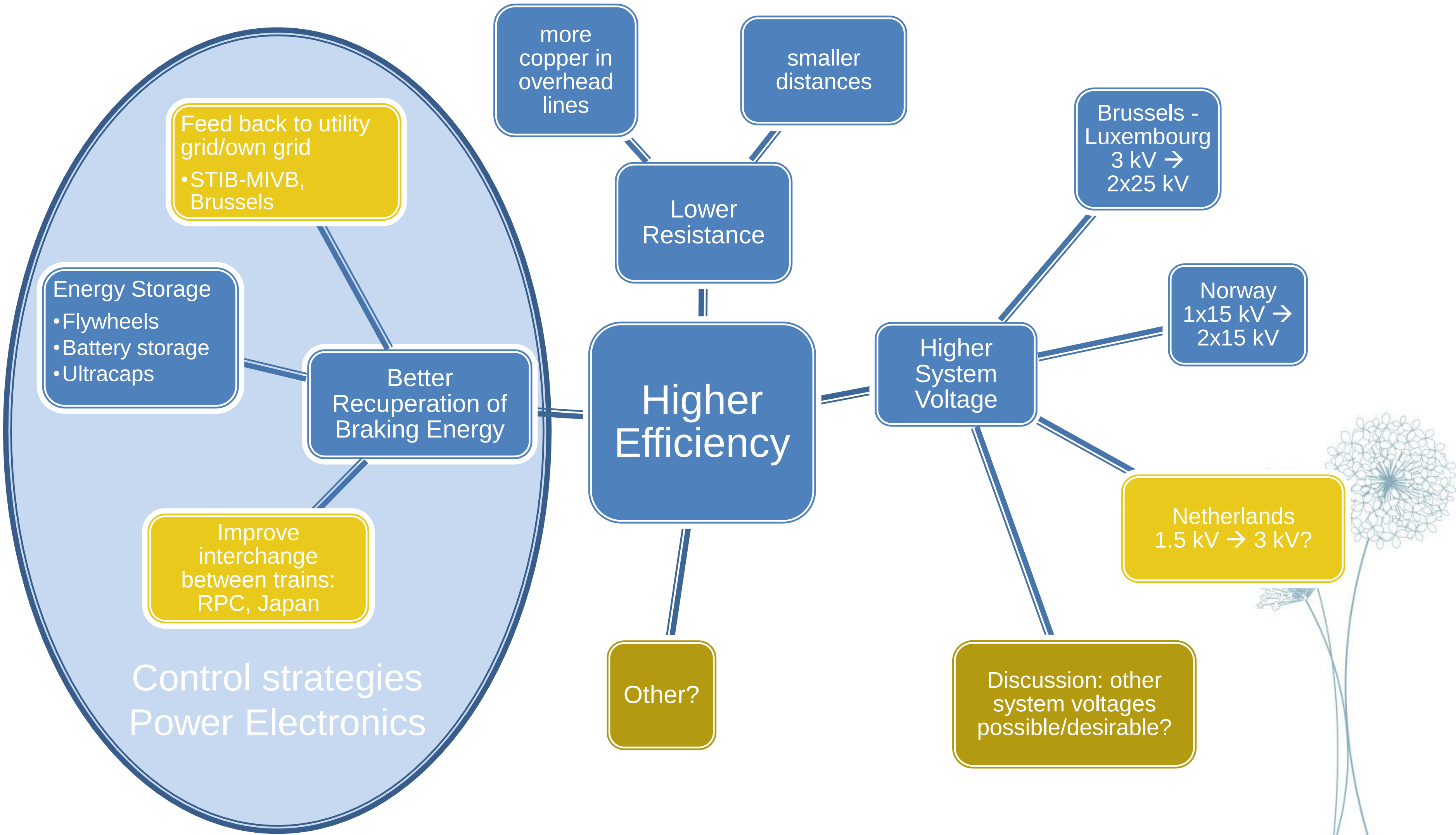
UIC ENERGY EFFICIENCY DAYS 2014

ANTWERPEN, 16 - 19 JUNE

ENERGY EFFICIENCY IN ELECTRIC TRACTION SUPPLY

INCREASING THE EFFICIENCY FROM SUBSTATION TO PANTOGRAPH… AND BACK

OVERVIEW



Feed back to utility grid/own grid
• STIB-MIVB, Brussels
Energy Storage
• Flywheels
• Battery storage
• Ultracaps
Better Recuperation of Braking Energy
Improve interchange between trains: RPC, Japan
Control strategies
Power Electronics
more copper in overhead lines
smaller distances
Lower Resistance
Higher Efficiency
Other?
Higher System Voltage
Brussels - Luxembourg 3 kV → 2x25 kV
Norway 1x15 kV → 2x15 kV
Netherlands 1.5 kV → 3 kV?
Discussion: other system voltages possible/desirable?

OVERVIEW

- Speakers:
  - Energy utilisation in a.c. traction power supply system by introducing RPC (Railway Static Power Conditioner)
    Kazumi Nagano, East Japan Railway Company, Japan
  - Braking Energy Recovery – from simulations to tangible results
    Ricardo Barrero, STIB-MIVB, Belgium
  - Energy efficiency by increasing the traction power supply voltage
    Fedor ten Harve & Marcel Walraven, ProRail, The Netherlands

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Braking Energy Recovery

From simulations to tangible results

Ricardo Barrero
Environmental Technology Officer
STIB-MIVB

Energy Efficiency, the best fuel to move our trains!

PRESENTATION AS PREZI

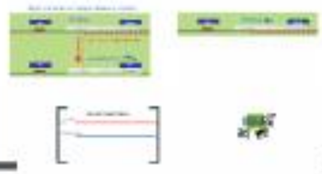
http://prezi.com/nsnstlepohex/?utm_campaign=share&utm_medium=copy&rc=ex0share

The next slides are some screen shots from this Prezi.

Braking Energy Recovery

Context

Principle

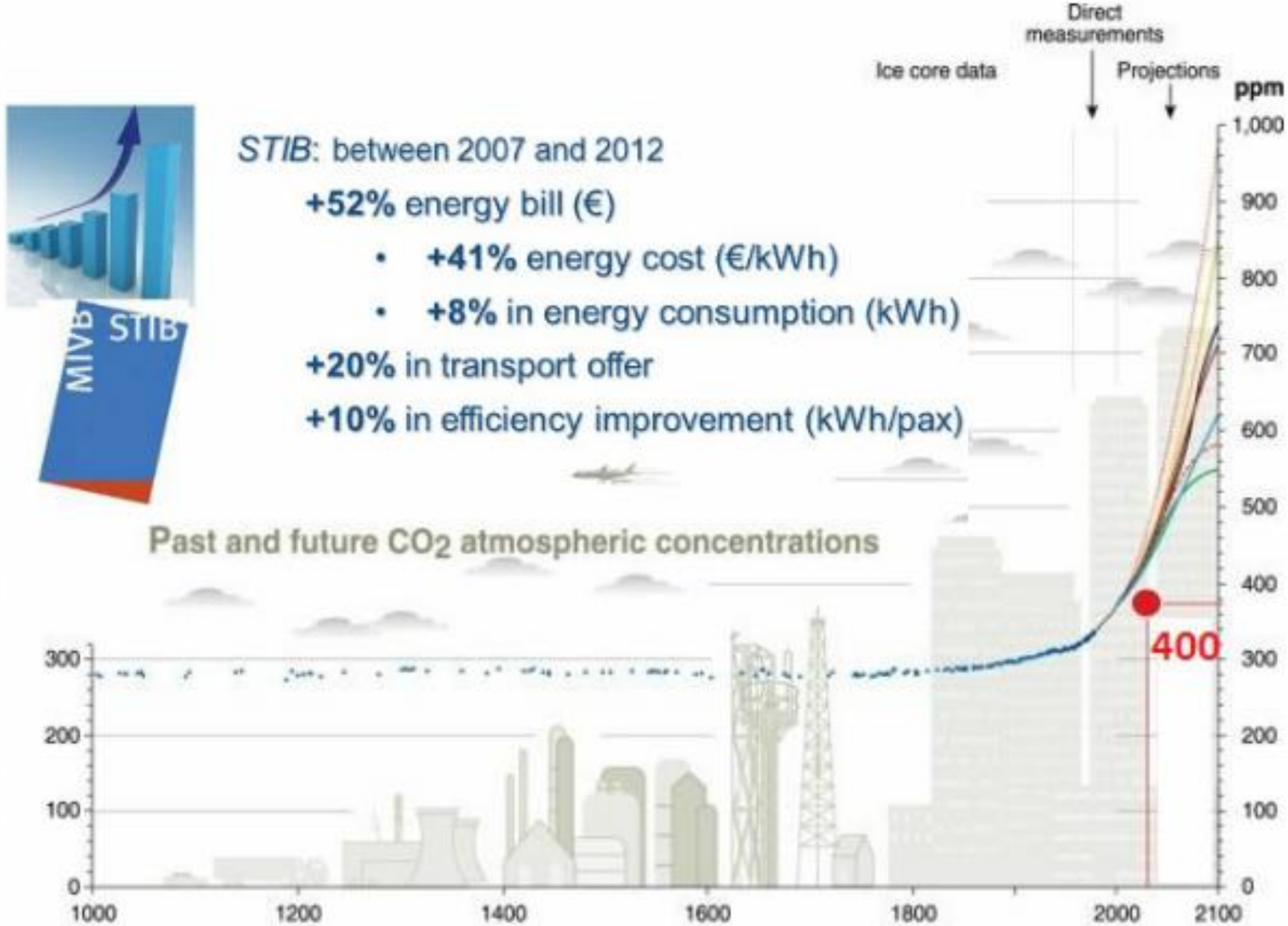


Real World Implementations

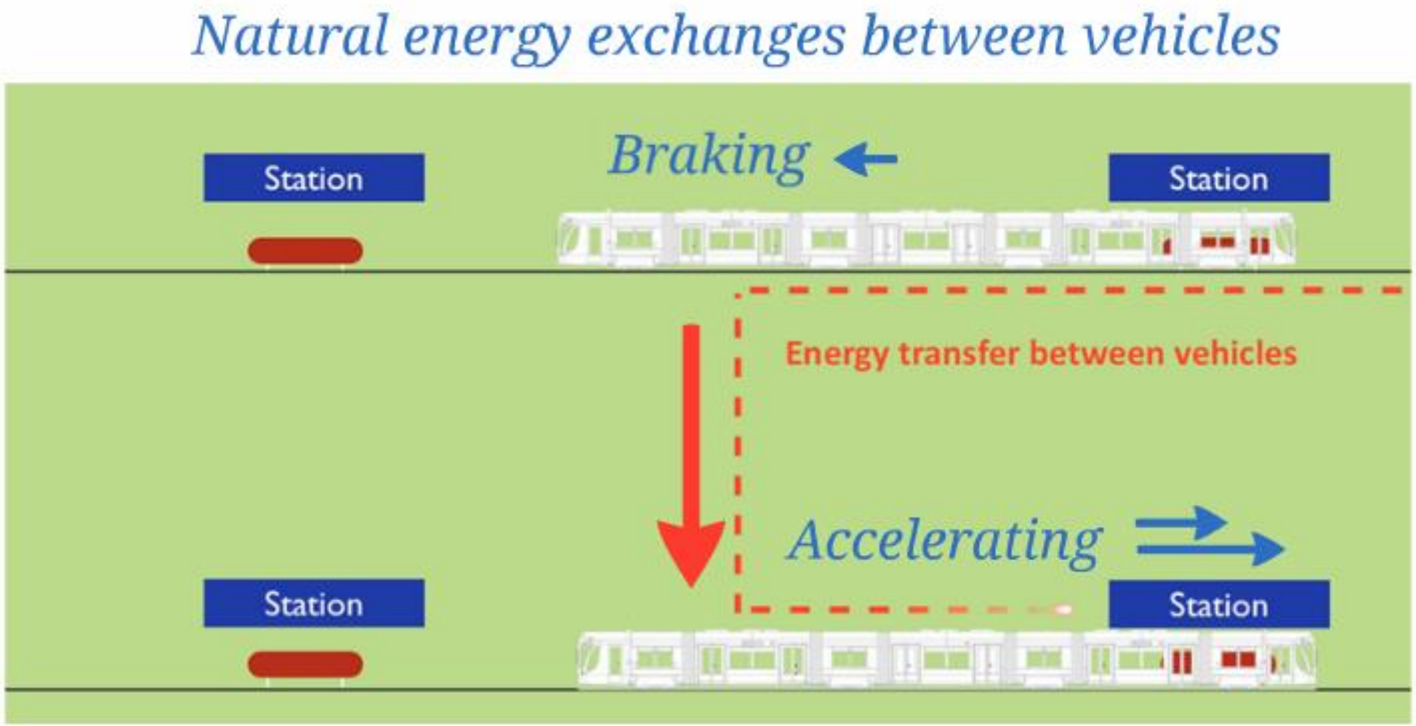
Need for energy efficiency in public transport

