Shift2Rail Energy KPI results

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FINE1 WP 4 Leader
17/10/2019, Paris, FINE1 & OPEUS Final Conference
1. Introduction – What is an energy KPI?
2. Future Technologies and Improvements
3. Mapping of Technologies and SPDs
4. KPI results
5. Conclusion
What is an Energy KPI?

Energy KPI quantifies relative savings of the TD innovations compared to the energy baseline.

The Energy KPI summarizes overall savings per SPD, assuming technical improvements reported by the TDs are applied.
Future Technologies and Improvements reported by TDs

TD1.1: independently rotating PM motor-wheel-system ➔ improved gearbox efficiency
TD1.1: Silicon Carbide (SiC) converter (Metro & Tram)
TD 1.3: Carbody mass reduction

Future Technologies and Improvements reported by TDs

30% WEIGHT REDUCTION
Doors: Concept design
Composite sandwich base with aluminium extruded profiles.

- Extruded profiles: aluminium.
- Composite part - materials:
  - Core: PET foam.
  - Semipreg Biaxial E-Glass epoxy resin FST
  - Semipreg Biaxial Carbon epoxy resin FST
- Window

26 kg ➔ 19 kg
TD3.9: New substation with double side feeding in 25 kV / 50 Hz AC networks avoids separation sections

Future Technologies and Improvements reported by TDs
## Mapping of Technologies and SPDs

<table>
<thead>
<tr>
<th>SPD</th>
<th>Smart Power Supply</th>
<th>Mass reduction carbody</th>
<th>Mass reduction doors</th>
<th>Mass reduction brakes</th>
<th>Improved line converter (SiC)</th>
<th>Improved motor converter (SiC)</th>
<th>Direct drive with improved gearbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST300</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>HST250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Intercity</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Regional 160</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Regional 140</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>n.a.</td>
<td>X</td>
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<tr>
<td>Metro</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>n.a.</td>
<td>X</td>
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<tr>
<td>Tram</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Freight</td>
<td></td>
<td></td>
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<td></td>
<td>X</td>
<td></td>
<td>X</td>
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</tbody>
</table>
Example: KPI improvement for SPD HST300

TD3.9: New substation with double side feeding in 25 kV / 50 Hz AC networks avoids separation sections

-2.2%
Example: KPI improvement for SPD HST300

Combined assessment of mass reductions and efficiency improvements – comparison of energy demand
Example: KPI improvement for SPD HST300

Combined assessment of mass reductions and efficiency improvements

<table>
<thead>
<tr>
<th>Energy savings [%]</th>
<th>traction energy (wheel)</th>
<th>total braking energy (wheel)</th>
<th>ED-braking energy (wheel)</th>
<th>braking energy (mech. Brakes)</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tr>
</tbody>
</table>

-6 -4 -2 0 2 4 6 8 10 12

1. traction energy (wheel)
2. total braking energy (wheel)
3. ED-braking energy (wheel)
4. braking energy (mech. Brakes)

DC link: traction energy
DC link: recuperated energy
DC link: auxiliary energy
DC link: rheostat braking energy
traction energy at the catenary
recup. energy at the catenary
net energy at catenary

net energy at catenary 5,04
recup. energy at the catenary -4,94
traction energy at the catenary 4,88
DC link: traction energy 0,00
DC link: auxiliary energy 0,47
DC link: recuperation energy -1,96
DC link: traction energy 1,76
braking energy (mech. Brakes) 11,87
ED-braking energy (wheel) 0,00
total braking energy (wheel) 2,39
traction energy (wheel) 3,10

Energy KPI improvement

17/10/2019
FINE1 & OPEUS Final Conference
Improvements of energy KPI between 3.5% (SPD Intercity) and 9.1% (SPD Regional140).

Metro and Tram: SiC converter application improves energy KPI by 1.7% (Metro) and 2.7% (Tram)
Mass reductions lead to significant reduction of brake wear
What FINE1 achieved:

• **S2R energy expert network was established**, connecting people and topics throughout S2R technological and cross-cutting activities;

• Development of **methodology, process and tool to assess S2R technologies** and their impact on energy demand;

• **Reference scenarios and system platform datasets** (energy baseline) have been defined and distributed in S2R;

• Validation and application of the **OPEUS single train energy simulation tool** for KPI analysis;

• Energy KPI evaluations indicated **energy savings of up to 9%** with future S2R technologies;
Questions and Answers
Thank you for your attention!
Henry Völker (BT), Mohamed Abdelgawad (BT)

FINE1 Eco-Labelling Proposal & Introduction to EN 50591

17th October 2019, Paris
1. Overview
2. Introduction Eco-Label
3. EN 50591: Energy consumption
4. Verification
5. Conclusion
1. Analysis of eco labelling in rail; other industries and stakeholders
2. Two separate labels are proposed, complementing each other:
   1. an EU-wise energy efficiency declaration and
   2. an operator-wise CO2 label.
Increasing variety of energy specification styles

