



Braking news

DC wayside products for energy efficiency in traction

MICHAL LODZINSKI – Although rail and tram are among the most efficient means of transport, they still consume a large amount of energy – especially when acceleration is involved. The amount of energy required to accelerate a vehicle weighing hundreds of tons up to even modest velocities is huge, so any increase in energy efficiency will have significant cost benefits. Regenerative techniques – in which braking energy is reused for acceleration – are well known but still hold much potential. ABB offers a complete suite of energy management solutions that enable braking energies to be better used, resulting in more energy-efficient urban rail transportation systems.



Recycling, or managing, surplus braking energy can reduce overall power consumption by as much as 10 to 30 percent, without the need to invest in new cars or network control systems.

Energy efficiency is a topic important to many industrial sectors and the urban rail-based public transport network is no exception. Even though travel by rail is already much more energy efficient than by most other means, improving energy efficiency even further is important to metro, light-rail and tram operators constantly challenged to reduce operational costs and to provide mass transport in a sustainable manner. ABB offers a complete suite of products to facilitate this – especially products aimed at managing surplus braking energy.

Title picture

Urban rail transport can be made more energy efficient through better use of the kinetic energy usually lost through braking. How does ABB's ENVILINE™ palette of products accomplish this?

Up to 80 percent of the total energy consumption of a rail transportation system is used to actually move the trains and recycling, or managing, surplus braking energy can reduce overall power consumption by as much as 10 to 30 percent, without the need to invest in new railcars or network control systems.

Today, many rail vehicles recycle braking energy. Most of the time, a small portion of this energy can be used to power on-board loads and the remainder can be sent into the electrical power network for reuse by a nearby vehicle. This kind of energy transfer is called natural receptivity. If the

energy cannot be recycled in this manner, the network voltage increases and the surplus energy is dissipated in on-board or wayside resistors.

However, recycling or managing the surplus braking energy intelligently can reduce overall power consumption. ABB's

The ENVILINE Energy Recuperation System (ERS) reduces energy costs by returning vehicle braking energy to the AC network.

ENVILINE™ products offer a way to accomplish this.



ENVILINE Energy Recuperation System

The award-winning ENVILINE Energy Recuperation System (ERS) reduces energy costs by returning vehicle braking energy to the AC network → 1-2.

As mentioned above, if the energy derived from braking cannot be reused immedi-

In addition, the ERS can support existing rectifiers, thanks to the active rectification made possible by the bidirectional operation of the system.

ately it is often dissipated in onboard braking resistors and wasted. However, the ERS, situated trackside, is able to recuperate this energy by feeding it from the DC traction grid back to the AC grid where it is used to power local auxiliary systems such as air-conditioning, heating, ventilation, lighting, etc. The ERS is an IGBT-based inverter installed at the DC

ABB received an award at the Railtex 2013 international exhibition for its ENVILINE Energy Recuperation System for DC traction applications that can reduce energy consumption by up to 30 percent as well as help reduce heat generation in underground tunnels and so contribute to efforts to "cool the tube."

New for 2013, the Railtex awards have been introduced to recognize excellence within the railway industry. ABB's award in the electrification category was presented by former England cricketer Phil Tufnell and BBC Radio presenter Garry Richardson at a ceremony held on May 1, 2013 in London.

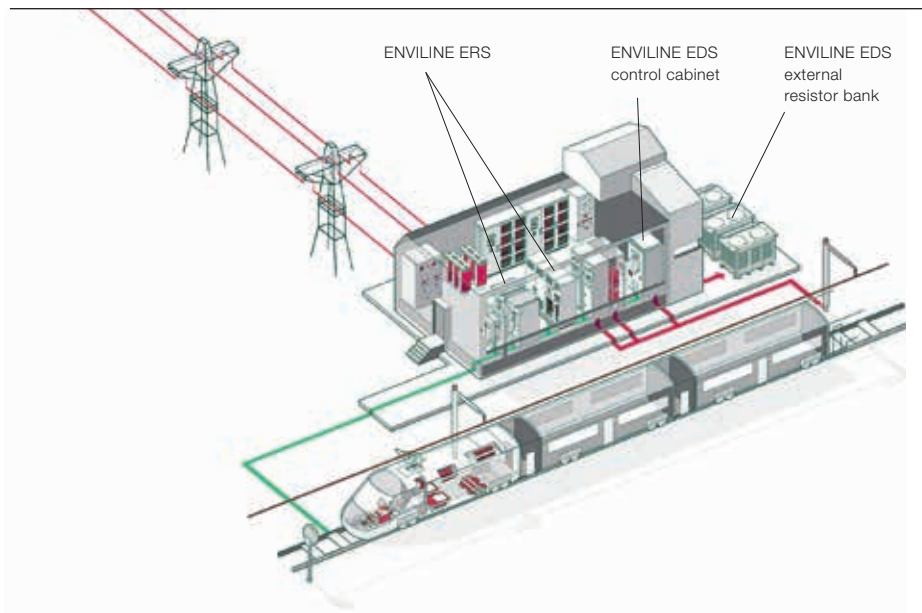
substation and connected in parallel with the existing diode rectifiers → 3-4.