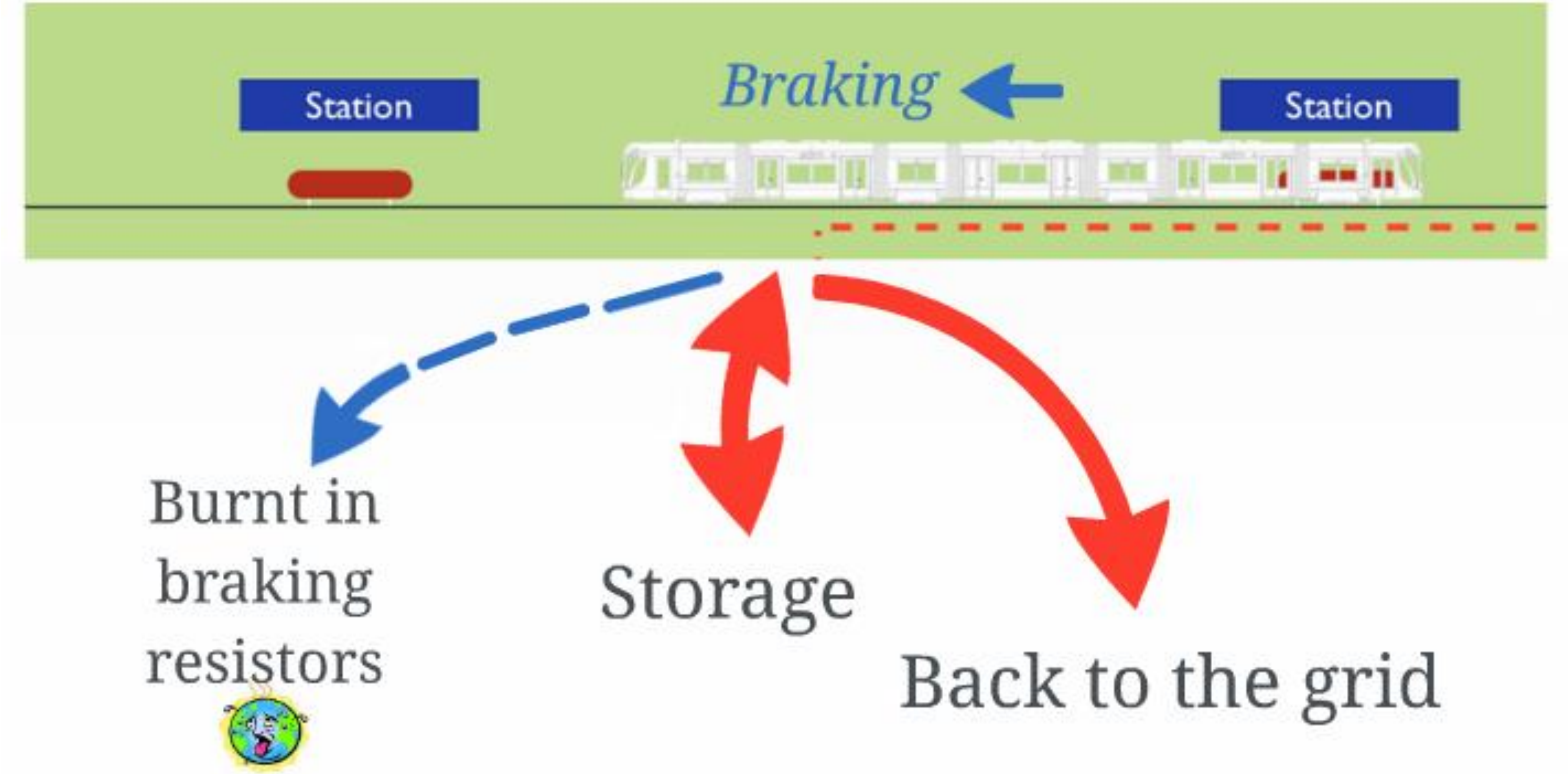
STIB: between 2007 and 2012

- **+52%** energy bill (€)
  - **+41%** energy cost (€/kWh)
  - **+8%** in energy consumption (kWh)
- **+20%** in transport offer
- **+10%** in efficiency improvement (kWh/pax)

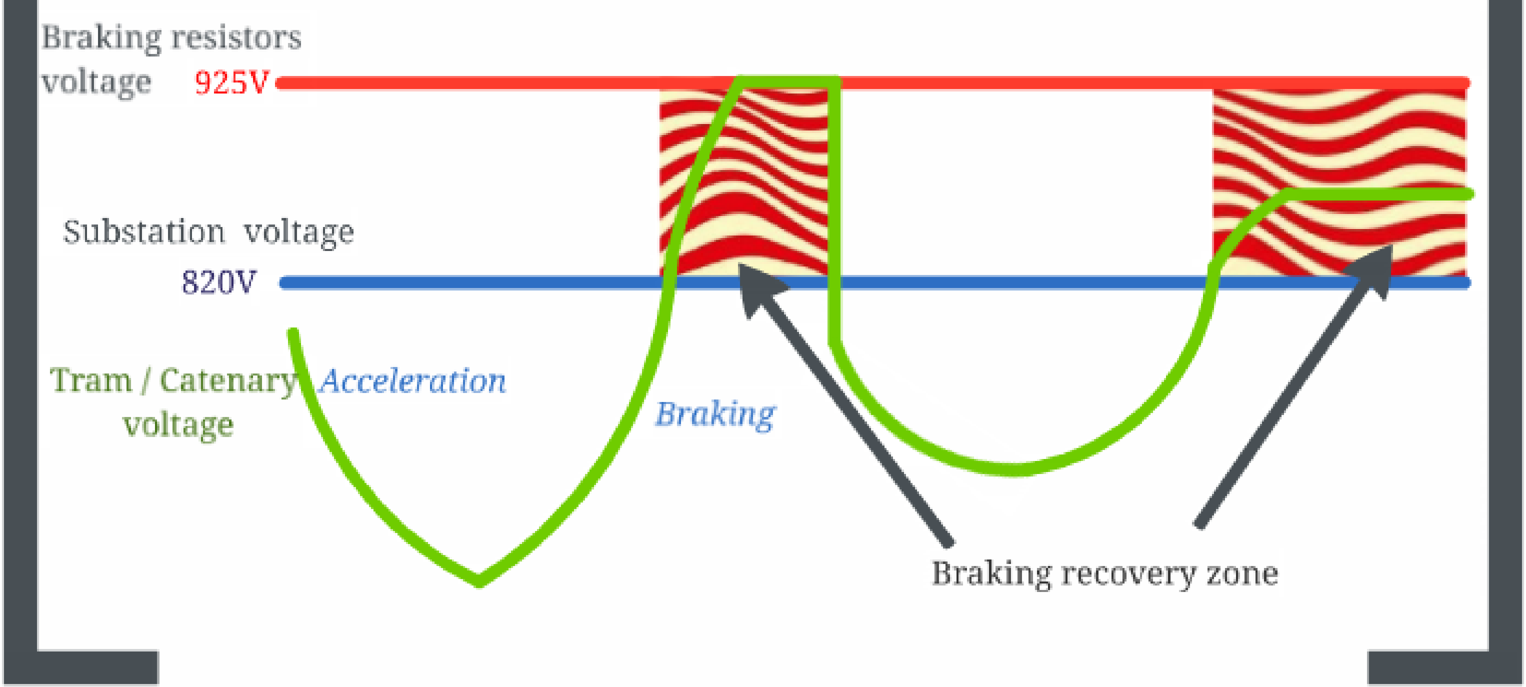


Mitigation and adaptation required


Natural energy exchanges between vehicles
Braking
Station
Station
Energy transfer between vehicles
Accelerating
Station
Station


Station
Braking
Station
Burnt in braking resistors
Storage
Back to the grid

Network Voltage Evolution



Stationary applications

Mobile applications

- Supercapacitors
- Batteries
- Flywheels
- Reversible substations

Challenges

Advanced simulations required
- Large set of data
- Good expertise

Follow market evolution

Evaluate potential

Select technology
Compare suppliers
Optimize
→ 5V error: Benefits -20% !
Adapt to network evolution

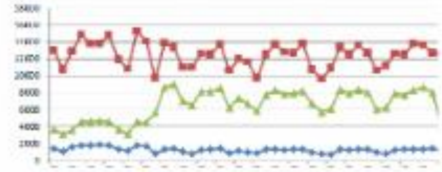
Implementation

Studies with Brussels university (2 PhD students)
Choice for reversible substations line 2-6
Tender answered by 8 companies (out of 11)
3 selected for trial

3 month comparison in the same substation

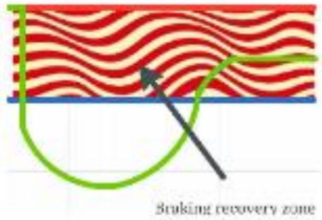
Trial

High variability in substation consumption

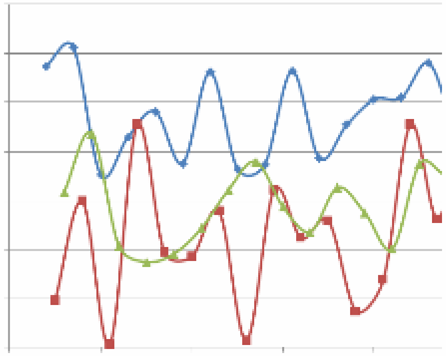


For a fair comparison we need the same reference

Other challenges: Substation OCV and braking resistors voltage vary



Results



Important note:
Three suppliers still see an important potential of optimization
+ challenging OCV and braking voltage

Energy consumption reduced by 9% when complete systems deployed

Payback time: Maximum 5 years for 6 systems (before optimization)

Results in line with University simulations

Difference in reactive power generated

Next steps

Complete installation of 6 systems on line 2-6
Potential new tender for line 1-5
Studies for tram which also has high potential

Three publications on this topic from the T2K partners


moBiel
Ein Unternehmen
der Stadtwerke Bielefeld
new inverter
inverter
inverter
Energy
storage
system

- moBiel happy with both flywheel and inverter
- Efficiency is lower (84%) with flywheel than reversible substations (98%)
- Decision to buy third reversible substation

Energy savings are close from the network calculations made by Elbas

With the 2 inverters and 1 flywheel, moBiel saves over 900.000 kWh/year

Payback time: Maximum 10 years for 4 systems (5 year with funding)

Two inverters made by IMTECH

Simulation results :

- Schiedam substation: 663,000 kWh/year
- Hekelingseweg: 560,000 kWh/year

Conclusion

Braking energy recovery is a complex technology becoming

Several real world implementations in Ticket to Kyoto projec
Savings up to 12% depending on network characteristics

