Energy Efficient Rolling Stock

Is dual hybrid the future?

Energy Efficiency Days 2014, Antwerp
Moderator Harald Jony
Specific Energy Consumption Factor

RailJet, 32 Wh/GBtkm

Taurus 1116, 18 Wh/GBtkm

Talent 4024, 44 Wh/GBtkm

4020, 55 Wh/GBtkm

1042, 20 Wh/GBtkm
Vectron – The new Siemens locomotive for European rail transportation
Why Vectron?
Future demands on European rail transportation

- Changing customer structure → Smaller order sizes
- Increasing customer demands for more flexibility in terms of setup and area of operation
- Changing requirements due to legislation and standards
- More stringent requirements regarding environmental sustainability
Vectron principle – Genuine flexibility in different performance classes for highly diverse transport tasks

- **MS locomotive**
  - High power
  - 6.4 MW 200 km/h

- **AC locomotive**
  - High power
  - 6.4 MW 200 km/h

- **AC locomotive**
  - Medium power
  - 5.6 MW 160 km/h

- **DC locomotive**
  - Medium power
  - 5.2 MW 160 km/h

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Vectron DE –
Already fulfills tomorrow’s requirements today

- Diesel engine power: 2,400 kW
- Weight: 84 to 88 t
- Max. Speed: 160 km/h

Vectron DE – The first diesel locomotive to fulfill EU97/IIIB
Vectron – Market-oriented flexibility
Double locomotive as a basis for hybrid

- Heavy freight trains – in case high tractive effort is more important than high power:
  → Vectron booster solution
- Commonality of parts to “standard” Vectron
- Space in booster section can be used for diesel engine or battery

From a Vectron double locomotive a hybrid locomotive can be derived
Vectron – Exceptional future-proof design
Genuine modularity in all performance classes

Machine room layout Vectron AC high power with shunting module

- Fire extinguishing system
- Traction converter
- Oil and water cooler
- Traction motor blower
- Auxiliary transformer rack
- Compressed air equipment rack
- Brake rack
- Low-voltage equipment cabinet
- Auxiliary equipment rack
- High-voltage AC equipment cabinet
- Train protection cabinet 1/2
- Train protection cabinet 3
- Shunting module
Vectors – Market-oriented flexibility
Shunting module: system set-up

Compact shunting module package consisting of engine rack, fuel tank and piping

• Optionally available for Vectron AC and DC
• Can be fitted as an option and is retrofittable
• All maintenance work possible from the aisle side
• No additives like AdBlue or similar required

Increased flexibility of electric locomotives by being independent of catenary system for shunting duties:

✔ on secondary lines
✔ on factory sidings
✔ for the “Last mile” in terminals
### Vectron – Lasting cost effectiveness
Minimizing LCC: extremely low energy costs

**Reference** measured energy demand and feedback values, ES64U4 Slovenia (SZ541)

<table>
<thead>
<tr>
<th>Energy required</th>
<th>Energy fed back</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AC network</strong></td>
<td></td>
</tr>
<tr>
<td>Locomotive 1</td>
<td>470,016 kWh (100 %)</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Locomotive 5</td>
<td>53,001 kWh</td>
</tr>
<tr>
<td><strong>Total for 5 locos</strong></td>
<td>795,579 kWh</td>
</tr>
<tr>
<td></td>
<td>114,379 kWh (24.3 %)</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>11,359 kWh (21.4 %)</td>
</tr>
<tr>
<td></td>
<td>183,896 kWh (23.1 %)</td>
</tr>
<tr>
<td><strong>DC network</strong></td>
<td></td>
</tr>
<tr>
<td>Locomotive 1</td>
<td>1,795,920 kWh (100 %)</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Locomotive 5</td>
<td>179,013 kWh</td>
</tr>
<tr>
<td><strong>Total for 5 loco</strong></td>
<td>2,426,584 kWh</td>
</tr>
<tr>
<td></td>
<td>242,580 kWh (13.5 %)</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>29,930 kWh (16.7 %)</td>
</tr>
<tr>
<td></td>
<td>344,434 kWh (14.19 %)</td>
</tr>
</tbody>
</table>
Increased electric braking effort 240 kN

Electric braking effort usual in Europe: 150 kN
In various countries, up to 240 kN permitted

- Use of the pneumatic brake can be dispensed with on steep downgrades (e.g. in the Alps)
- Less wear on brake pads and brake discs of the locomotive
- Additionally gained braking energy can be fed back into the network

