Panel 2
“Best of” Reversible DC Substation

Railenergy Final Conference
Brussels
25th November, 2010

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Transport Authorities and their suppliers today seek Energy Efficiencies as a contribution to both:

- Their overall business performance
- Their identity as modern & responsible public service organisations

This presentation is about the original design and validation of a reversible DC substation conceived by ALSTOM and shared with Railenergy Trackside works:

- It is one of several ALSTOM solutions developed to address customer demand for superior energy management capability in public transport.

- It is also the fruit of initiatives and research work that go back to a time before “Sustainable Development” became fashionable.
“Best of” reversible DC substation
New technology

Grid
Transformer
Controlled Rectifier
Inverter + Active Filter
DC Railway Network

REGENERATION
TRACTION

U_{max}
U_{max1}
U_{max2}

Control range

3 \cdot l_{inv} 1,5 \cdot l_{inv} \cdot l_{inv} 0 \cdot l_{inv}

0 \cdot l_{rect} 1,5 \cdot l_{rect} 3 \cdot l_{rect}
“Best of” reversible DC substation
Simulation and evaluation

- +7% energy saving on Utrech-Zwolle regional line, Netherlands
- Improved line receptivity (from 77% to 99%)
- Simplified model has been used for simulation purposes
- In reality, line receptivity likely to be 100%
- Rheostatic braking not used anymore (lower tare mass/equip. volume)

1.5 kV DC
87 km long
15 stations
15 min headway
6-to-12 car EMU
“Best of” reversible DC substation
Sensitivity analysis

Amount of Energy saving is dependent upon:

- Operational headways
- Frequency of the stop points
- System voltage
- Line gradients
- Rolling stock auxiliaries power consumption
Operational headways:

LINEAR NET and GROSS BRAKING POWER (absolute)
Regional #1 (3kV - 4km) & Regional #2 (1.5kV - 4km)

- Reg. #1 - Linear Gross Braking Power (kW / line km)
- Reg. #1 - Linear Net Braking Power (kW / line km)
- Reg. #2 - Linear Gross Braking Power (kW / line km)
- Reg. #2 - Linear Net Braking Power (kW / line km)

KWh/h per line kilometer

Headway (mn)
“Best of” reversible DC substation
Sensitivity analysis

Frequency of the stop points:

It is the absolute value of energy saving that matters for the business case!

Regional Baseline

Daily average recovered (% of traction energy)
“Best of” reversible DC substation
Sensitivity analysis

System voltage:

Daily average recovered (% of traction energy)

Regional Baseline

DC Voltage (V)

0 750 1500 2250 3000 3750

0% 1% 2% 3% 4% 5% 6% 7% 8%

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"Best of" reversible DC substation
Sensitivity analysis

Line gradients:

1500 V: Base / 1% / 2%

SS_i SS_j

1% hills +8.5% savings
2% hills +9% savings

Regional Baseline gradient +7% savings
Train auxiliary power:

Average train auxiliary power [% of rated power]

Daily average energy savings (% of traction energy)

Regional Baseline

“Best of” reversible DC substation
Sensitivity analysis

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Energy saving targets were reached, and sensitivity analysis was carried out confirming the great potential of reversible substations for energy savings,

Validation by LCC analysis and Technical Assessment Report were done,

A TecRec (UIC-UNIFE Technical Recommendation) on reversible substation is under progress for future integration into CENELEC standards,

An industrial plan is being built on ALSTOM side for 1500V and 3000V DC substation, to be “Free for tender” after validation of a full scale substation on a railway network.

Clip of HESOP project presentation