Independant electrical and network simulations are key to n
benefits

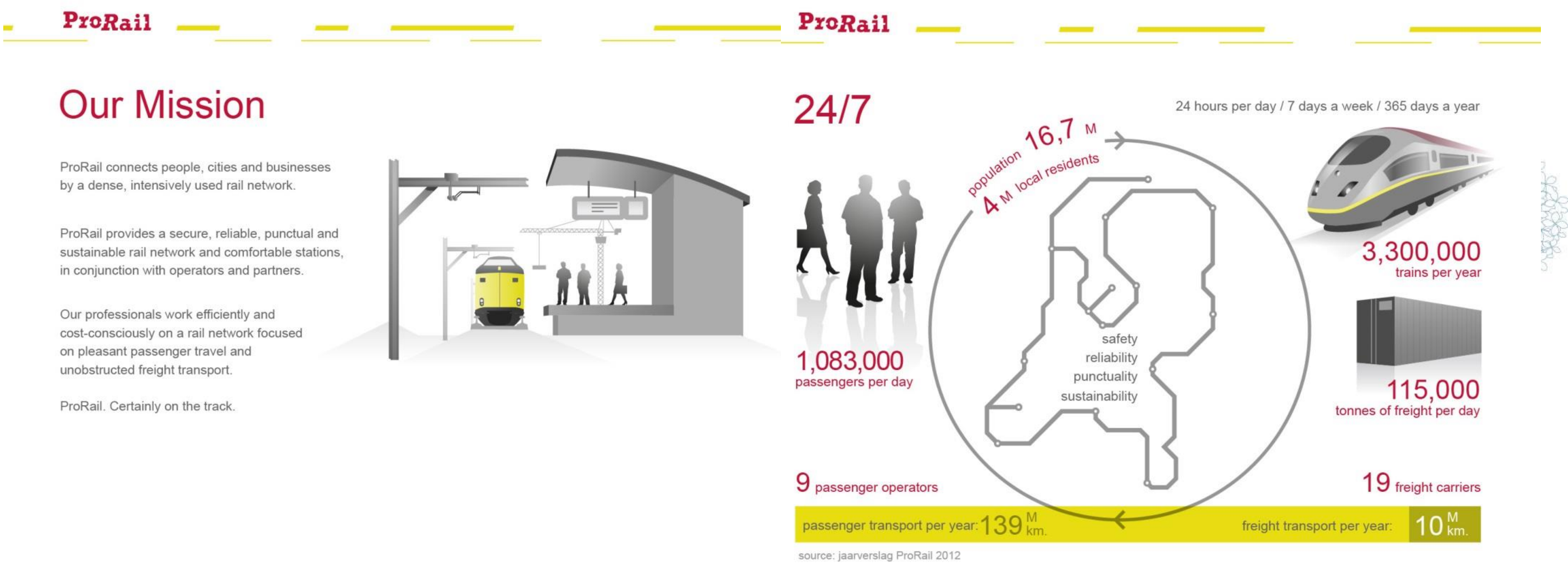

Thank you for your attention

ENERGY EFFICIENCY BY INCREASING THE TRACTION POWER SUPPLY VOLTAGE

MARCEL WALRAVEN AND FEDOR TEN HARVE

INTRODUCTION PRORAIL

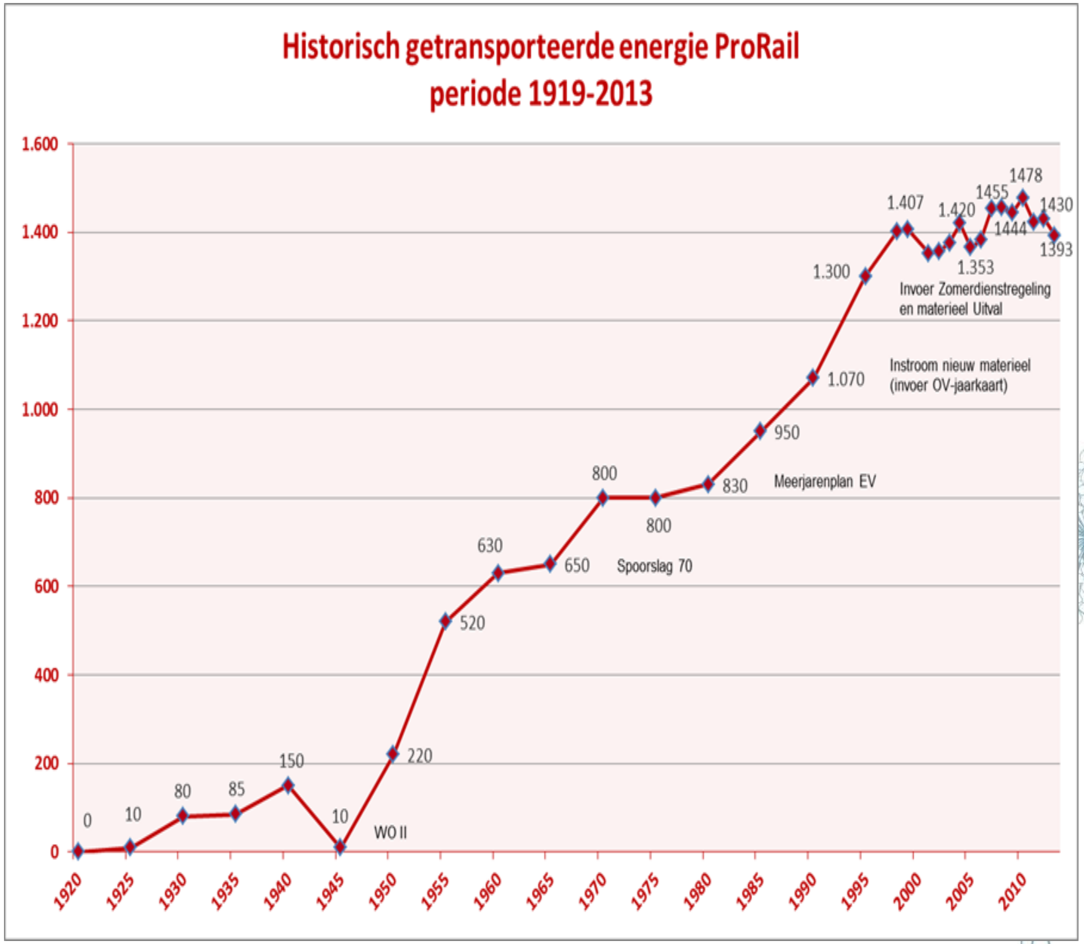
- Independent
- Railinfrastructure manager
- Railinfra network operator



FACTS & FIGURES

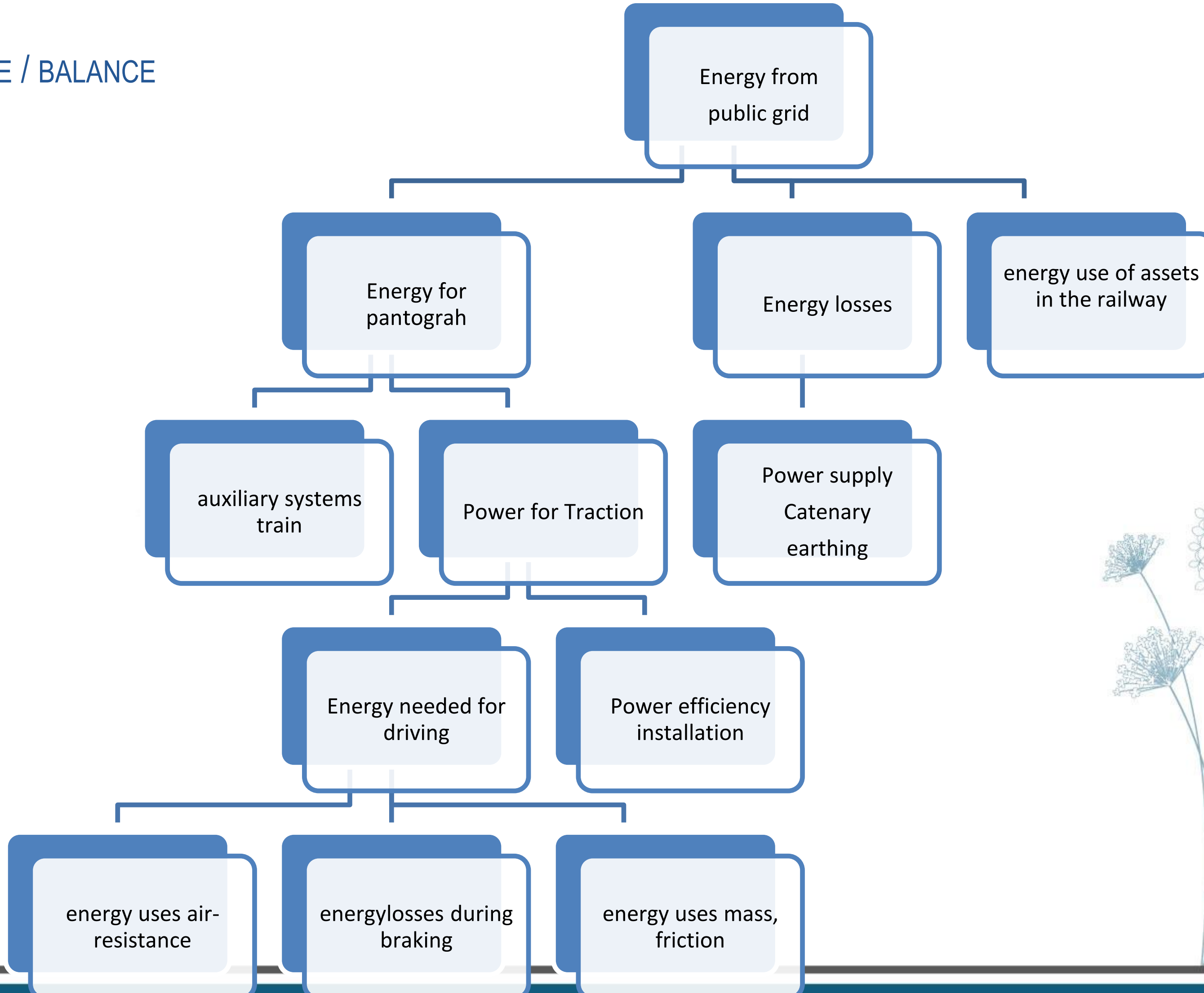
- 1500 V Power Supply
- 2100 km electrified.
- 243 substations (2.5 – 12 MVA).
- 130 track sectioning stations.
- Distance between substations 3 – 21 km, average 6 km.
- Trains max: 4000 A.
- Energy use yearly : 1400 GWh.

History of traction energy

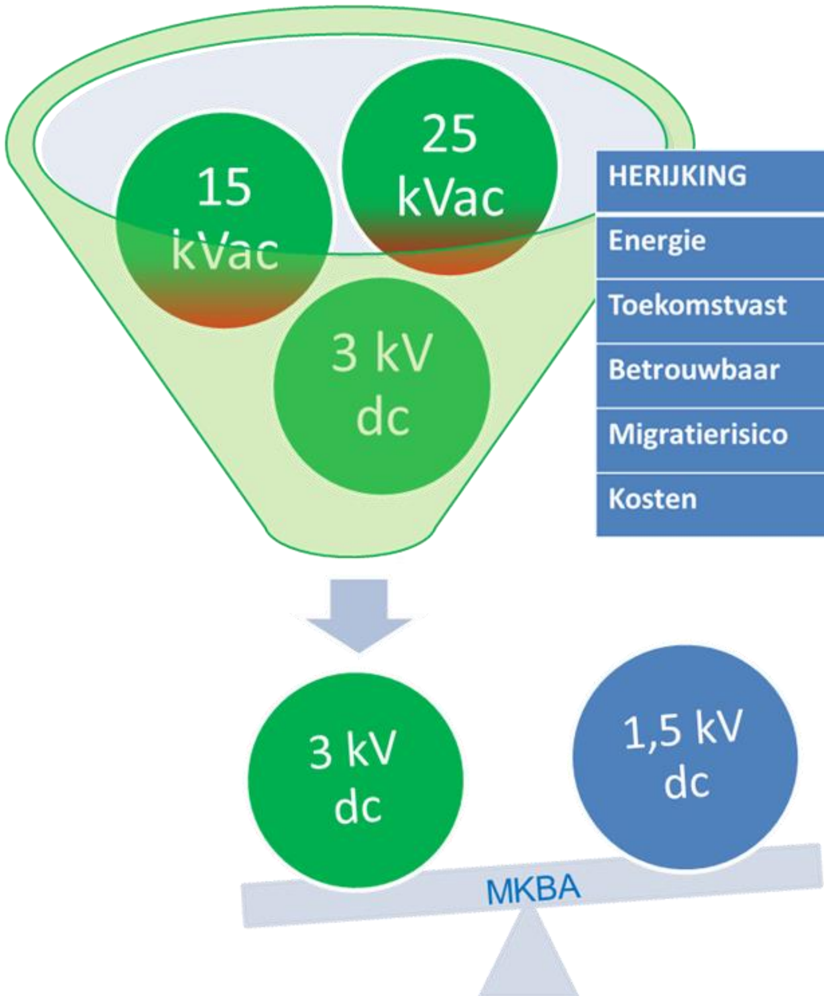


Analysis of Energy Effects

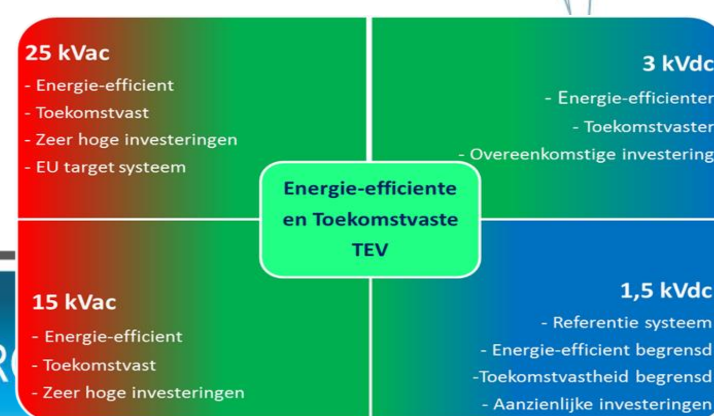
Energy usage / balance



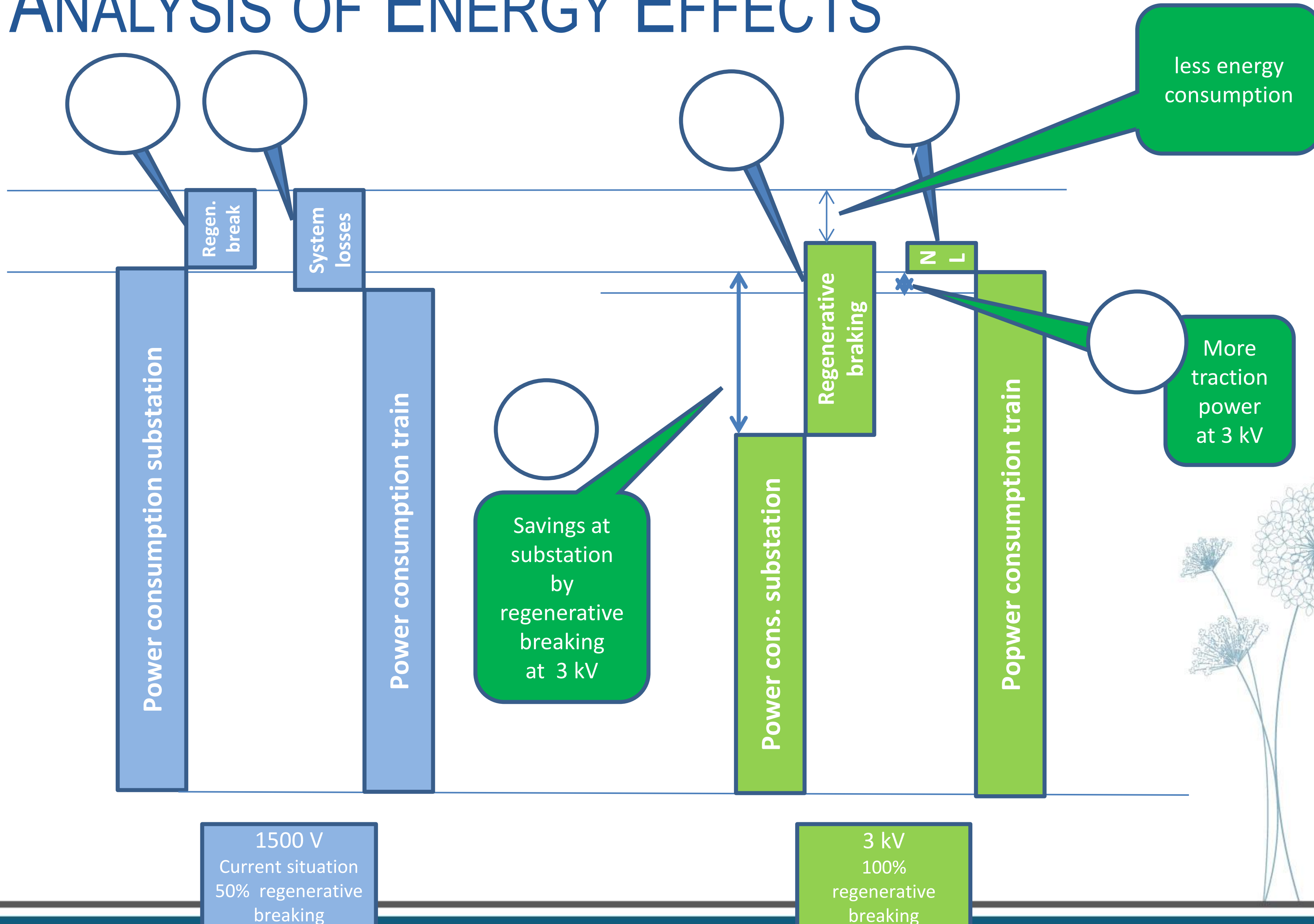
RE-EVALUATION OF TRACTION SYSTEM 2011/2012