Energy and cost saving by additional feedback
Reduced noise and dust
Vectron – Lasting cost effectiveness
Minimizing LCC: extremely low energy costs

Further measures

Energy consumption display to optimize driving behavior
-20 % energy saving potential

Low-energy parking:
Eco Locomotive energy-saving mode to reduce power of auxiliaries at standstill

Optimized air guidance in the traction motor air duct + traction motor

Optimized cooling air guidance in the engine compartment
Eco-mode

- Shutdown of one transformer coolant pump and associated cooling tower fan
- Shutdown of one converter incl. blower and pump
- Reduced noise emission at standstill

40 % energy saving with set-up locomotive at standstill
 Vectron – Environmentally compatible sustainability
Development: energy-saving measures while driving

Driver assistance system (DAS) utilizes leeway in timetable by
• reducing speed
• optimizing coasting phases
• optimizing use of electric-brake

Necessary data for energy-saving driving style with DAS
• Track data
• Timetable data
• Train data

DAS manages speed via automatic driver braking system (ADBS)
Example: 1,620 t freight train on the route Hamburg – Munich – Hamburg

Energy-saving in driving approx. 10%

The saving equal the yearly energy consumption of two single family homes
Thank you for your attention!
H3 Hybrid Locomotive

Thorsten Bomke
UIC Energy Efficiency Days 2014
18/06/2014
Some facts about diesel locos in Europe

- 55% of the installed base
- 200 ton average weight
- 50% of Co2 emissions per year/loco
- 26 years average age
- 4% growth rate of energy cost per year
- 50% shunting locos

Alstom Customer Need Review

Energy is one of the top 3 issues identified as main area for improvements

- Train Maintenance: 76%
- Parts Supply and Component Overhaul: 67%
- Energy Efficiency: 64%
- Knowledge Management: 62%
- Obsolescence and Lifecycle Management: 50%
- Train Life Extension: 43%
- Asset Management: 43%
- Modernisation for Passenger Comfort: 43%
- Future Regulations: 40%

Source: Alstom Transport Customer Needs review, 2013
Alstom V100 Hybrid Locomotive
Alstom’s V100 Hybrid Experience

6 years of experience in operation of hybrid locomotives

- **Small adaptation** to hybrid technology for train drivers
- **High gain in comfort** thanks to emission reductions
- **Over 80,000 operation hours** for the hybrid fleet
- **Excellent resistance** of the NiCad batteries

6 years of operation with the original batteries
The Results

Significant emission and cost reduction

- 42% Diesel Savings
- 52% Particle Reductions
- 48% CO Reductions
- 10dB (A) Noise Reductions

Large acceptance within the driver community
Alstom H3 Hybrid Locomotive
## H3 Family at a Glance

<table>
<thead>
<tr>
<th></th>
<th>H3 Akku</th>
<th>H3 Hybrid</th>
<th>H3 Dual Engine</th>
<th>H3 Single Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power supply</strong></td>
<td>external</td>
<td>350 kW generator</td>
<td>2 x 350 kW generator</td>
<td>1000 kW generator</td>
</tr>
<tr>
<td><strong>Energy storage</strong></td>
<td>NiCad Battery</td>
<td>NiCad Battery</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>600 kW</td>
<td>700 kW</td>
<td>700 kW</td>
<td>1000 kW</td>
</tr>
<tr>
<td><strong>Tank volume</strong></td>
<td>-</td>
<td>2.000 l</td>
<td>2.000 l</td>
<td>2.000 l</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td>-</td>
<td>9-20l/h</td>
<td>15-20l/h</td>
<td>25-40l/h</td>
</tr>
<tr>
<td><strong>Field of operation</strong></td>
<td>Light shunting operation</td>
<td>Medium shunting operation</td>
<td>Heavy shunting operation</td>
<td>Medium distance mainline operation</td>
</tr>
<tr>
<td><strong>Key advantage</strong></td>
<td>Emission free</td>
<td>30-50% diesel savings, autonomy</td>
<td>15% diesel savings, redundancy</td>
<td>8% diesel savings, high power</td>
</tr>
</tbody>
</table>
### Technical Parameters

