



NEW DEPENDABLE ROLLING STOCK FOR A MORE SUSTAINABLE, INTELLIGENT AND COMFORTABLE RAIL TRANSPORT IN EUROPE

D8.1 - Energy Norms & Standards Application guide for KPI generation

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EXECUTIVE SUMMARY

Throughout work package 8.1 norms and standards concerning energy norms and standards relevant to railway applications were examined with the following goals:

1. Collection of requirements about content and scope of a future norm that defines boundary conditions for energy consumption calculation and measurement
2. Recommendation of an existing norm that can serve as a basis for further development
3. Collection of suitable aspects from other norms to improve the recommended norm (see goal 2)

It is recommended to further develop TS 50591. A list of improvement proposals is given in chapter 5.

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LIST OF ACRONYMS

Acronym	Definition
CAF	Construcciones y Auxiliar de Ferrocarriles
CDM	Complete Drive Module
CENELEC	European Committee for Electrotechnical Standardization
CER	Community of European Railway and Infrastructure Companies
DB	Deutsche Bahn
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DMU	Diesel Multiple Unit
ECE	Economic Commission for Europe
EMU	Electrical Multiple Unit
EN	European Norm
ENE	Energy Subsystem
EPA	Extended Product Approach
ESS	Energy Storage System
HVAC	Heating, Ventilation and Air Conditioning
IATA	International Air Transport Association
IE	International Efficiency
IEC	International Electrotechnical Commission Norm
IES	International Efficiency System
ITD	Integrated Technical Demonstrator (testing of combinations of components and sub-systems already verified and validated within the S2R Technology Demonstrators, to be developed in S2R)
KPI	Key Performance Indicator
LRV	Light Rail Vehicles
PDS	Power Drive System
prEN	Draft European Norm
RCDM	Reference model for a CDM

Acronym	Definition
RM	Reference model for a Motor
RPDS	Reference model for a PDS
SAM	Semi-Analytic Model
SNCF	Société Nationale des Chemins de fer Français
SORT	Standardised On-Road Test Cycles
SPD	System Platform Demonstrator (proof of rail systems, design and functions on fully representative innovative railway configurations in an integrated environment to be develop in S2R)
TEC REC	Technical Recommendation (UIC/UNIFE standard designed to be used within the European region)
TS	Technical Specification
TSI	Train Specification for Interoperability
UIC	Union internationale des chemins de fer
UITP	Union Internationale des Transports Publics
UNIFE	Union des Industries Ferroviaires Européennes
WP	Work Package

1. INTRODUCTION

1.1 DELIVERABLE CONTEXT

Roll2Rail project aims to develop key technologies and to remove already identified blocking points for radical innovation in the field of railway vehicles, as part of a longer term strategy to revolutionise the rolling stock for the future.

The high level objectives of Roll2Rail project are to pave the way to:

- Increase the capacity of the railway system and bring flexibility to adapt capacity to demand;
- Increase operational reliability and therefore punctuality of the vehicles;
- Increase availability of vehicles;
- Reduce the life cycle costs of the vehicle and the track;
- Increase the energy efficiency of the system; and
- Improve passenger comfort, thereby increasing the attractiveness of rail transport to passengers.

Low energy consumption of railway rolling stock is a key contributor to the attractiveness of rail transportation. Sustainability of mobility solutions is driven by energy efficiency and energy cost is an important part of lifecycle cost. Furthermore a standardised methodology for energy consumption quantification is needed to evaluate efficiency improvement potentials.

Roll2Rail is paving the way for Shift2Rail, where it is foreseen that the energy performance will be monitored by a dedicated indicator. It is then of major importance to push and monitor all energy savings actions in Roll2Rail work packages and consolidate the work progress in energy field at global Roll2Rail levels.

Shift2Rail Joint Undertaking is a public-private partnership in the rail sector, established under Horizon 2020, to provide a platform for coordinating research activities with a view to driving innovation in the rail sector in the years to come.