HERIJKING	25 kVac	15 kVac	3 kVac	1,5kV
Energie				
Toekomstvast				
Betrouwbaar				
Migratierisico				
Kosten				



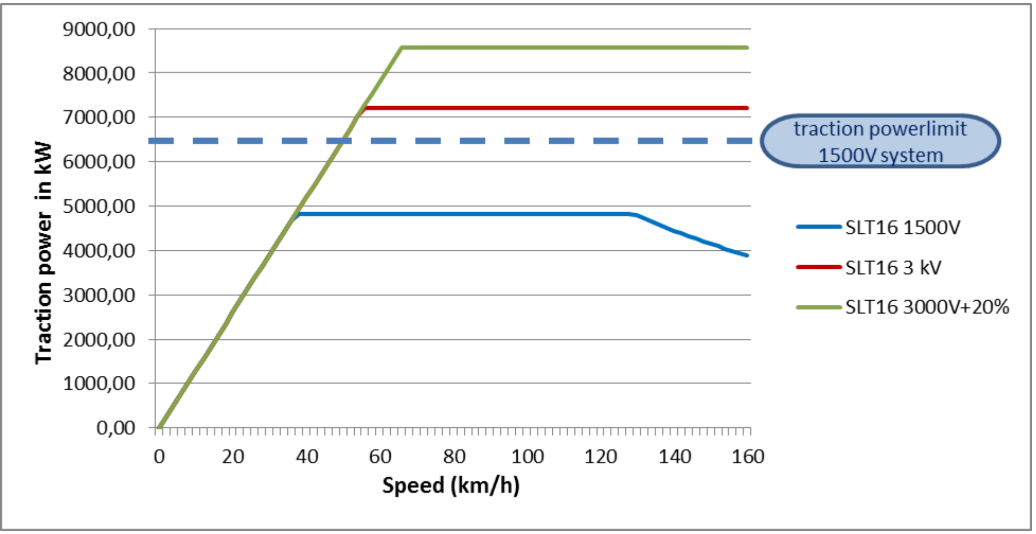
Analysis of Energy Effects

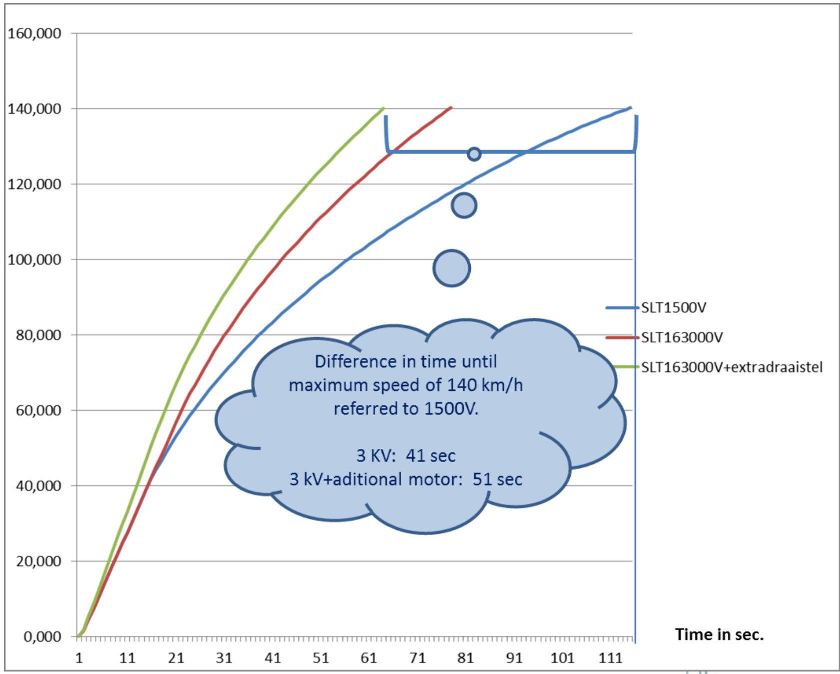


ANALYSIS OF TRAVEL TIME SAVINGS EFFECT

Power per train

Achievable acceleration





MONETARY BENEFITS (INDICATIVE)

Energy

- Efficiency
- More recuperation

- 20 - 22% saving
- 290 GWh/yr or 133 kton CO_2/yr

€.. mio/yr

Travel time

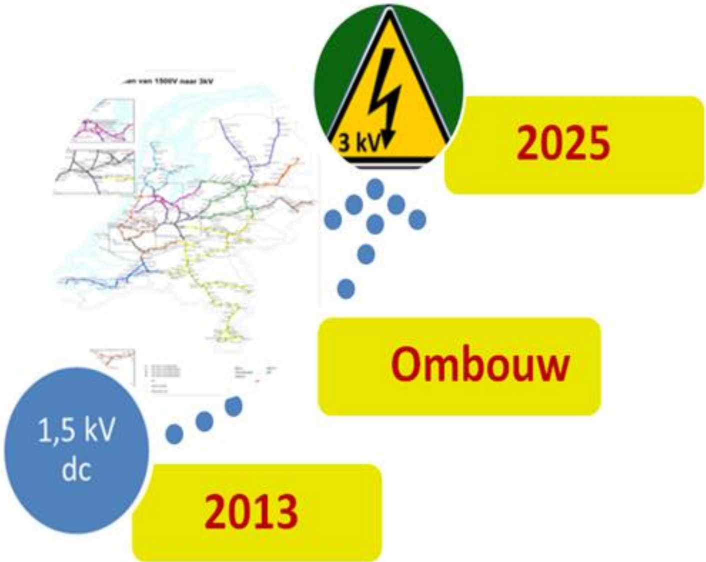
- Travel time savings (passenger)
- Excl benefits intercity trains
- Rolling stock reduction

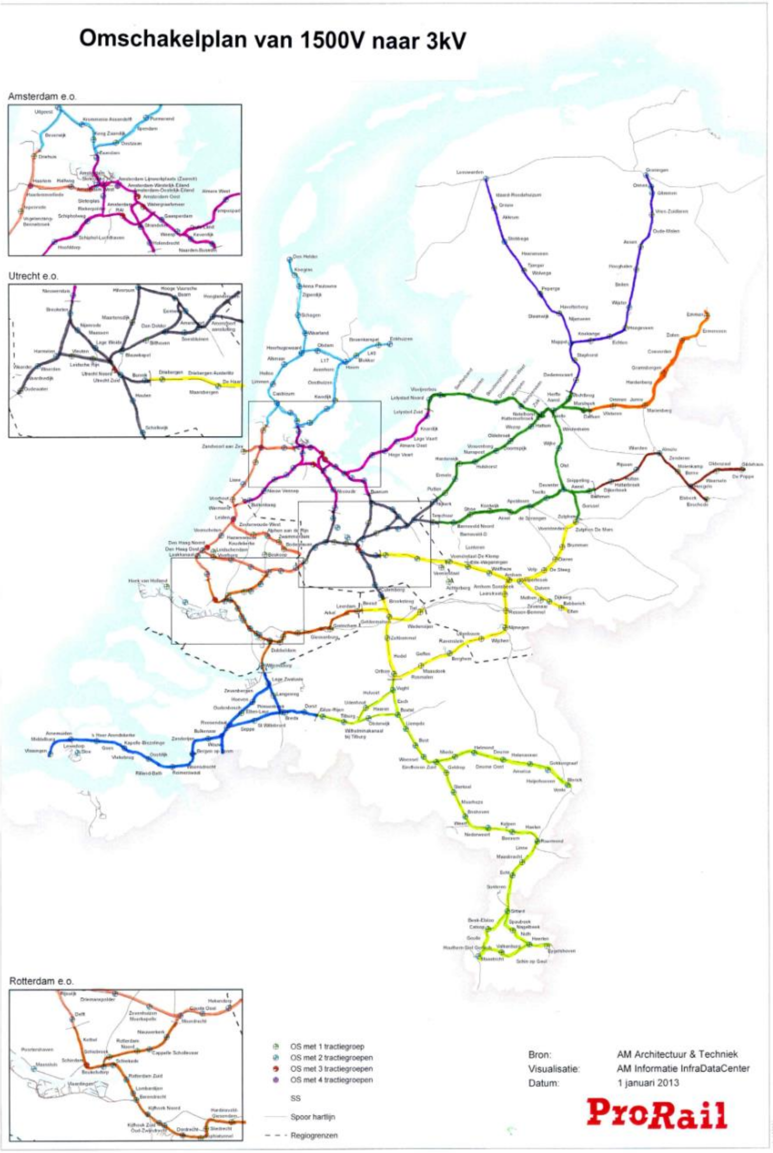
7 - 14 sec saving in timetable per stop

€.. mio/yr

- **Exclusing freight and regional traffic**

MIGRATION PLAN





Costs (indicative)

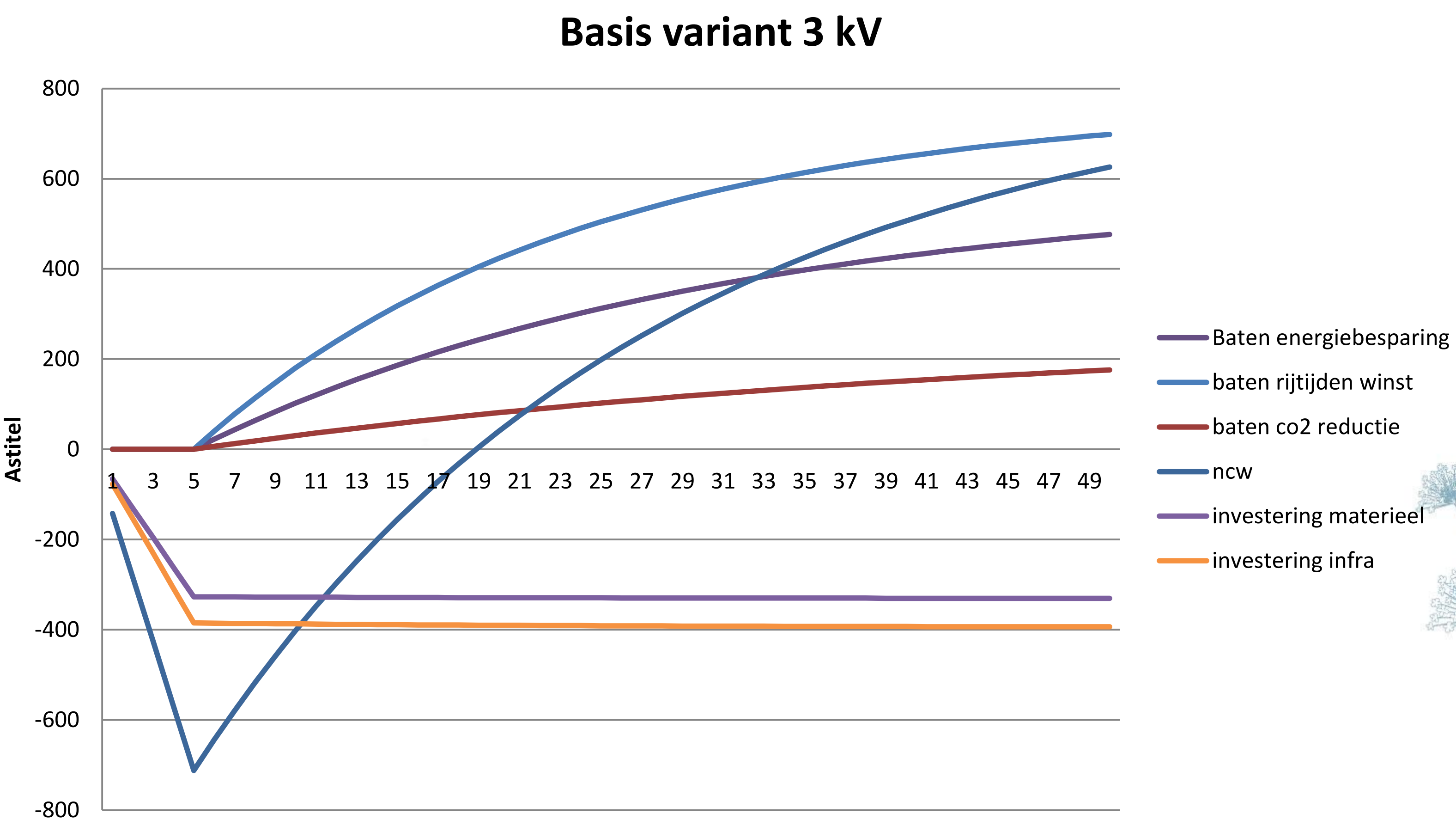
.. mio*

.. mio

.. mio

❖ Exclusing freight and regional traffic

INDICATION OF CASH FLOWS (INDICATIVE)



CONCLUSION

- Increasing power supply voltage effects energy and travel time savings.
- A decision has not made yet

INFRABEL UIC

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REGENERATIVE ENERGY UTILIZATION IN A.C. TRACTION POWER SUPPLY SYSTEM BY INTRODUCING RPC (RAILWAY STATIC POWER CONDITIONER)

KAZUMI NAGANO

EAST JAPAN RAILWAY COMPANY

Energy Efficiency, the best fuel to move our trains!