#### Physical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length (buffer to buffer)</td>
<td>12,800 mm</td>
</tr>
<tr>
<td>Max. width</td>
<td>3,130 mm</td>
</tr>
<tr>
<td>Max. height</td>
<td>4,245 mm</td>
</tr>
<tr>
<td>Gauge</td>
<td>1,435 mm</td>
</tr>
<tr>
<td>Axle configuration</td>
<td>A‘AA‘</td>
</tr>
<tr>
<td>Distance between wheel sets</td>
<td>3,200 mm</td>
</tr>
<tr>
<td>Minimum curve radius</td>
<td>60 m</td>
</tr>
<tr>
<td>Minimum vertical radius</td>
<td>250 m</td>
</tr>
<tr>
<td>Max. mass</td>
<td>67,5 t</td>
</tr>
<tr>
<td>Maximum axle load</td>
<td>22,5 t</td>
</tr>
<tr>
<td>Operation temperatures</td>
<td>-25°C to + 40°C</td>
</tr>
<tr>
<td>Traction force</td>
<td>240 kN</td>
</tr>
<tr>
<td>Traction power (nominal power)</td>
<td>3 x 253 kW</td>
</tr>
<tr>
<td>Max. speed (active)</td>
<td>100 km/h</td>
</tr>
</tbody>
</table>

#### Certification
- TSI
- EBA
- BOA
Performance

- Generator power only
- Generator and battery power
- Train resistance 0t load
- Train resistance 200t load
- Train resistance 600t load
- Train resistance 1500t load
- Train resistance 2500t load
Individual Axle Control

Based on S-tog Copenhagen design, in operation with 1200 axles since 1996

- Hydraulic axle control: passive radial positioning
- Stability at speeds of 100 km/h, 60 m curve radius
H3 soon in operation!

**Volkswagen AG**

- Three H3 Hybrid locomotives will be operated at the VW Wolfsburg sites end of 2014.
- The VW operates already the Alstom V100 Hybrid Locomotive

**DB Regio Bayern**

- Five H3 Hybrid shunting locomotives will be operated in Würzburg and in Nürnberg
- Start of operation is planned for 2015
H3 @ Innotrans 2014

100 km/h maximum speed for all versions

Reduction of emissions of up to 50%

Reduction of maintenance cost of up to 15%

Reduction of diesel consumption of up to 50%
Bombardier Locomotives

the

Future Locomotives

Energy efficiency & Dual hybrid locomotives
TRAXX locomotives are established throughout Europe ... to cover the different railway requirements through modular structures

- **TRAXX AC**
  - 15 and 25 kVAC
  - Italy, Spain, Poland
  - North – South Corridors

- **TRAXX DC**
  - 3 kVDC
  - Benelux, Italy, Poland

- **TRAXX MS**
  - 15/25 kVAC & 1.5/3 kVDC
  - Non-electrified lines

- **TRAXX DE**
  - diesel-electric

- 18 countries
- 1,749 TRAXX locomotives sold
- 1,530 TRAXX locomotives in operation
The modular TRAXX Platform allows for customer specific configurations and provides substantial advantages:

### Power Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>(15 &amp; 25 kV)</td>
</tr>
<tr>
<td>DC</td>
<td>(1.5 &amp; 3 kV)</td>
</tr>
<tr>
<td>MS</td>
<td>(AC &amp; DC)</td>
</tr>
<tr>
<td>Diesel</td>
<td>Engine</td>
</tr>
</tbody>
</table>

### Country packages & options

- One layout
- One control electronic
- One propulsion equipment
- One carbody
- One cab

### Type of operation

- **Cargo**: 140 km/h
- **Regional**: 160 km/h
- **Passenger**: 189 km/h

### Options

- **Nose suspended drive**: 140 km/h
- **Fully suspended drive**: 160 km/h

### Additional Information

- **Last Mile Diesel** available to bridge non-electrified sections
- Provides the appropriate power with the **lowest specific fuel consumption**
- **Low energy consumption** and up to 96% recyclability
The TRAXX AC3 minimizes energy consumption ... with a multitude of specific energy saving features

**eco**

<table>
<thead>
<tr>
<th>High power efficiency</th>
<th>Increase power regeneration</th>
<th>Operational savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Large traction transformer with low losses</td>
<td>▪ High dynamic braking effort producing large energy savings increasing the regeneration of braking energy</td>
<td>▪ Energy meter for Billing</td>
</tr>
<tr>
<td>▪ Modern traction converter with 4.5 kV IGBT</td>
<td>▪ Regenerative braking power is also fed to the passenger cars</td>
<td>▪ Driving Advisory Systems: EBI Drive 50</td>
</tr>
<tr>
<td>▪ LED headlights</td>
<td>▪ Energy meter for Billing</td>
<td>▪ Optimized power control at low traction power</td>
</tr>
<tr>
<td>▪ Optimized traction system cooling and air-conditioning</td>
<td>▪ Display of energy consumption and regeneration to the driver for ECO Driving</td>
<td>▪ Display of energy consumption and regeneration to the driver for ECO Driving</td>
</tr>
</tbody>
</table>
The objectives of our developments are to support railways to reduce overall operating costs and to increase competitiveness.