Consolidation & Best practice

Future

Adoption of EN 50591 method for rolling stock procurement + energy validation

EN 50591
Specification and verification of energy consumption for rolling stock
<table>
<thead>
<tr>
<th>EN 50591 (SC9XB)</th>
<th>FINE1</th>
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<tbody>
<tr>
<td>Alstom</td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td></td>
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<tr>
<td>CAF</td>
<td></td>
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<tr>
<td>DLR</td>
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<tr>
<td>Siemens</td>
<td></td>
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<tr>
<td>SNCF</td>
<td></td>
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<tr>
<td>-</td>
<td>Talgo</td>
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<td>-</td>
<td>TRV (KTH)</td>
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<tr>
<td>Emkamatik</td>
<td>-</td>
</tr>
<tr>
<td>Ricardo/NS</td>
<td>-</td>
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<tr>
<td>SBB</td>
<td>-</td>
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<tr>
<td>Trenitalia</td>
<td>-</td>
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<td>(DB [not in WP2])</td>
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</table>

Overlap of participants lists ensured a smooth flow of best practice and knowledge.
The principle of energy labeling contains three key elements:

**Protocol**
- Measure energy usages of different models with different functions and make the different energy usages comparable.

**Standard**
- Define efficiency and efficiency classes (optional).

**Label**
- indicating the energy efficiency and some other key features.
Household products comparative labels

**Top-Runner Label**
- Japan

**ENERGYGUIDE**
- North America

**EU energy label**
- 280 Wh/Wh
- 155 L
- 54 L
- 38 L

**Some variants**
- India
- Australia
- China

**Endorsement labels**

*See extra report FINE 1 Review of Energy labelling Systems (Tohmmy Bustad, Zhendong Liu, Mats Berg)*
### Objective

<table>
<thead>
<tr>
<th></th>
<th>End customer</th>
<th>Train operator</th>
<th>Transport authority</th>
<th>Certification authority</th>
<th>Train manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of rail sustainability</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Comparison of trains regarding energy</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>(x)</td>
<td>x</td>
</tr>
<tr>
<td>Comparison between rail and other modes of transport</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketing campaign to promote rail</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation of end users to use rail more</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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</tbody>
</table>

### Conclusion

- **Energy labelling can support this objective.**
- **It has the risk of technology leakage. Competition can be increased. The old trains seem inefficient.**
- **It is not easy to reflect the energy efficiency of other modes of transport.**
- **It has the potential and further action is needed to effectively use it.**
- **It has the potential and further action is needed to effectively use it.**
• Rail services grouped into six service categories:
  1. Suburban (passenger service)
  2. Regional (passenger service)
  3. Intercity (passenger service)
  4. High speed (passenger service)
  5. Freight mainline
  6. Metro (passenger service)

• Label format the same as EU household products
• Comparison only within the same train service category

Efficiency indicator: \( E = \frac{E}{D \cdot r \cdot C} \)

where \( E \) - energy in Wh, \( D \) - travelling distance, \( r \) - occupational rate and \( C \) - maximum capacity. Unit in \( W\cdot h/\text{Passenger-km} \), for freight train \( W\cdot h/\text{ton-km} \).
Eco-labelling shall be voluntary

- Which rail vehicle
- Which information
- Begin / end of application + disclosure period

Disclosure to public needs approval from manufacturers, train operators and transport authorities

No market entry barrier!

- Labelling / Classification shall not lead to minimum requirements on energy efficiency (antitrust laws, Europe needs internal competition)
- Focus on transparency and comparability of energy declarations
Part 1: Traction and auxiliaries with commercial operation, without HVAC.

Part 2: Traction and auxiliaries without commercial operation and in parking mode, without HVAC.

Part 3: HVAC (depending on geographical zone).
Operating conditions

Payload

- In-service mode with commercial operation – Passenger trains: 50% seated
- In-service mode without commercial operation – Passenger trains: No staff or passengers
- Freight trains: trailing consist according to EN 50591

Environment

- Traction: 15 °C, wind 1 m/s
- HVAC: According to e.g. EN 13129 temperatures etc.