OUTLINE

- BACKGROUND
- INTRODUCTION
- BODY
- CONCLUSION AND FUTURE WORK

- BACKGROUND
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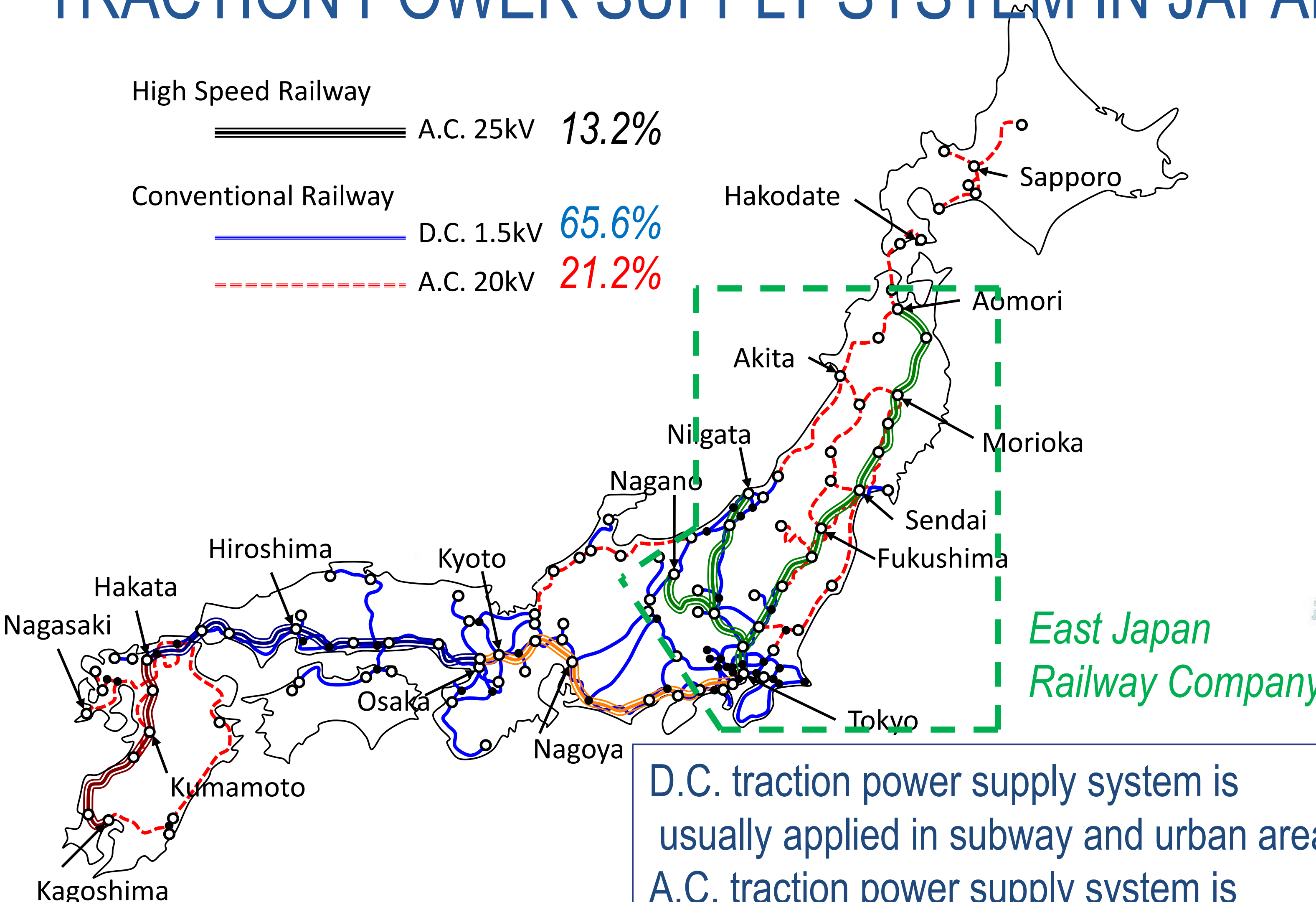
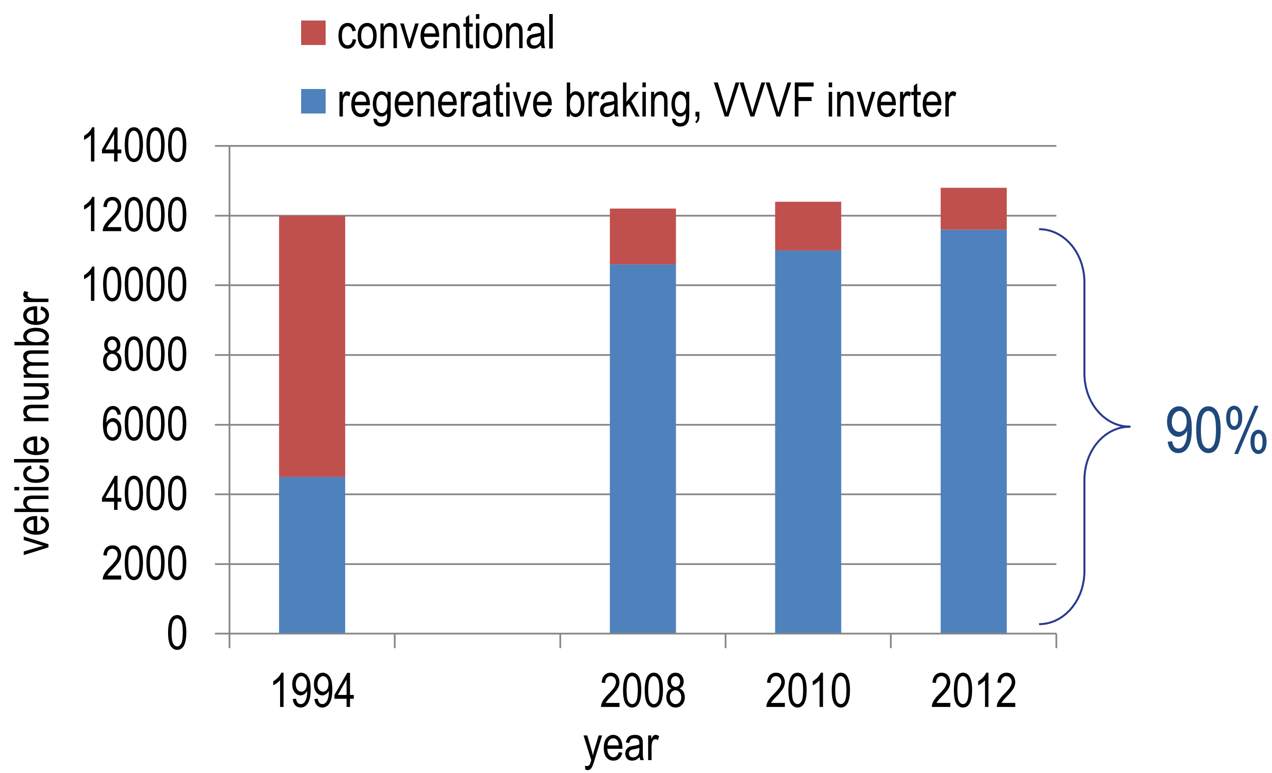
TRACTION POWER SUPPLY SYSTEM IN JAPAN



D.C. traction power supply system is usually applied in subway and urban area.
A.C. traction power supply system is usually applied in high speed railway and local line.

TRAIN IN EAST JAPAN RAILWAY COMPANY



JNR 415 series (1971)

JRE 531 series (2005)

Most vehicle use regenerative braking system in 2012.

We have continuingly made effort to reduce energy consumption by regenerative energy utilization.

REGENERATIVE ENERGY UTILIZATION

Regenerative energy utilization methods

- *Regenerative inverter*
- *Energy storage system*
- *RPC (Railway static Power Conditioner)*

Energy storage system has already introduced in DC traction power supply system.

First Li-ion battery has introduced at HAIJIMA Substation in February 2013.

ENERGY STORAGE SYSTEM

Specification

- *Li-ion battery*
- *battery capacity : 170V, 5.5Ah*
- *rated capacity : 2000kW*

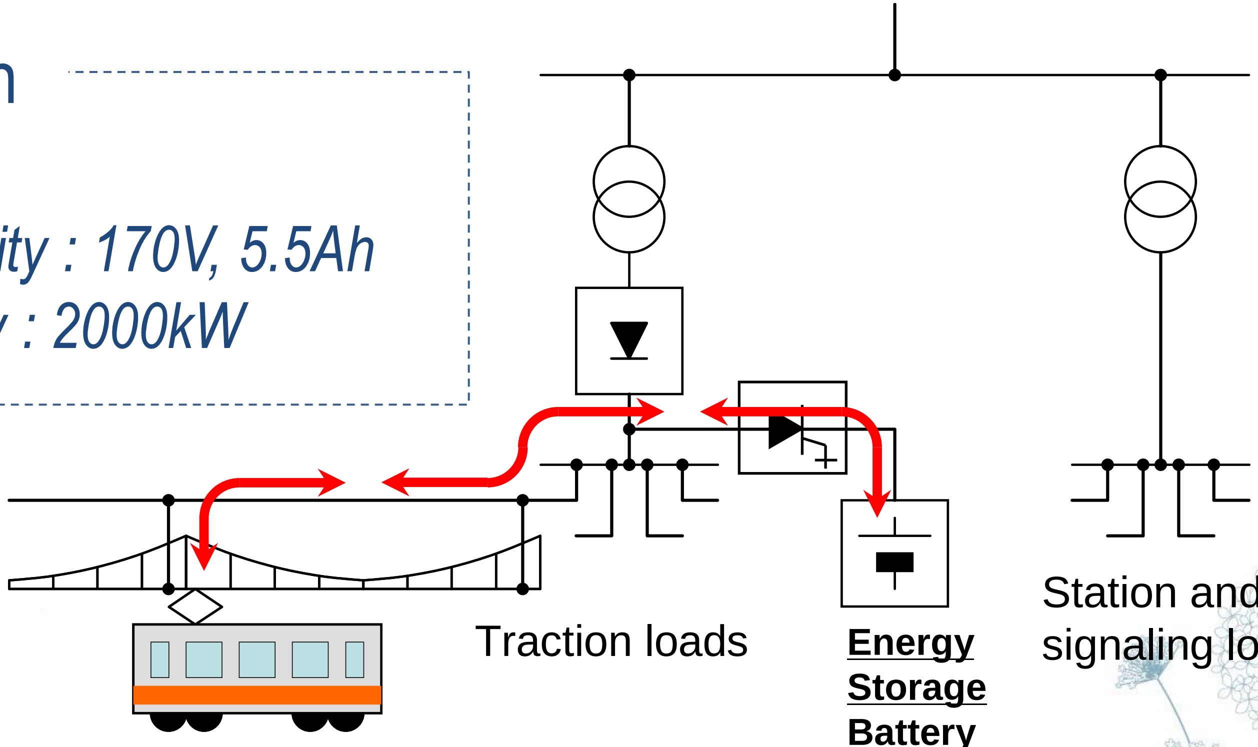


Figure : circuit configuration of energy storage system

Battery system is connected to DC 1.5kV bus and charge and discharge of the batteries are controlled by DC/DC converters.