**Dual-mode loco**
Operation with electric and diesel traction ➔ one-seat ride

**Last Mile**
Electric loco
With small diesel engine ➔ operation without catenary

**Multi-engine diesel loco**
With 4 robust industrial diesel engines ➔ Lower fuel and maintenance costs
**Last Mile on TRAXX locos:** Provides access to non-electrified tracks and can substitute Diesel traction

Small diesel engine in Electric Locomotives
Additional power with a battery for traction
Extends the range of an electric loco to operate into non-electrified terminals, harbors and sidings
New logistic concepts without shunting locos
One-man operations with radio control for shunting

**Deutz engine**
230 kW, Stage IIIB

**TRAXX AC3:** 4-axle E-loco with 6 MW at wheels, with Last Mile consisting of diesel engine + battery

**TRAXX AC3, machine room layout**
The last mile Functionality brings 300 kN. The AC 3 is equipped with Traction Battery.

Corner points:
- $F_{\text{max}} \ LMD + \ LMB = 300\text{kN}$
- $F_{\text{max}} \ LMD = 260\text{kN}$

Load (Velim) = 2'000 t

Maximum speed Last Mile
The energy cost of electric Traction are much lower than the costs of diesel Traction

**Summary**
- The fuel cost for diesel traction are more than double the energy cost for electric traction

**Assumptions**
- Identical trains hauled by either diesel or electric locomotives
- Data used for the comparison
  - 1.23 Euro/liter diesel fuel
  - 0.10 Euro/kWh
  - 1 liter fuel corresponds to 5 kWh (based on simulations)
  - 180’000 km/year
Company profil

- Private Austrian railway undertaking
- Subsidiaries in NL, DE, SK, CZ, HU and RO
- Founded in 2000
- Shareholder
  - Porr Infrastruktur GmbH (2000-2010) and
  - Graz - Köflacher Bahn und Busbetrieb GmbH (since 2000, since 2011 100% owned)
• 2013  LTE Germany GmbH, LTE Romania S.r.l.
• 2012  LTE Netherlands BV
• 2009  LTE Swiss
• 2008  LTE Hungaria Kft.
• 2006  Adria Transport d.o.o.
• 2005  LTE Czechia S.r.o.
• 2004  LTE Slovakia S.r.o.
• 2000  LTE Austria GmbH
### Employee

<table>
<thead>
<tr>
<th>AT</th>
<th>CZ</th>
<th>DE</th>
<th>NL</th>
<th>HU</th>
<th>RO</th>
<th>SK</th>
<th>March 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>27</td>
<td>4</td>
<td>23</td>
<td>40</td>
<td>4</td>
<td>35</td>
<td>187</td>
</tr>
</tbody>
</table>
Locomotive Equipment

• E-Lok
  
  3 x Bombardier 185 (Homologation: D-A-HU)
  2 x Bombardier 185 (D-A)
  2 x Bombardier 186 (D-A-NL)
  4 x Siemens 1216 (D-A-SLO + HU-SK-CZ)
  3 x Siemens 182 (D-A-HU mit ETCS)
  5 x Siemens 189 (D-A-CZ-SK-SLO-PL-HU)

• Diesel
  
  4 x Siemens ER 20 (D-A-CZ-SK)
  2 x Siemens ER 20 (D-A-HU-SK-CZ-SLO)
  4 x CKD 740 (SK-CZ)
  2 x MAK 6400 (NL-D)
The requests on a future locomotive

• Certification
  From the North Sea to Black Sea;
  In the porter areas

• Hybrid-Engine
  Diesel for 2000t and 25kmph

• Maintenance
  Moulded spare parts

• Operation
  EC energy bill with one certificated meter
Kunden

OMV

ARS

Gleencore International AG

IFB

Hödlmayr Logistics Austria

Cargo Center Graz

GUNVOR

sappi

voestalpine

EINEN SCHRITT VORAUS.

DHL