Braking energy recovery on the metro network – STIB (Brussels)

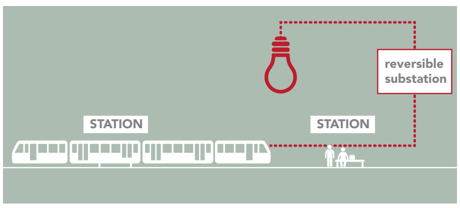
CONCEPT

Most recent rail vehicles have the ability to brake electrically using regenerative braking techniques. In that case, the electric motor can work as a generator recovering the vehicle's kinetic energy and converting it into electricity. However, the energy recovered will only be used by another vehicle accelerating nearby, thus reducing greatly the potential energy savings. Given STIB owns its high-voltage electrical network, STIB invested in several inverters (reversible substations) to improve the braking energy recovery level on its metro network.

SUPPLIER

Inverters (reversible substations):
INGETEAM (Spain)

Technical Data	
Technology	IGBT
Voltage range	400-1000 VDC
Maximum power	1.5 MW
Feedback current	680 A AC
Efficiency rate	98%
Weight	4.8 tons

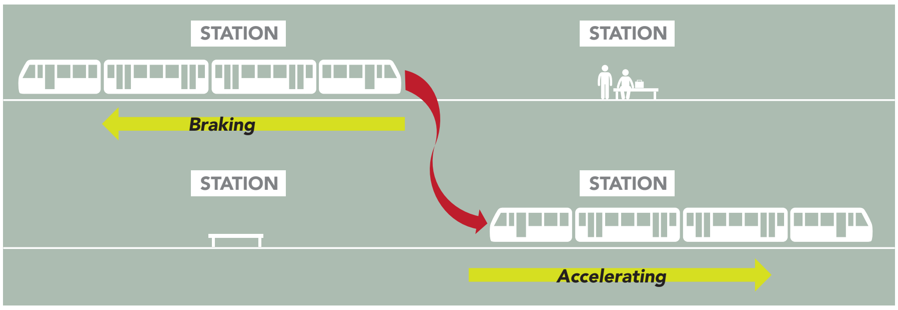


OBJECTIVES

- Reduce the energy consumption and the related CO_2 emissions of the metro traction;
- Compare different systems in terms of efficiency and delivered savings;
- Communicate about the advantages of installing braking energy recovery systems to raise the awareness of the passengers.

INVESTMENT DESCRIPTION

Metro vehicles are propelled by electric motors supplied by substations placed along the tracks. The electricity is transferred via a third rail. All the metro trains used on the Brussels network have the ability to brake electrically using regenerative braking techniques. A small portion of the recovered kinetic energy can be reused to power vehicles auxiliaries whereas the remaining energy is sent back to the electrical network. If a vehicle is accelerating nearby, the accelerating vehicle takes advantage of this energy transfer. If that is not the case, the network voltage increases due to the energy surplus and this extra energy has to be dissipated in braking resistors.



Braking energy recovery technologies have been studied at STIB since 2004. After meeting with firms presenting their latest products, STIB soon realised that it would have to adopt a global approach in order to grasp the different aspects of this field. Research projects with local universities produced interesting results regarding the implementation of supercapacitor-based technologies, particularly for the metro network. A first version of a simulation tool was tested for calculating the energy flows between the vehicles and potential energy savings. This work was deepened during the Ticket to Kyoto project and led to the development of a robust simulation tool able to evaluate any type of braking energy recovery equipment. In parallel, a multicriteria analysis was completed to see what technology would best suit the STIB's needs. Given STIB owns its high-voltage electrical network, inverters appeared to be the most cost-effective solution.

Results	
Investment costs (€)	€1,800,000
Energy savings (%)	9%
Annual maximum production (kWh)	3,400,000 kWh
Lifetime CO_2 savings (TCO_2)	568 TCO_2
Payback time (years)	5 years

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A European tender was launched and three suppliers were invited to test their system on the network for several months in order to compare their efficiency and the delivered savings. This empirical approach produced useful insights on the way braking energy can be recovered by the use of inverters. The best system is now progressively installed on the entire metro network.

COST AND FUNDING

The investment costs for the deployment of inverters on whole lines 2 and 6 is €1,800,000.

RESULTS

The results of these investments were very successful. Based on the preliminary results with only one substation equipped with an inverter, STIB extrapolates that the traction energy consumption of metro lines 2 and 6 will be reduced by 9% with energy savings of some 3,400,000 kWh per annum and 568 TCO_2 savings.

LESSONS LEARNED

It was the first time STIB implemented braking energy recovery techniques on its network. Throughout the Ticket to Kyoto project, the partners demonstrated that it is not easy to compare technologies, assess performance and determine the optimal technological solution. Finding the best-adapted technology and opting for the right implementation require a holistic approach that takes many parameters into consideration. One key element when investigating braking energy recovery technologies is simulation. A comprehensive analysis of the network and a clear evaluation of possible gains are recommended. A fine-tuning of the system is also required as STIB calculated that a difference of 5V when defining the energy recovery threshold can result in a reduction of 20% of the energy savings. STIB also underestimated the civil works for implementing the systems and connecting the inverters to the existing equipment. Following this successful pilot project, STIB intends to deploy this innovative technology on the entire metro network and continue studies for its tram network.

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