<u>Consumption power is reduced about 1MWh/day. (5% of total)</u>

OUTLINE OF RPC

Regenerative energy utilization methods

- *Regenerative inverter*
- *Energy storage system*
- *RPC (Railway static Power Conditioner)*

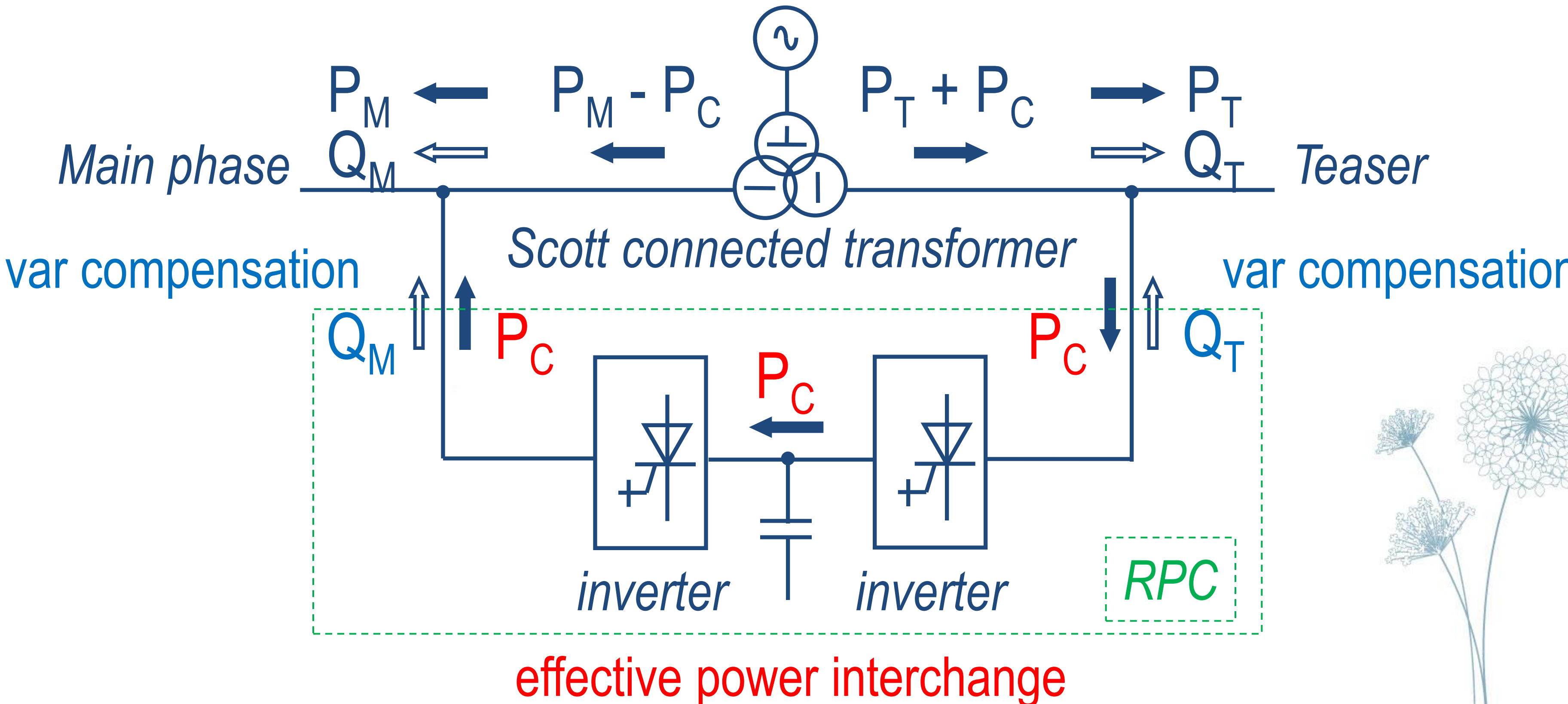
RPC has already installed some traction substations for high speed railway in Japan.

The purpose is not for regenerative energy utilization.

OUTLINE OF RPC

Purpose

- *Compensation for three phase unbalance*
- *Voltage compensation*

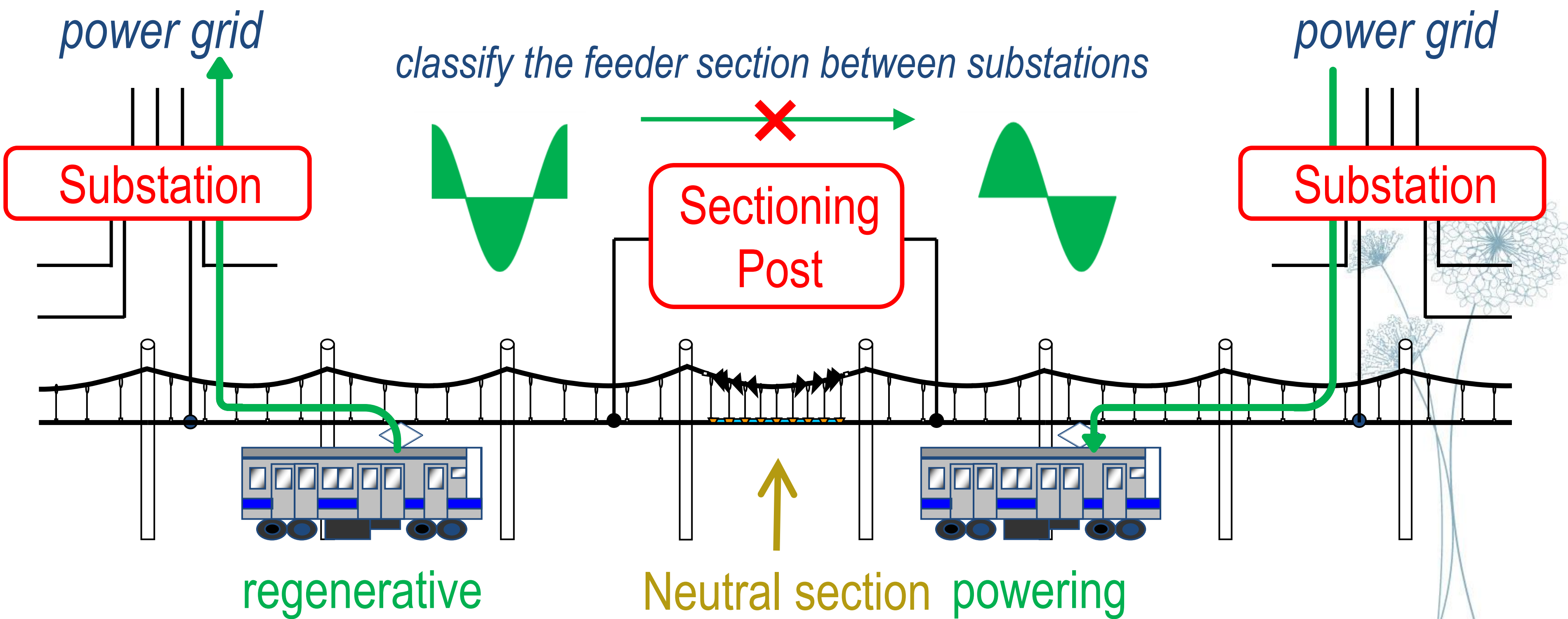


We introduced RPC as regenerative energy utilization for the fist time.

AC TRACTION POWER SUPPLY SYSTEM

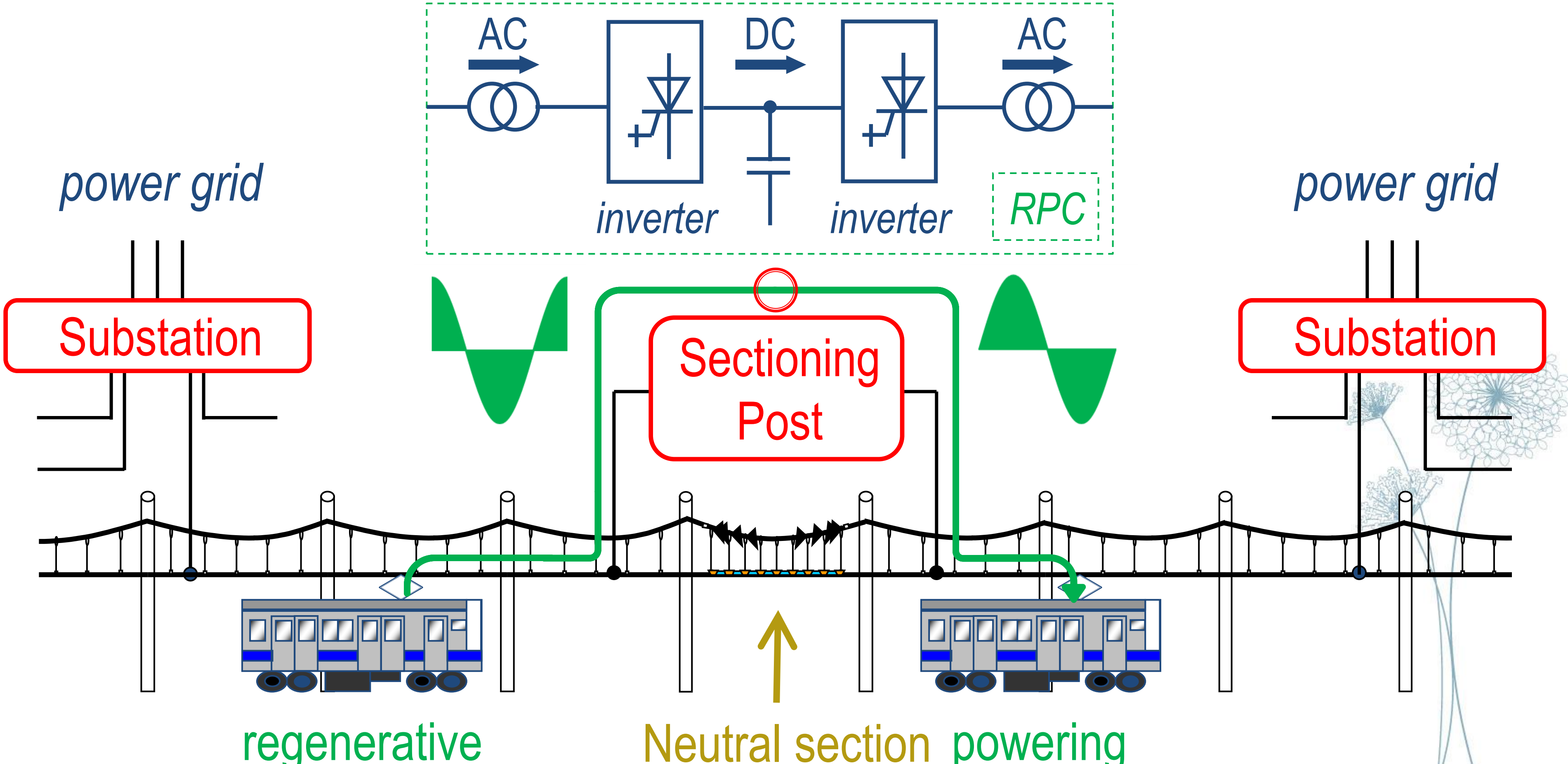
The regenerative power is not consumed unless powering train is in the same feeder section.

Regenerative power is back-flown to the power grid.



AC TRACTION POWER SUPPLY SYSTEM

It becomes possible to increases the utilization opportunity of the regenerative energy in ac traction power supply circuits.



