Energy Management Solutions
DC Traction Power Supply
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Yann Langlois Eng. – Product Marketing Specialist Rail Segment - AMERICAS
Energy Management Solutions

ABB’s Value proposition - DC traction power supply
Energy recuperation system Enviline™ - ERS
Energy storage system Enviline™ - ESS
Automatic Receptivity Unit Enviline™ - ARU

Q&A
With a history of excellence stretching back more than 130 years ABB is a leading global technology company that energizes the transformation of society and industry to achieve a more productive, sustainable future.
ABB Traction Power Solutions
Value proposition DC traction power supply
ABB: Fully decentralized business model with 18 Divisions

**BUSINESS AREAS**

- Electrification
  - Distribution Solutions
  - Smart Power
  - Smart Buildings
  - Power Conversion
  - Installation Products

- Industrial Automation
  - Energy Industries
  - Process Industries
  - Marine & Ports
  - Turbocharging
  - Measurement & Analytics

- Motion
  - Motors & Generators
  - Drive Products
  - Systems Drives
  - Service
  - Traction
  - MPT

- Robotics & Discrete Automation
  - Robotics
  - Machine Automation
  - Power Grids

*About 110,000 as of July 1, 2020*
Electrification Products Division – Transportation Rail & Infrastructures

Solution provider for each projet steps

From ...

- Tunnels
- Electrification
- Control & Signaling
- Passenger station
- Rolling Stock

...to

- AC Power distribution
- DC Power distribution
- Grid integration
- Automation

- Energy efficiency
- Control & Protect
- Safety
- Reliability

- Digitalization
- Internet of Things, Services and People
- Service

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DC Traction Power Supply

Value propositions

1. LV, MV Products and Solutions
   - DC E-House, complete DC TPS packages, MV & LV Switchgear

2. Power Conversion
   - Transformer-Rectifier Groups, Traction Controlled Rectifiers

3. DC Distribution and Protective Devices
   - DC HSCB, DC Switchgear & Voltage Limiting Devices

4. Energy Management Systems
   - Energy Recuperation
   - Energy Storage Systems
   - Automatic Receptivity Unit

One-stop shop for urban transport applications
Rail networks are never 100% receptive

Receptivity
- Receptivity is the capacity of a Traction power System of always absorbing/capturing excess braking energy
- Without an energy management system, trains would go into over voltage conditions and need to brake mechanically
  - Mechanical braking is costly to maintain
  - More preventative surveillance is required
- Traditional solution is onboard braking resistors
Path to energy management

- Electric rail transit operators are amongst the largest consumers of electricity.
- Recycling the braking energy is the single largest opportunity to improve the energy efficiency.
- Recoverable excess braking energy can be as high as 30%.
- ABB offers a complete range of smart energy management systems improving the energy efficiency significantly.
- ARU optimal solution for test tracks, and wayside resistors for monorails and APM's.
Energy Management Solutions
Energy recuperation system Enviline ERS
DC Traction Power Supply
Energy recuperation systems

Enviline ERS Benefits – Increasing energy efficiency

Enviline ERS returns the surplus braking energy back to the medium-voltage grid, increasing the energy efficiency while reducing at the same time the energy bill.

- Lowers energy costs through energy recuperation
- Low upfront and maintenance costs
- Small footprint, easy installation and low maintenance
- Compatible with new and existing systems
- High reliability
- Easy deployment with no downtime of the DC traction substation
- Connection in parallel to the existing transformer rectifier-group
- Fast commissioning
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Energy recuperation systems

Enviline ERS – System integration

Enviline ERS energy recuperation system can be used in different configurations.

1. **Additional inverter**
   - Compact solution. Ideal for retrofitting existing substations.
   - Autotransformer adapts the voltage level for connection to the rectifier transformer

2. **Reversible converter**
   - Reversible converters combine the function of controlled rectifiers and inverters

3. **Autonomous inverter**
   - Direct connection to the medium-voltage grid in parallel with the diode rectifier
   - A separate transformer is connected in front of the rectifier to adapt the voltage
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Energy recuperation systems

Enviline ERS – Modularity

Enviline ERS is a modular system, meeting different power needs. It can easily be adapted to customer needs and requirements.
- Converter power up to 1 MW @ 750 VDC
- Converter power up to 2 MW @ 1500 VDC

By having additional control and connection module, we can increase the total converter power to 4 MW +

1 2 3

Converter Module + Control and connection module + Autotransformer module (optional) =

500 kW ERS with AT

1000 kW ERS with AT
ENVILINE ERS
Multiple installations worldwide

ERS in the substation
DC Traction Power Supply
Regenerative Braking and Receptivity

ERS - Design parameters

- Traction power network values (see input data questionnaire)
- Utility interconnection guidelines (UL1741, distributed resources)
- Not required to be at same Power level as Rectifiers
- Total harmonic distortion less than 5%
- To determine the opportunity, the client should perform a load flow evaluation to assess the best location
Energy Management Systems
Energy storage system Enviline ESS
ENVILINE Energy Storage System (ESS)

Infrastructure Asset for Transit Authorities

**ESS Benefits: Multiple Applications**

Value stacking proposition for the ESS asset

1. Recovers surplus regen braking energy
2. Reduces peak power demand
3. Provides Voltage stabilization
4. Smart Grid services (Behind the meter)
5. Emergency ride home (back up power)

**ENVILINE ESS helps to lower OPEX AND CAPEX**
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Energy storage systems

Enviline ESS – Modularity

Enviline ESS has a modular architecture to meet power and energy needs.