Within the Roll2Rail project WP8 “Transversal Activity – Energy”, partners from industry, operators and research centers will work together to agree on methodologies and roadmap for the Shift2Rail future energy work. This transversal activity looks for a coherent alignment with other energy discussion and standardisation groups (e.g. UNIFE, UIC, UITP, CER, CENELEC...), and with existing standards or normative. Moreover it is intended to support technical and scientifically other work packages on the energy specific aspects and to push on potential new solutions and/or evaluation and pull on local results at early stage of technologies developments.

1.2 OBJECTIVES

Specifically this work package is intended to cover the following objectives:

- Provide a clear status on applicable existing Norms and Regulations to Railway rolling stock energy consumption quantification
- Define and agree on the technical process to translate local energy improvements at component or sub-system level to global macro level (consumption at train or line level) for all type of foreseen System Platform Demonstrators described in Shift2Rail and associated Energy targets.

These two first steps will support and help the kick start of Shift2Rail energy work, especially the quantification of energy baselines for the demonstrations that would be the reference for all quantification of energy improvement in Shift2Rail.

Energy concern has generated many official texts the past years in Europe. Quantifying energy consumption is the first step to achieve complete knowledge and understanding of the normative environment in order to re-use normative approaches when suitable.

This deliverable compiles the work of task 8.1 “State of the art of applicable Norms & Regulation on energy efficiency for railway operation”, with the objective to link the energy related targets to the most appropriate standardized approach for determination of energy efficiency in railway operation.

The work done by the WP partners to fulfil this objective has been:

- Collection of all energy related norms by means of database search
- Analysis of norms and generation of a summary table of content giving a self-explanatory description of the content of each standard, presented in chapter 3.
- Proposal of the most suitable norm based on expert reasoning as a base for Shift2Rail energy KPI generation (define state of the art)
- Proposal for amendments of the most suitable norm
- Development of application guide for usage in ITD’s and SPD’s

This deliverable is structured in order to give brief overview over existing norms and guidance to execute energy quantification. At first requirements are defined which serve as a benchmark to evaluate which norm is the most suitable. Results of norm collection from database search and analysis are presented thereafter. After expert analysis, the most suitable norm is chosen and gaps in this norm are identified, giving as well gap closing proposals. Finally it is described how to go forward to calculate and demonstrate energy saving potentials in integrated technical demonstrators and system platform demonstrators.

The outcome of this task 8.1 will be used in:

- Roll2Rail
 - Task 8.2 “Energy calculation methodology, boundary conditions & link with Shift2Rail targets”

- Work package 9 “System integration”
- Shift2Rail
 - Cross-cutting activity working area 5.1 “Energy and Sustainability”

2. REQUIREMENTS TO ENERGY NORMS AND STANDARDS

The group partners have determined the minimum list of **general requirements** that an energy norm should fulfill, so the application of this norm can be used later for energy performance indicators.

The norm shall ...

- Allow test on track
- Allow for defined prediction (simulation)
- Take into account revenue and non-revenue service (e.g. parking)
- Take into account the whole vehicle including all systems
- Be internationally applicable

The listed requirements are used to evaluate the applicability of the norms found in the database search.

3. RESULTS OF DATABASE SEARCH

Existing energy norms and standards for railway rolling stock have identified in a database search. Each norm has been reviewed by one or two WP partners, stated in the column “reviewer”. The results of the database search are described in Table 1 until Table 10; every table is summarizing one standard.

Table 1: TS 50591

	Reviewer	Norm: TS 50591 (TECREC 100_001)
Title	-	Specification And Verification Of Energy Consumption For Railway Rolling Stock
Relevance	SNCF, DB	Yes, 100% mainlines
Maturity	SNCF, DB	Existing and published
Abstract	SNCF	The document describes the way to simulate and measure energy consumption of rolling stock in all operating modes. 35 parameters are defined (infrastructure, electric supply system, commercial service, parking service, ambient conditions)
	DB	Parameters are defined that have an influence on the energy