When not being used to recover energy from trains, the ERS can be employed to mitigate reactive power in the network. It can also provide active filtering, thus reducing the effect of harmonics. These functions exploit the ability of the IGBT-based inverter to shape the current waveform. This allows independent control of either the active or reactive power. The basic principle is that the DC voltage coming from the traction system is transformed by IGBT inverters to a sinusoidal output waveform. Due to the pulse-width modulation technique used, the output waveform, which is modulated at a frequency of several kHz, does not contain harmonics.

In addition, the ERS can support existing rectifiers, thanks to the active rectification made possible by the bidirectional operation of the system. If there

is a need to send extra power to the moving vehicles, the ERS can inject this using the same transformer that is used to send the recuperated energy back to the AC network.

The ERS power range goes from 0.5 to 1 MW, with up to 2 MW units scheduled to be available soon. It can be overloaded



As well as sending energy back into the network with the ERS, it can also be stored by the ENVILINE Energy Storage System.

up to 225 percent for a short period of time and operates with an efficiency of 97.5 percent. Because it has a small footprint and is compatible with new and existing systems, the ERS is easy to install and its modular architecture enables it to be expanded to meet any growth in demand. Low maintenance requirements and a long operating lifetime mean the ERS saves substantial amounts of energy over many years with little intervention. The ERS can reduce the total energy consumption of a rail transportation system by 10 to 30 percent.

ENVILINE Energy Storage System

The recycled braking energy can be sent back into the network with the ERS, but the energy can be stored, too, by using the ENVILINE Energy Storage System (ESS) → 4-6. This is especially useful for those rail transportation authorities who connect their substations directly to the local electric company and who are thus unable to sell surplus energy at attractive rates. The ESS is also of benefit to authorities who may have power supply and quality issues. The ESS is the industry's smallest, yet most modular and flexible, wayside energy storage system. It is equipped with either supercapacitors, for short-term storage and recovery of the surplus braking energy, or batteries, when revenue generation or heavy-duty power provision is of interest. Like the ERS, the ESS can reduce the total energy consumption of a rail transportation system by 10 to 30 percent.

The benefits of the ESS go further: As well as helping to recycle energy, it can also be installed at a specific location to sustain the voltage where large sags occur; it can be used to augment the traction power capacity during acceleration; and the penalties or demand charges associated with high-demand peaks can be reduced by intelligent use of stored ESS power.

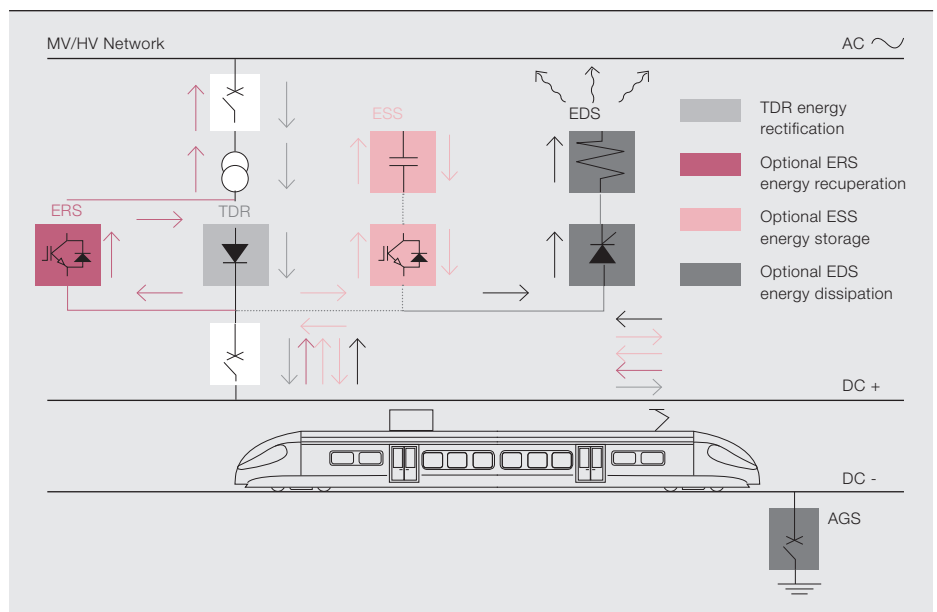
The ESS is compatible with existing train systems and it can be flexibly programmed to ensure optimum operation at each site. Its modular packaging allows independent sizing of power and storage. Operation is further eased by the provision of remote access with multilingual and email notification, energy metering, operational dashboards and downloadable data files. The ESS operates on 600V and 750V nominal lines and is expandable to 4.5 MW and 60 MJ per lineup. Parallel configurations are possible for large applications.