Line profile

- See EN 50591 (based on TecRec 100.001)
Energy units and CO₂ efficiency

Energy:
- Electric energy unit Wh recommended (eWh for diesel train)
- Net energy intake from pantograph, third rail or tank considered
- Efficiency metric, W·h/Passenger-km and W·h/ton-km
- Simulations for the standardized conditions recommended

CO₂:
- Goal: comparison of transport modes
- Challenge:
  - Variation per country
  - Changes over time
  - Different conditions (e.g. HVAC off in automotive cycle)
- Passenger trains: gCO₂/pkm (= Wh/pkm x gCO₂/Wh)
- Freight trains: gCO₂/tpkm (= Wh/tpkm x gCO₂/Wh)
- gCO₂/Wh depends on energy used / bought by operator
- Mainly operation and energy sourcing strategy is benchmarked
1. Simulation:
   – Synthetic track
   – Defined conditions according to EN 50591

2. On-track measurement:
   – Real track
   – Performed in testing conditions according to EN 50591

3. HVAC: verification acc. to EN50591, e.g. climate chamber measurement

Manufacturer and operator have the right to choose method.
For comparability: Simulation is recommended for energy labelling due to difficulties in matching real operations close to standardized conditions.

CO₂ label is subjected to update, e.g. due to lowered CO₂ intensity
Eco-labelling: Conclusion

Eco-labelling proposal based on EN50591 defined
Common format proposal for annual energy acc. to EN50591
Clarity + comparability in procurement and verification
Voluntary and market to be kept open for all products
Following a global trend
Reinforce attractivenesss of railway transport

EN 50591 is released (August 2019) and should be used in vehicle tenders.
Eco-Labelling: 1st proposal exists, refinement planned for upcoming FINE2 project.
Thank you for your attention

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EU energy-efficiency politics
The EU has set itself targets for reducing its greenhouse gas emissions progressively up to 2050.

- Key climate and energy targets are set in the:
  - 2020 climate and energy package
  - 2030 climate and energy framework

- These targets are defined to put the EU on the way to achieve the transformation towards a low-carbon economy as detailed in the 2050 long-term strategy.

- The EU tracks its progress on cutting emissions through regular monitoring and reporting.

- Before proposing new policies, the Commission carefully assesses their potential impacts.
The 2020 package is a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020.

- The package sets three key targets:
  - 20% cut in greenhouse gas emissions (from 1990 levels)
  - 20% of EU energy from renewables
  - 20% improvement in energy efficiency
2030 Climate and Energy Framework

• The 2030 climate and energy framework includes EU-wide targets and policy objectives for the period from 2021 to 2030.

• Key targets for 2030:
  • At least 40% cuts in greenhouse gas emissions (from 1990 levels)
  • At least 32% share for renewable energy
  • At least 32.5% improvement in energy efficiency

• The framework was adopted by the European Council in October 2014. The targets for renewables and energy efficiency were revised upwards in 2018.
• Climate-neutral Europe by 2050

- FULLY DECARBONISING EUROPE’S ENERGY SUPPLY
  Large scale electrification of the energy system coupled with deployment of renewables will decarbonise our energy supply and significantly reduce our dependency on third country suppliers.

- ROAD TO CLIMATE NEUTRAL ECONOMY: STRATEGIC PRIORITIES
  EMBRACING CLEAN, SAFE AND CONNECTED MOBILITY
  Decarbonising the transport sector by using alternative means of transport, connected and automated driving combined with the roll-out of electric vehicles and enhanced use of alternative fuels.

- MAXIMISING BENEFITS FROM ENERGY EFFICIENCY
  Reducing energy consumption by close to half between 2005 and 2050.

- PUTTING INDUSTRIAL MODERNISATION AT THE CENTRE OF A FULLY CIRCULAR ECONOMY
  Reaping first mover benefits by modernising existing installations and investing in new carbon-neutral and circular economy-compatible technologies and systems.

- DEVELOPING SMART NETWORK INFRASTRUCTURE AND INTER-CONNECTIONS
  A modern and smart infrastructure, ensuring optimal sector coupling and enhancing regional cooperation, is the cornerstone of the energy transmission and distribution landscape of tomorrow.

- REAPING THE FULL BENEFITS OF BIO-ECONOMY AND CREATING ESSENTIAL CARBON SINKS
  Creating natural sinks by developing more sustainable land-use and agriculture.

- TACKLING REMAINING CO2 EMISSIONS WITH CARBON CAPTURE AND STORAGE
  Compensating for remaining greenhouse gas emissions in our economy and creating negative emissions.
GHG emissions trajectory

Figure 5. GHG emissions trajectory in a 1.5 °C scenario

Land use, land-use change, and forestry (LULUCF)
Three main sector producing greenhouse gas:
  • Energy supply
  • Road Transport
  • Industrial system

Total Equivalent CO₂ emissions
4321.4 Millions Tons
Transport Global Emissions in EU (2017)

Share of emissions in transport:
- Road Transport: 71.1%
- Maritime: 13.6%
- Aviation: 13.3%
- Other Transportation: 0.5%
- Railways: 0.5%

Total Equivalent CO₂ emissions for transport:
1097 Millions Tons

EU (Convention) — Share of transport greenhouse gas emissions

- Road transport: 72.1%
- Maritime: 13.5%
- Aviation: 13.3%
- Other Transportation: 0.5%
- Railways: 0.5%
CO$_2$ emissions from passenger transport