	Reviewer	Norm: TS 50591 (TECREC 100_001)
		consumption of rolling stock and are necessary for simulation Typical reference service profiles are defined
Useful findings	SNCF	All operating modes are taken into account (driving style, pre heating, parking,...)
	DB	Good basis for verification of energy consumption in Shift2Rail
Shortcomings	SNCF	Infrastructure description with train current limitation, Reference driving style to be defined, Specified temperatures (15°C and 30°C) in the TEC REC are not equivalent with the temperatures indicated in the EN13129 (air conditioning tests) Precisions of the running resistance simulations versus precision of energy consumption need, TEC REC require a list of 35 parameters :30 additional parameters needed for full detailed simulations (parameters of the aerodynamics resistances, weight, thermal insulation, number of passengers,...), Uncertainties in wind speed measurements, Use of regenerative braking facility linked to infrastructure possibilities, Single train approach
	DB	Additional parameters should be added, especially for rolling stock (e.g. weight, max. braking force) traction unit (e.g. efficiency of traction modules) and consumer power (e.g. HVAC). Some service profiles should be adapted and another high speed profile should be added. Different simulation and measurement methodologies incl. the applicability should be explained

Table 2: TSI ENE

	Reviewer	Norm: TSI ENE
Title	-	TSI Energy subsystem
Relevance		

	Reviewer	Norm: TSI ENE
Maturity		
Abstract	DB	Definition of mechanical and electrical parameters incl. rated, minimum and maximum values of the overhead contact line and pantograph.
Useful findings	DB	Definition of electrical parameters of the overhead line (clause 4.2.3 - 4.2.5).
Shortcomings		

Table 3: EN 50598 1-3

	Reviewer	Norm: EN 50598 1-3
Title	-	Energy Efficiency of drive systems
Relevance	Vossloh, Alstom	<p>Partly</p> <p>This is a standard for industrial applications.</p> <p>This standard applies to motor driven equipment from 0.12 to 1,000 kW (100 to 1,000 V).</p> <p>However, a similar methodology in EN 50598-2 could be applied to rail vehicles traction packages ($P < 1,000 \text{ kW}$).</p>
Maturity	Vossloh, Alstom	<p>Standard is produced by CENELEC.</p> <p>Existing and published (Parts 1 & 2 in Dec 2014 and Part 3 in May 2015).</p> <p>Used by power drive system, motor starters and power electronics providers.</p>
Abstract	Vossloh, Alstom	<p>It is a 3 part standard for Ecodesign for power drive systems, motor starters, power electronics and their driven applications.</p> <p>EN 50598-1 “General requirements for setting energy efficiency standards for power driven equipment using the extended product approach (EPA) and semi-analytic model (SAM).”</p> <p>EN 50598-2 “Energy efficiency indicators for power drive systems and motor starters.”</p> <p>It defines energy efficiency indicators (“IE” and “IES”) for the complete drive module (CDM) and the combination of the CDM and motor to form a “power drive system” or PDS. The standard includes methodology to determine the CDM and PDS losses, assigning the IE and IES values (operation points are considered).</p>

	Reviewer	Norm: EN 50598 1-3
		<p>Type Testing methodology is also included.</p> <p>EN 50598-3, “Quantitative ecodesign approach through life cycle assessment including product category rules and the content of environmental declarations.”</p>
Useful findings	Vossloh, Alstom	<p>Complete systems are considered (not individual components).</p> <p>The standard provides reference models for a load/motor “RM”, the CDM, “RCDM” and PDS, “RPDS.”</p> <p>Motor and drive manufacturers determine the IE (International Efficiency) or IES (IE System) classifications for their products.</p> <p>The standard could be applicable to any rail vehicle with power drive systems of < 1,000kW (metros, LRVs, EMUs and DMUs, and shunters), but not to freight locomotives or High Speed trains, due to the power limitation.</p> <p>Part 2 may serve for reference or copy paste on efficiency determination.</p>
Shortcomings	Vossloh, Alstom	<p>No obligation for rail industry.</p> <p>No possible application to high power rail applications: High Speed or Main line Locomotives.</p>
Other comments	Vossloh, Alstom	The new standard plays a significant role when it comes to improve the overall understanding of energy efficiency in industry.