- It can be provided with supercapacitors, batteries or a combination of both.
- Modular power MW and storage enables ABB to adapt the system to each application and transit agencies requirements.
- Lowers utility demand charges.
- Reliable power in case of outages.
- Lower cost than TPSS.
**DC Traction Power Supply**

Energy storage systems

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**Enviline ESS – Main technical data**

<table>
<thead>
<tr>
<th>Main technical data</th>
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<tbody>
<tr>
<td>Nominal voltage</td>
<td>750 VDC</td>
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<tr>
<td>Maximum system power (kW)</td>
<td>2700</td>
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<tr>
<td>Converter cabinet current</td>
<td>1500 A</td>
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<tr>
<td>Continuous rated power</td>
<td>580kW</td>
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<tr>
<td>Efficiency</td>
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<tr>
<td>Maximum system storage</td>
<td>45.6 MJ</td>
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<tr>
<td>Cabinet dimensions (CU)</td>
<td>1000 x 1600 x 2300 mm</td>
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<tr>
<td>Cabinet dimensions (CCU)</td>
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<tr>
<td>Enclosure</td>
<td>NEMA2 / IP21D</td>
</tr>
<tr>
<td>Remote access</td>
<td>TCP/IP and RS485 (Modbus)</td>
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<tr>
<td>Standards</td>
<td>IEC 62924:2017</td>
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</tbody>
</table>
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Energy storage systems

**Enviline ESS – Design parameters**

- Traction power network values (see input data questionnaire)
- Not required to be at same Power level as Rectifiers
- To determine the opportunity, the client should perform a load flow evaluation to assess the best location
- Determine IEC Duty cycle Class

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**System rating acc. to IEC 62924 duty cycle class V**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Rated DC current (I_{RD})</td>
<td>1182 A</td>
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<tr>
<td>Rated power (P_{RC})</td>
<td>886 kW</td>
</tr>
<tr>
<td>Storage min voltage (U_{S\text{min}})</td>
<td>500 V</td>
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<tr>
<td>Storage max voltage (U_{S\text{max}})</td>
<td>960 V</td>
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## ENVILINE ESS

### Multiple references

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Location</th>
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<tbody>
<tr>
<td>2009</td>
<td>Voltage Support</td>
<td>SRT, Sacramento Regional Transit, USA</td>
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<tr>
<td>2012</td>
<td>Energy Optimization System (energy recovery and grid regulation)</td>
<td>South Eastern Pennsylvania Transit Authority, USA</td>
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<td>2014</td>
<td>Hybrid Energy Optimization System and grid regulation</td>
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<td>2015</td>
<td>Braking Energy Recovery</td>
<td>Metro Warszawskie (Warsaw), Poland</td>
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<td>2016</td>
<td>7x Energy Optimization System and grid regulation</td>
<td>South Eastern Pennsylvania Transit Authority, USA</td>
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<td>2017</td>
<td>Braking Energy Recovery</td>
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<td>2018</td>
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<td>2018</td>
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<td>NYCT/MTA</td>
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<tr>
<td>2020</td>
<td>Emergency Power</td>
<td>LAX, California, USA</td>
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</table>
Energy Management Systems
Automatic Receptivity Unit - ARU
ARU Benefits: Low cost & easy energy management

- Traditional solution is onboard braking resistors, however certain remove onboard resistors to:
  - Reduce train weight and space
  - Reduce train cost
  - Easier heat management (especially in tunnels)
- Least expensive energy management solution
- Reliability (GTO are well proven technology with over 20 years in the field)
- Convection cooling (no audible noise) compared to Choppers
- Minimal maintenance
- Low EMC (ARU turns on/off GTOs statically, with no high frequency switching and therefore no EMI issues
- Designed to metal enclosed IEEE and IEC switchgear standards
ARU - How does it work

- Natural line receptivity is favored by having high ARU trigger level without causing train overvoltages
- Maintain ARU voltage above no load rectifier voltage when turned ON without causing train overvoltages
DC Traction Power Supply

ARU

ARU – How does it work

- Separate power and control compartment
- ARU uses a 3 or 6-section parallel topology
  - ARU is the equivalent to a resistive load on the line (very stable and no EMI)
  - ON/OFF voltage & time delay setpoints
  - Rectifier current based turn off

AARU current

Braking current

Rectifier current

AARU dissipation ~ 108% of surplus braking power

Surplus braking power
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Energy recuperation systems

Envilone ARU – Modularity

- 2 standard ARU sizes: 3x GTO's and 6X GTO's
  - Peak power exceeds 2500kW/830V, 6x GTO is required
  - Duty cycle is need (ex 30 sec on- 90 sec off)
  - ABB performs Thermal analysis
  - Resistor bank size and type offers the most flexibility (footprint, ohmic values, etc)
Energy Management Solutions

Summary
ENVILINE Energy Management

ENVILINE recovers the braking energy to AC or DC

- EMS system should be deployed every 2-4 km for optimum financial performance
- EMS captures the braking energy from local and distant trains
- Ohm’s law applies, the further away, voltage drops, and less energy is recoverable
- Wayside or on-board resistors will dissipate the surplus energy which cannot be recovered
# DC Traction Power Supply

**EMS Estimate**

## Beyond Price

- Is there enough space
- Is the headway optimal
- What is the chopper resistor voltage setpoint
- What is the no load voltage
- What is the distance between TPSS
- What is the Loop resistance
- Is there a grade

<table>
<thead>
<tr>
<th>Technology</th>
<th>CU Converter</th>
<th>CCU Connec</th>
<th>Dimensions (WxDxH)</th>
<th>Budget Price (Unit Price) USD</th>
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<td>ESS 1350 kWpk</td>
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<td>Storage unit 7.6MJ</td>
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<td>ARU 6x GTO</td>
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<td>Resistors*</td>
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<td>2900X 27600X 1970mm</td>
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</tbody>
</table>
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