<table>
<thead>
<tr>
<th>Vehicle and number of passengers</th>
<th>grams of CO$_2$ per passenger kilometre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplane</td>
<td>285</td>
</tr>
<tr>
<td>Car</td>
<td>158</td>
</tr>
<tr>
<td>Van</td>
<td>104</td>
</tr>
<tr>
<td>Scooter</td>
<td>72</td>
</tr>
<tr>
<td>Minivan</td>
<td>68</td>
</tr>
<tr>
<td>Van</td>
<td>55</td>
</tr>
<tr>
<td>Car</td>
<td>42</td>
</tr>
<tr>
<td>Car</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: The figures have been estimated with an average number of passengers per vehicle. The addition of more passengers results in fuel consumption - and hence also CO$_2$ emissions - penalty as the vehicle becomes heavier, but the final figure in grams of CO$_2$ per passenger is obviously lower. Inland ship emission factor is estimated to be 245 gCO$_2$/km but data availability is still not comparable to that of other modes. Estimations based on TRACC5 database, 2013 and TERM027 indicator.

Source: EEA report TERM 2014 eea.europa.eu/transport
Evolution of CO₂ emissions in Railways

- Electrification of railways has cut by two the emissions in 25 years
  - Evolution of fleet (diesel to electric by electrification)
  - Type of electric primary source has a strong impact in CO₂ emissions (nuclear, coal)
Electric railways is far the better for energy efficiency (10g CO$_2$/passenger/km today)

Electric railways is the most efficient solution for medium and long distance transportation

Electric railways will take full advantage of zero emission electric power generation (renewable, nuclear)

By developing freight and long distance passenger transportation, that will drastically cut the emissions for transport

Autonomous trains with batteries or hydrogen will replace last diesel trains

Electric railways can reach the GHG neutrality before 2050.
Reference Documents

• Reference documents for EU policy:
  • Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019
  • EU Reference Scenario 2016 – Energy, transport and GHG emission – Trends to 2050
  • https://ec.europa.eu/clima/policies/strategies_en
OPEUS POSITION PAPER
On energy usage, generation and savings

Partners: UNEW (leading); UITP, UIC (contributing)

Presenter: Laurent DAUBY, Rail Director, UITP

D 7.2
INTRODUCTION

✓ Alarming climate change situation acknowledged
✓ Paris agreement: transport is key
✓ Transport decarbonisation possible
✓ Immediate and concerted action
✓ Investment in low and zero-C rail transport delivers benefits
✓ And adds up other benefits for individuals, business and authorities
Strategies and convergence

✓ Intergovernmental actions
  ○ UN UNFCCC
  ○ UN Development goals
  ○ EU SETA and resource efficient transport; Climate neutral Europe.

✓ Sector actions
  ○ UIC low C rail challenge (2014)
  ○ UIC railway climate response pledge 2015
  ○ UITP Climate leadership declaration
  ○ UITP Action reporting since 2014
  ○ UITP Climate Change manifesto (2019) and ONEPLANet campaign
  ○ Railsponsible industry initiative
  ○ CER Voluntary targets since 2008
  ○ Rail Freight Forward
IMPLEMENTATION

✓ CO₂ footprint reduction requires “Avoid-Shift-Improve” strategy

✓ Avoid : policy, life-style, renewable energy sources...

✓ Shift : from C-intensive to C-efficient modes

✓ Improve : Technologies and Operation
  o Areas of influence of R&I, S2R etc...
OPEUS CONTRIBUTION

✓ Simulation method and associated tools to evaluate and optimize energy consumption in rail systems
✓ Supports activities of other initiatives (S2R MAAP) on energy efficiency
✓ Robust, stable and readily available assessment methodology
CONCLUSIONS

✓ Holistic approach will deliver benefits towards decarbonisation
✓ Technical measures are important, however their impact is more limited than other measures
  "A teacher will not improve class performance by working with the best in class"
  o Land-use and urban planning with mobility policy supporting most energy-efficient modes
  o Regulatory framework and financial incentives supporting decarbonisation
  o Technical improvement of assets and operation

✓ Coordinated efforts by sector to tackle emission problems to be continued and reinforced
  o Concerted endeavors “avoid-shift-improve”
  o Maximize potential of technological developments into wider implementation strategies
CAMPAIGN MESSAGING

One Planet, One Plan

We only have **one planet**, and we only need **one plan**…

*so what are you waiting for?*

**STEP 1:** **PRIORITISE** breathable and walkable streets through urban planning

**STEP 2:** **STRENGTHEN** public transport’s role as the backbone of all mobility services

**STEP 3:** **GUARANTEE** financial incentives and a regulatory framework for an emission transition

**STEP 4:** **ENSURE** clean energy sources are accessible to further reduce carbon footprint