- BACKGROUND
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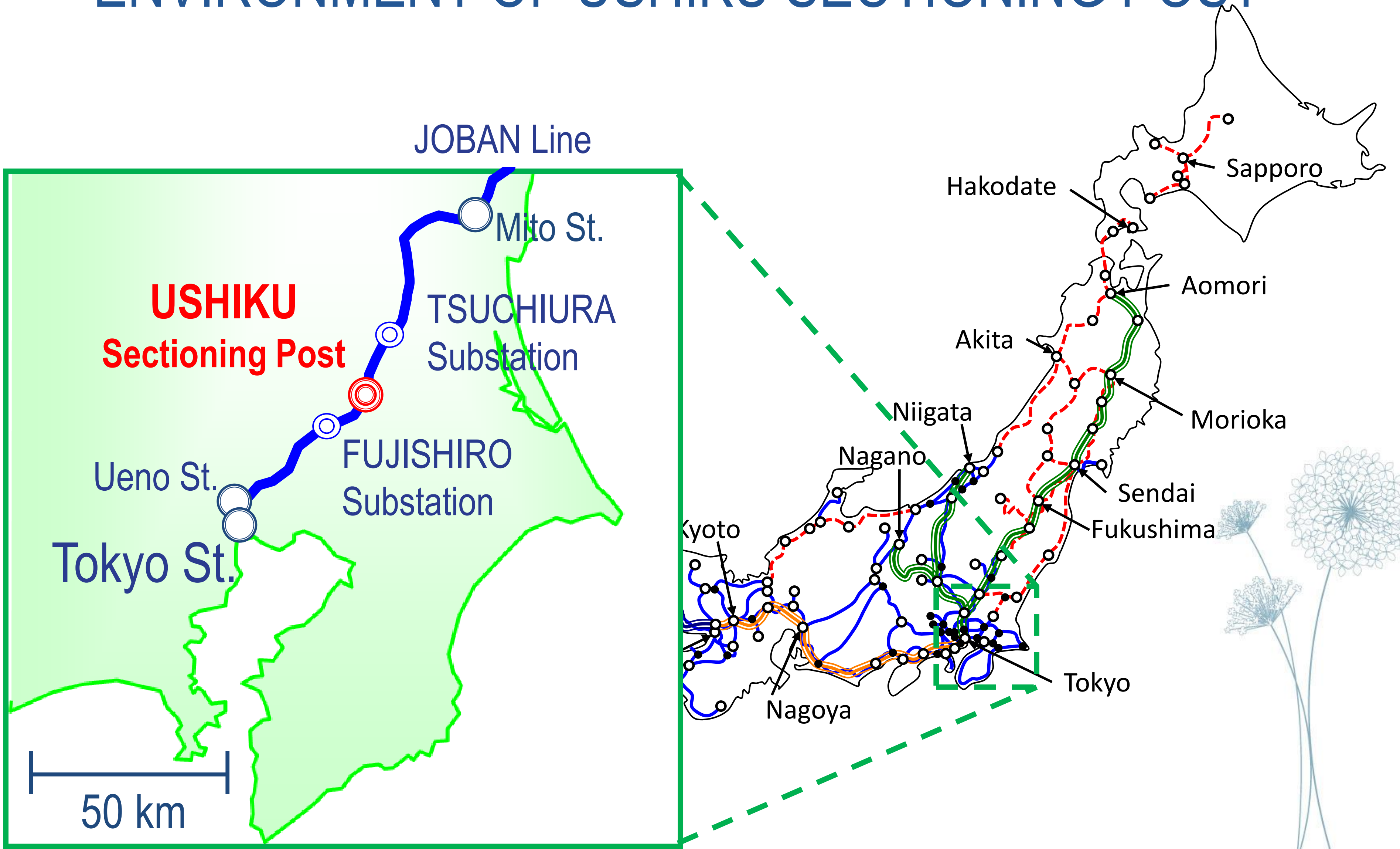
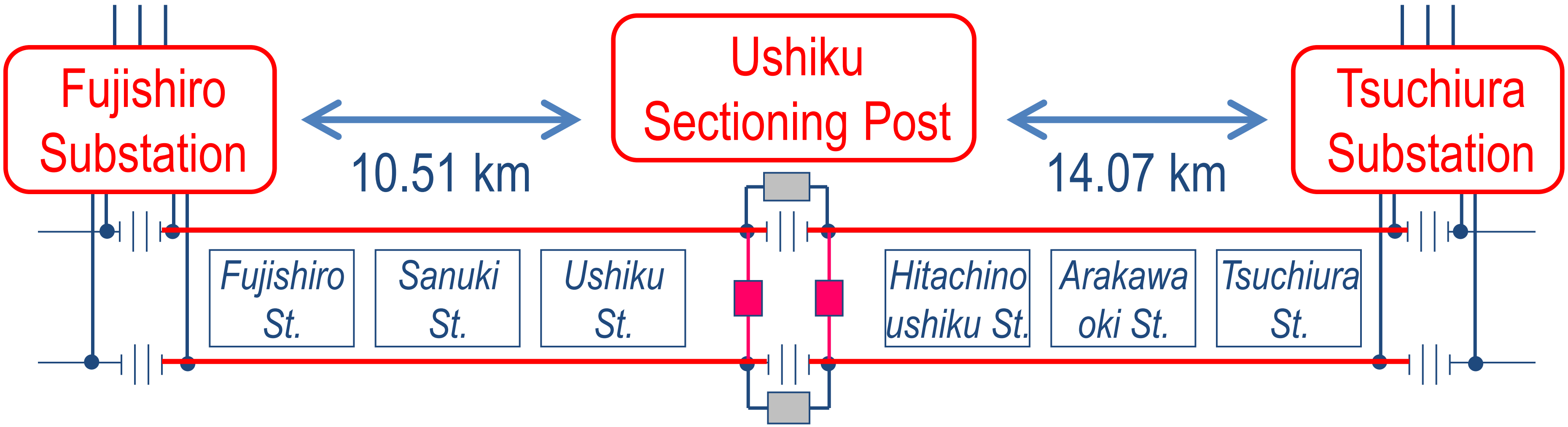
ENVIRONMENT OF USHIKU SECTIONING POST

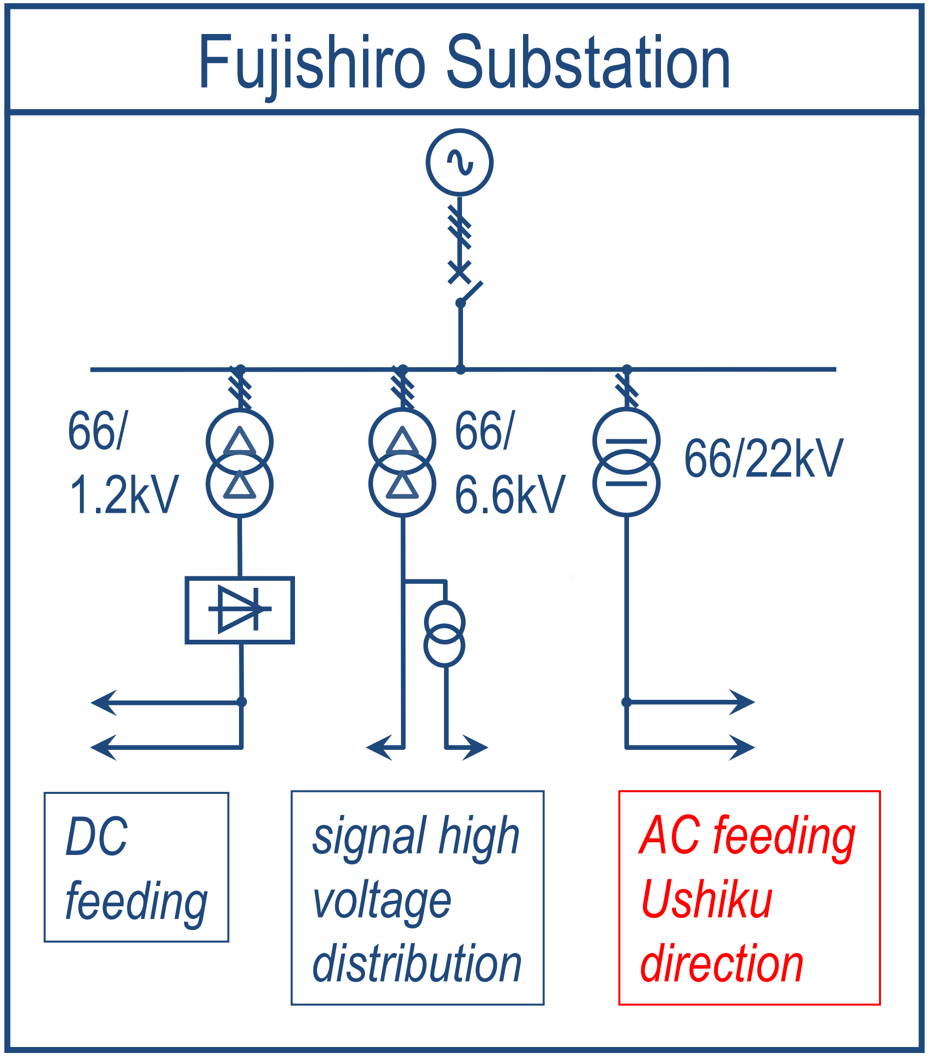


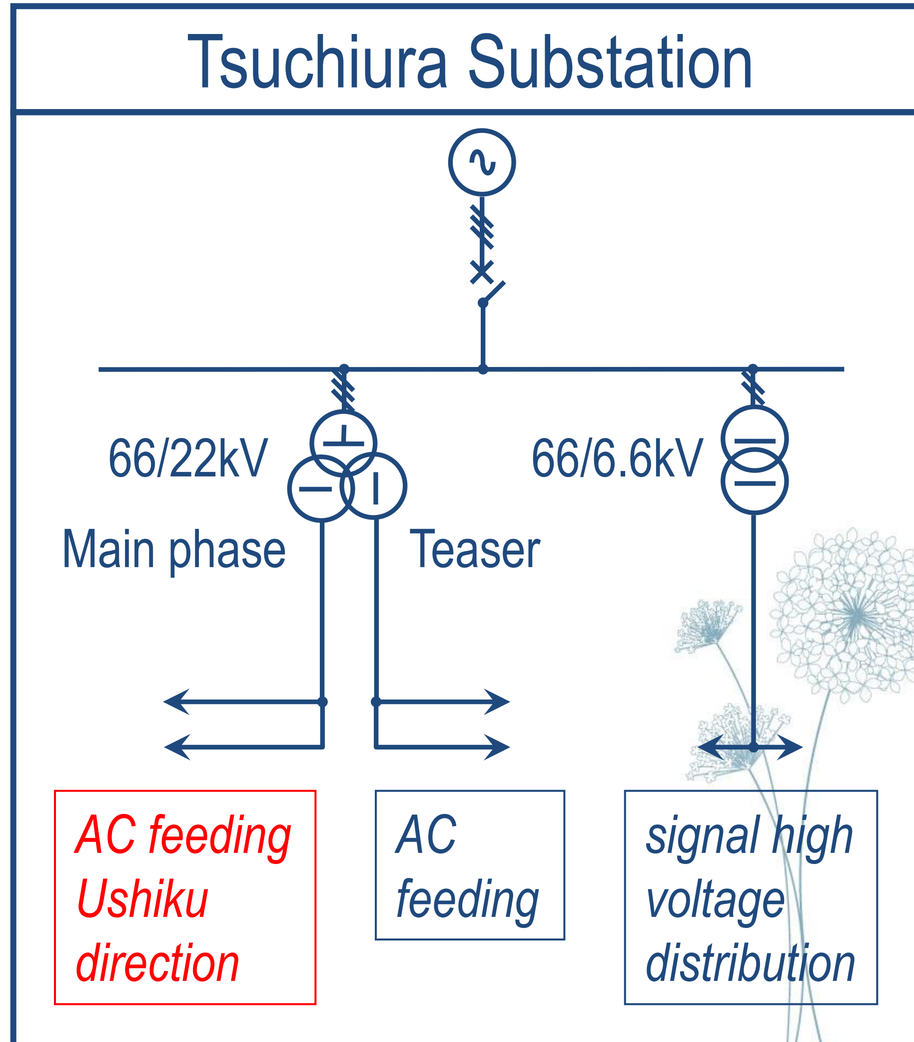
ENVIRONMENT OF USHIKU SECTIONING POST



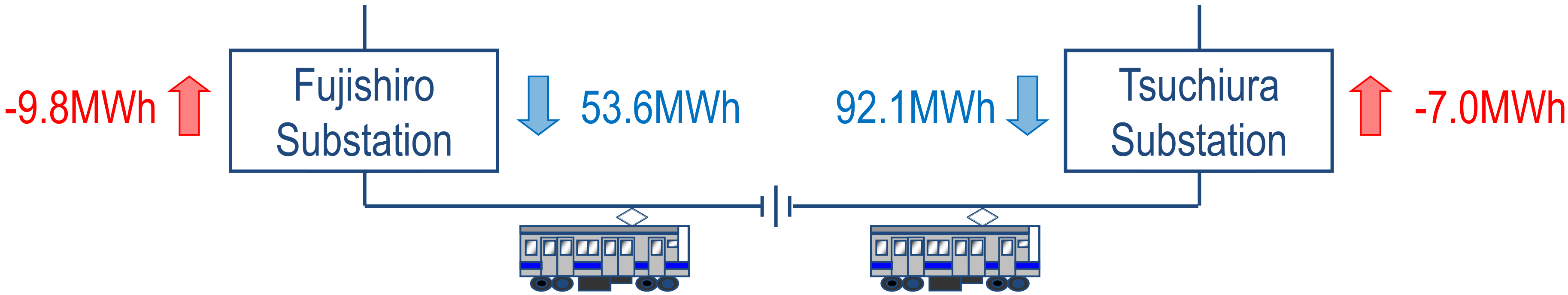
	E531	E657	EH500
			
Train type	local train	limited express	freight car
Brake type	regenerative brake	regenerative brake	dynamic braking
Number / day	136	74	6
Rated power	3360 kW	3480 kW	3390 kW

ENVIRONMENT OF USHIKU SECTIONING POST





ENVIRONMENT OF USHIKU SECTIONING POST



Fujishiro Substation		Tsuchiura Substation	
consumption	surplus regenerative	consumption	surplus regenerative
53.6 MWh / day	-9.8 MWh / day	92.1 MWh / day	-7.0 MWh / day

regenerative rate ： 18.3 %	regenerative rate ： 7.6 %

Surplus regenerative power is about 500MWh per month

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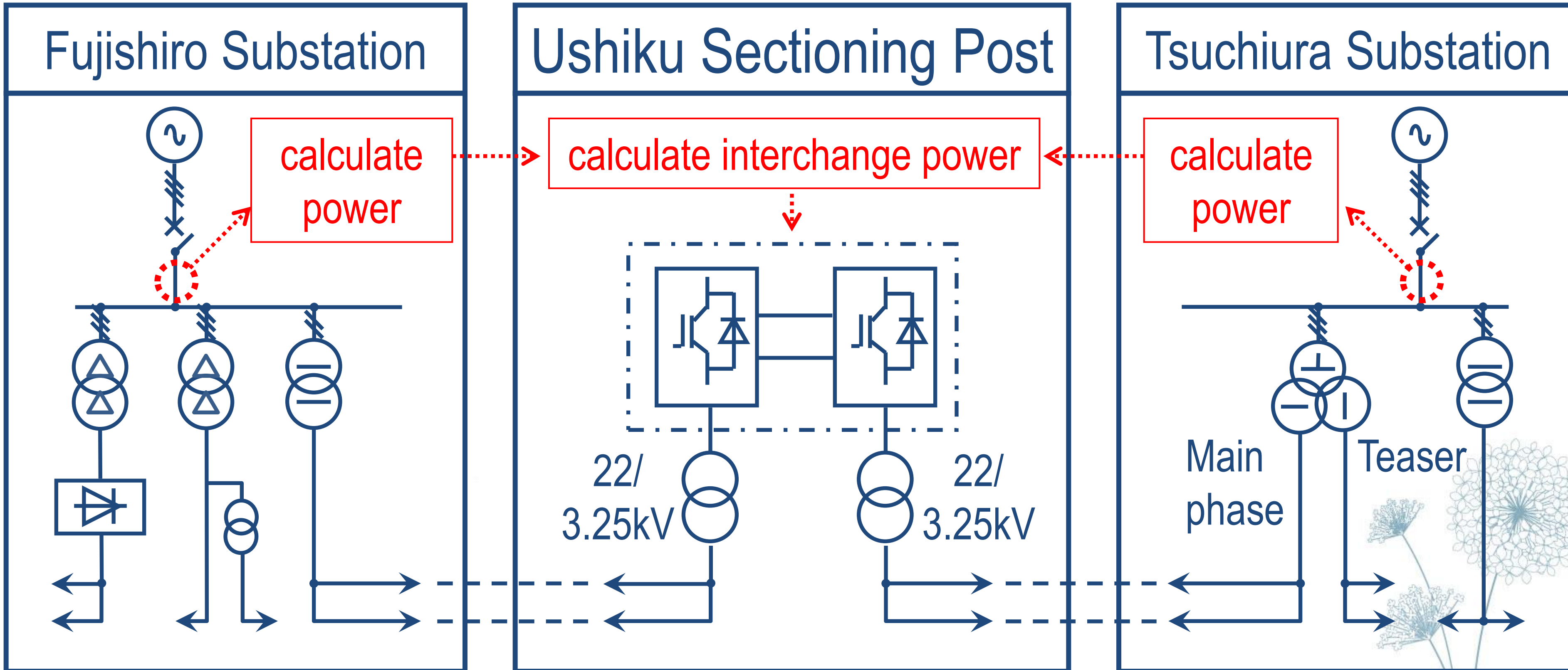
CONTROL SYSTEM OF RPC