Opportunities beyond energy efficiency

On top of being the single best means to improve energy efficiency, the ESS can also become an off-grid traction power supply. In addition to the surplus braking energy, further energy can be added via the traction power line or a small rectifier, usually in between train arrivals. Such off-grid schemes are less expensive and more energy efficient than traditional grid-connected traction power supplies.

The ESS can be installed at a specific location to sustain the voltage should large sags occur.

4 ENVILINE schematic



When coupled with batteries providing larger energy reserves, the ESS can also become a smart grid asset capable of providing emergency power or demand-response services to the local utility.

Retrofit

A very important advantage of both the ERS and the ESS is that they are designed for retrofit. In refurbishment projects, all fixings and connections are predefined. This presents a tougher chal-

ENVILINE Energy Dissipation System

In certain cases, some of the regenerated energy cannot be used and must be dissipated. However, installing braking resistors on the vehicle to do this adds weight and increases maintenance effort. The ENVILINE Energy Dissipation System (EDS) provides a low-cost solution to this problem in DC rail systems. By deploying the wayside EDS instead of onboard resistors, the rail operator can reduce vehicle weight and energy consumption,

eliminate heat generation in tunnels or enclosed stations and deploy a solution that is easy to access and maintain.

The EDS senses the rising line voltage caused by regenerated or sur-

On top of being the single largest means to improve energy efficiency, the ESS can also become an off-grid traction power supply.

plus energy and connects an appropriate resistive load to maintain the voltage within safe operating limits, avoiding the need to use (and wear out) the mechanical brakes. The EDS consists of an indoor power control cabinet and an outdoor resistor bank. The system ensures track receptivity during regenerative braking by dissipating the surplus energy that cannot be absorbed by other onboard loads or nearby trains. The EDS is compatible with any new, or already installed, DC traction power substation. It can also operate in coordination with wayside energy storage

lenger than fitting new equipment in a new installation. Both systems are based on a modular architecture, which allows independent scaling of power per single system. In order to achieve the best return on investment, it is necessary to evaluate the available surplus energy, estimate the power of the system to be used and choose the optimal connection points. Both products are transparent to the existing system, which means they can be isolated without interrupting normal operation.



6 ESS batteries and converter cabinets in an installation in Philadelphia, PA, United States



and energy recuperation systems to ensure that the braking energy is recycled effectively and that any dissipation into resistors occurs only as a last resort. The controller cabinet can be mounted directly in the DC switchgear lineup or separately with other equipment such as negative disconnects and automatic grounding switches.

The resistor bank is placed outside the substation, where the heat can be dissipated passively → 3. This fan-free solution is not only economical but is also noise-free, both from the acoustic and EMC standpoint.

The EDS not only protects against over-voltage, but it also improves the power quality and operational reliability. It has other advantages too:

- Lower cost than chopper-based designs
- Lower operational and maintenance costs than onboard units

- Easy maintenance with remote monitoring and access
- Advanced controls with remote testing capability and programmable firing to ensure optimum performance and to avoid false triggering → 7
- Time balancing of the GTO and resistor operation to share operational wear and maximize life expectancy

The ENVILINE series includes other products, such as the traction diode rectifier (TDR) used to convert AC to the DC commonly used in urban public transport infrastructures → 4.

ABB's long experience in traction means customers will receive expert advice in choosing the ENVILINE solution that precisely meets their requirements – allowing them to benefit from a comprehensive, flexible and high-performance solution that will deliver cost and energy savings for many years.

For more information on ENVILINE, see www.abb.com/enviline or write to enviline@pl.abb.com.

Michał Łodziński
ABB Discrete Automation and Motion,
Power Control
Aleksandrow Łódzki, Poland
michal.lodzinski@pl.abb.com

