Braking energy recovery moBiel (Bielefeld)

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. moBiel invested in two types of braking energy recovery technologies for reducing the energy consumption of its light rail network: one flywheel allows to recover the braking energy and to store it mechanically and two inverters (reversible substations) recover the braking energy and send the energy back to the main electrical grid; using it for elevators, stairs, lighting in stations.

SUPPLIER

Flywheel:
PILLER (Germany)

Inverters (reversible substations):
INGETEAM (Spain)

OBJECTIVES

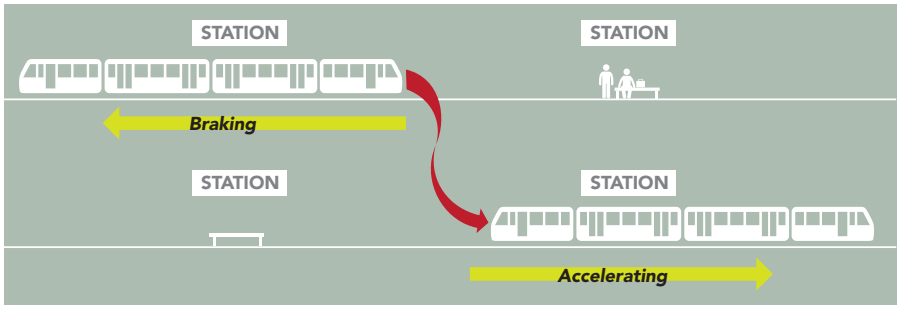
- Reducing the energy consumption and the related CO_2 emissions of the light rail traction;
- Compare different technologies in terms of efficiency and lifecycle;
- Communicate about the advantages of installing braking energy recovery systems to raise the awareness of the passengers.

INVESTMENT DESCRIPTION

Light rail vehicles are propelled by electric motors supplied by substations placed along the tracks. The electricity is transferred via an overhead line through the pantograph. All the vehicles used on the moBiel 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.

However, in many situations, the energy cannot be recovered on the network because no vehicle is accelerating exactly when another is braking. To avoid these energy losses and to reduce overall energy consumption, moBiel invested in a braking energy recovery systems to decrease the energy consumption of its light-rail network. The first step was a network study done by an external consultancy, to gain an overview of the potential savings and identify potential locations for implementing the recovery systems. In a second step, moBiel launched a European tender and opted for a flywheel and two inverters.

The flywheel is located at the end of one line but this line will be extended by 1.5 km in a near future. Due to its weight (10 tons), the ground below the substation had to be consolidated. The system is very noisy (96 dB(A)) and obliges staff to wear acoustic protection when close to the equipment. During installation, some jerking problems occurred with one type of vehicles when braking, but this



Technical Data of the flywheel system	
Effective energy	4.6 kWh
Maximum power	1MW (for 16 seconds)
Maximum number of rotation (storing)	3,600 round/ minute
Minimum number of rotation (discharging)	1,800 round/ minute
Maximum discharging current	1,500 A
Efficiency rate	84%
Weight	10 tons
Noise	95 dB(A)

Technical Data of the inverter	
Technology	IGBT
Voltage range	400-1000 VDC
Maximum power	1 MW
Feedback current	680 A AC
Efficiency rate	98%
Weight	3.6 tons
Noise	<65 dB(A)

Results	
Investment costs (€)	€825,000
Energy savings (%)	6%
Annual energy savings (kWh)	960,000
Annual CO_2 savings (TCO_2)	470 TCO_2
Payback time (years)	Maximum 10 years (5 years with T2K funding)

CONTACT

moBiel
Annekathrin Bode
00 49 521 51 46 69
info@moBiel.de

could be fixed. The results of the flywheel exceeded the expectations stemming from the network study. moBiel also invested in two inverters located on two different tram lines. The inverters are less heavy and not noisy. The results of both systems are in line with expectations and the systems are currently fine-tuned to optimise energy savings.

COST AND FUNDING

The cost for the three systems was €825,000.

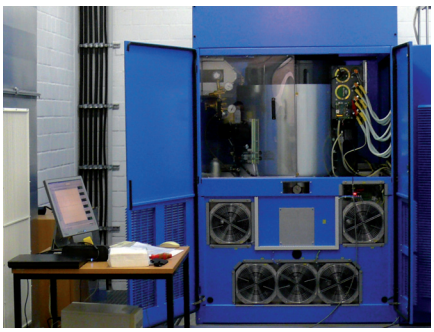
RESULTS

The results of these investments were very successful. Based on the measured figures for all three investments, the annual energy reduction exceeds 900.000 kWh. The flywheel system allows saving around 320,000 kWh per annum whereas the first inverter recovers 310,000 kWh and the second 330,000 kWh. The three systems recover some 10% more than the theoretical savings calculated in the network study.

LESSONS LEARNED

It was the first time moBiel implemented braking energy recovery techniques on its network. It was important to have a network study beforehand in order to choose the right locations. It has been a learning process together with the suppliers, which required a constant optimisation of the equipment. moBiel experienced jerking problems of the more recent vehicles when implementing the flywheel system on the network. Thanks to the close cooperation with the supplier PILLER, the problem has been fixed. As far as the inverters are concerned, no specific problem occurred. moBiel noticed that the temperature variations, especially in winter, can have a strong impact on the results of braking energy recovery systems as the energy consumption rises for heating the vehicles. moBiel also expects to see variations in energy savings during holiday periods when less passengers are on board of the vehicles

Following this successful pilot project, a third inverter will be purchased in the near future.



Flywheel

Inverter