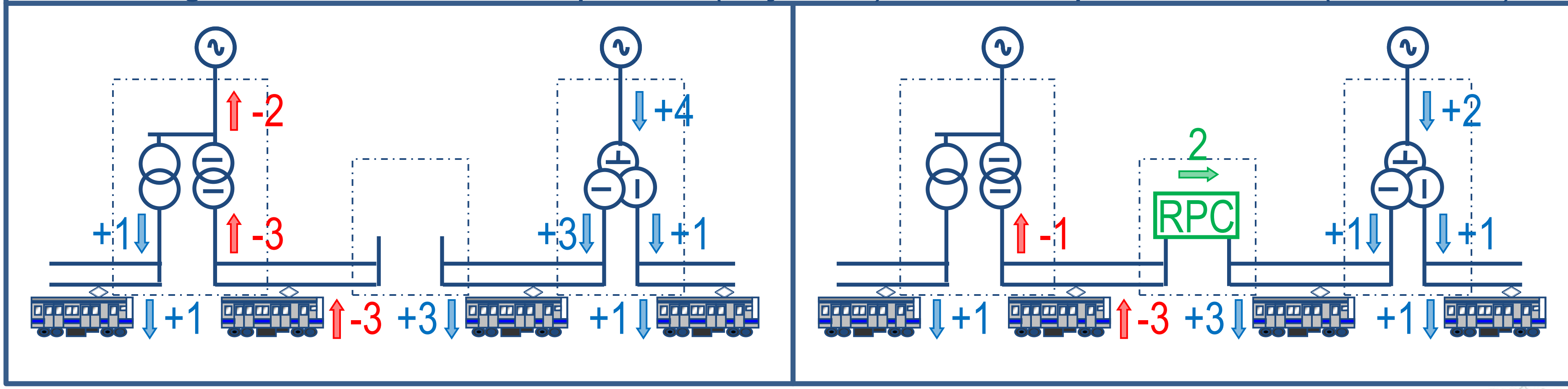


When consumption power of a substation is plus and other substation is minus

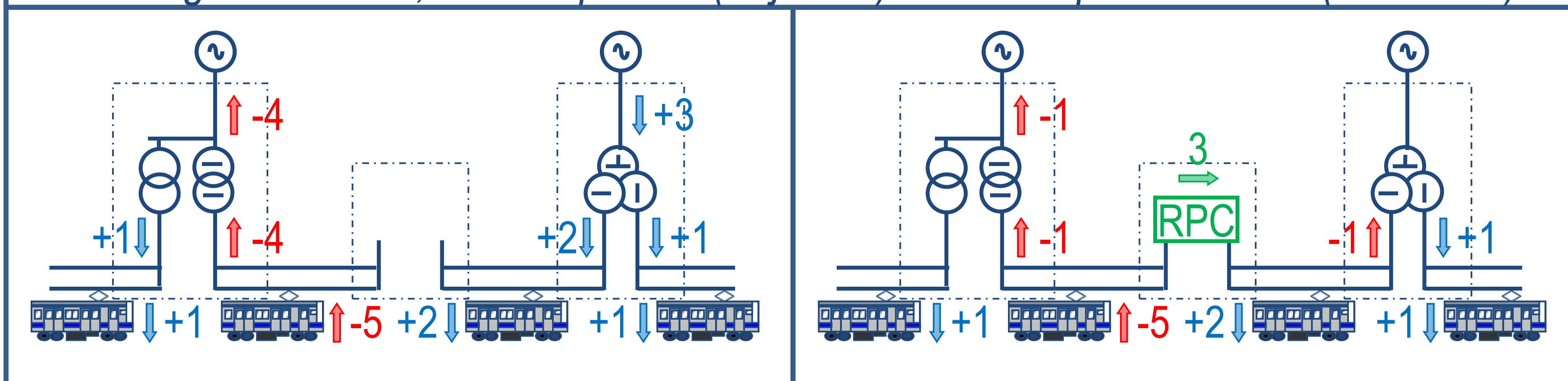
RPC interchanges regenerative power

CONTROL SYSTEM OF RPC

Ex1 *regenerative:3 , consumption:1 (Fujishiro) / consumption:3 and 1 (Tsuchiura)*



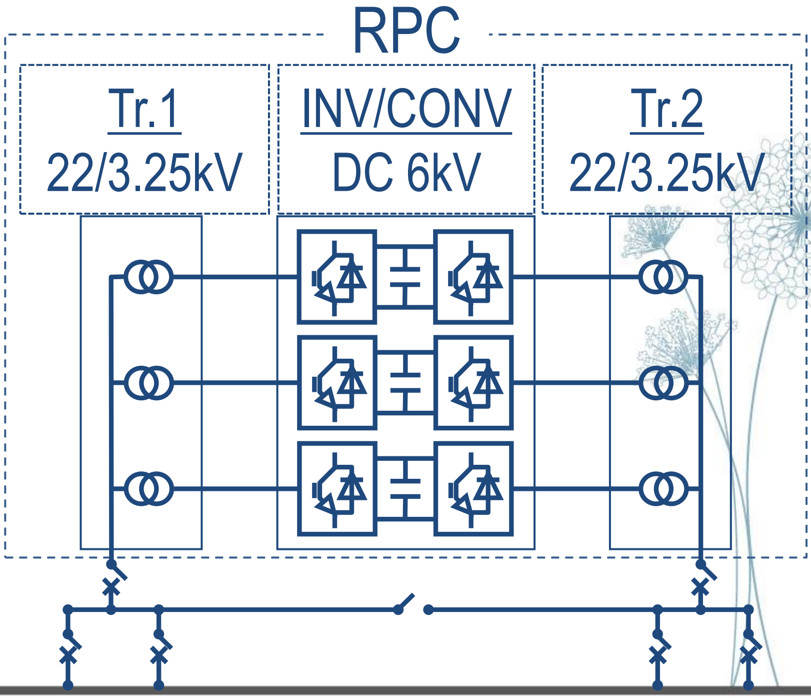
Ex2 *regenerative:5 , consumption:1 (Fujishiro) / consumption:2 and 1 (Tsuchiura)*



CONTROL SYSTEM OF RPC

Specification of RPC

- *rated output : 1.3MVA*
- *rated voltage : 22 / 3.25kV*
- *rated frequency : 50Hz*
- *overload capacity : 5.3MW , 1 min.*
- *response speed : within 1 sec.*



EFFECT OF INTRODUCING RPC

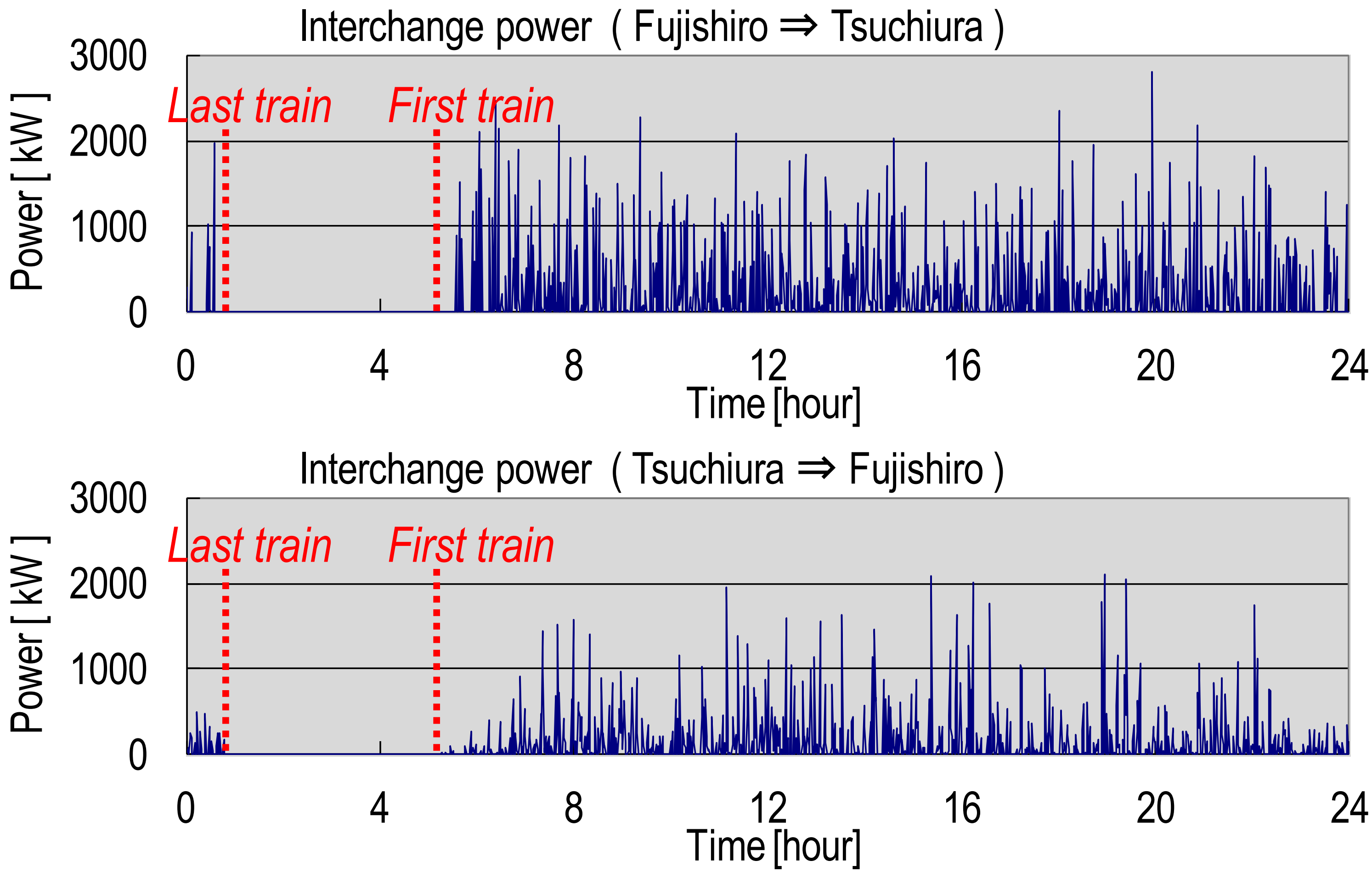


Figure : Interchange power by RPC for one day

RPC interchanges regenerative power from the first train to the last train.

EFFECT OF INTRODUCING RPC

Table : Interchange power after introducing RPC

	consumption power		Interchange power		
	Fujishiro	Tsuchiura	Fujishiro → Tsuchiura	Tsuchiura → Fujishiro	Total
day 1 *(Jan. 31)*	57.1 MWh	101.3 MWh	4.8 MWh	2.8 MWh	7.6 MWh
day 2 *(Feb. 1)*	54.1 MWh	101.0 MWh	4.9 MWh	2.7 MWh	7.6 MWh
day 3 *(Feb. 2)*	44.8 MWh	94.3 MWh	4.0 MWh	2.2 MWh	6.2 MWh
day 4 *(Apr. 24)*	47.3 MWh	83.5 MWh	4.7 MWh	3.0 MWh	7.7 MWh
day 5 *(Apr. 25)*	48.8 MWh	85.0 MWh	4.6 MWh	3.1 MWh	7.7 MWh

delay of trains

Total interchange power is about 7.6MWh / day.

Surplus regenerative power is reduced about 220MWh / month.

RPC will turn a profit after 14 years, when this energy saving effect continues.

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CONCLUSION

- RPC has started operation since the February 2014 at Ushiku sectioning post of Joban Line.
- Before RPC introduction, surplus regenerative power is about 500MWh per month.
- Surplus regenerative power is reduced about 220MWh per month by introducing RPC.

FUTURE WORK

- Stable operation of RPC is a future work.
- We verify the effect of RPC continuingly.

This is the end of my presentation.
Thank you for your kind attention.