Table 4: IEC 62864

	Reviewer	Norm: IEC 62864
Title	-	Power supply with onboard energy storage system
Relevance	Alstom, SNCF	Yes, chapter 8.6 Energy efficiency and consumption.
Maturity	Alstom, SNCF	62864-1: circulation date: 2015-02-20; closing date for voting : 2015-05-22
Abstract	Alstom, SNCF	The IEC 62864-1 describes and define hybrid components and hybrid railway traction, based on electric main source, diesel source or fuel cell source. It covers several aspects of hybrid vehicles (power source configuration, functional and system requirements, different type of tests, combined tests). There is a dedicated chapter on energy efficiency and consumption.

	Reviewer	Norm: IEC 62864
Useful findings	Alstom, SNCF	
Shortcomings	Alstom, SNCF	Very limited description on methodology to define and measure energy consumption of hybrid vehicles, but progress could be done within Shift2Rail to combine IEC62864-1 and EN50591 for ML hybrid vehicles

Table 5: IEC 62928

	Reviewer	Norm: IEC 62928
Title	-	Railway applications – Rolling stock equipment - Onboard lithium-ion traction batteries
Relevance	Vossloh, SNCF	Not applicable to our project.
Maturity	Vossloh, SNCF	9/2068/CD It is Draft of IEC TC Electrical equipment and systems for railways. The document is still under study and subject to change.
Abstract	Vossloh, SNCF	This Standard applies to onboard lithium-ion traction batteries for railway applications. It specifies the design, operation parameters, safety recommendations, data exchange, routine and type tests, as well as marking and designation. Battery systems described in this standard are used for energy storage system (ESS) for traction power of rolling stock. Auxiliary batteries are excluded.
Useful findings	Vossloh, SNCF	It is rail relevant for the use of Li Ion traction batteries, having definitions well described and unified, specifications, interchange data between battery manufacturer, integrator and user, and all tests. However, no relation for energy consumption.
Shortcomings	Vossloh, SNCF	Hybrid storage system is not covered in this standard. No relation for energy consumption.

Table 6: EN 15663

	Reviewer	Norm: EN 15663
Title	-	Definition of vehicle reference masses

	Reviewer	Norm: EN 15663
Relevance	Talgo	Partly
Maturity	Talgo	Standard is produced by CENELEC. Existing and published
Abstract	Talgo	<p>Defines a common set of vehicle reference masses on which the assessment of loads and performance can be based on for design, testing and operation purposes.</p> <p>Definition of vehicle reference masses is dependant of the type of rolling stock and/ or the level of comfort associated with the type of service being provided. Three categories of vehicles are distinguished:</p> <ul style="list-style-type: none"> • high speed and other long distance trains, • passenger vehicles other than high speed and long distance trains and • freight vehicles.
Useful findings	Talgo	<p>Clear definition of Operational Mass under Normal Payload for high speed vehicles and for passenger vehicles (other than high speed and long distance). This standard also states that this mass "may be used to determine scheduling and energy consumption".</p> <p>Also the TEC REC Specification and verification of energy consumption for railway rolling stock refers to EN15663 in section 6.2.3 recommending using passenger load conditions that correspond to the expected operation of the rolling stock or the normal operational payload as defined in EN 15663.</p>
Shortcomings	Talgo	A clear guideline defining what vehicle mass should be used to determine the energy consumption is missing; only recommendations are given.

Table 7: ECE R 101

	Reviewer	Norm: ECE R 101
Title	-	Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy

	Reviewer	Norm: ECE R 101
		consumption and electric range.
Relevance	Talgo	Partly. This standard applies to passenger cars (automotive industry).
Maturity	Talgo	Existing and published.
Abstract	Talgo	Regulates the procedure to measure the emission of CO ₂ , fuel consumption and the measurement of electric energy consumption of vehicles, differentiating between: <ul style="list-style-type: none"> • vehicles powered by an internal combustion engine only, • vehicles power by an electric power train only and • vehicles powered by an hybrid electric power train.
Useful findings	Talgo	Annex 6 describes the method of measuring the fuel consumption of vehicles powered by an internal combustion engine only. This method could be applied to measurements of fuel consumption in diesel trains. Annex 8 describes the method of measuring the fuel consumption and the electric energy consumption of vehicles powered by a hybrid electric power train. Two tests are carried out: one with a fully charged power storage device and another with the power storage device in minimum state of charge. The measured values for the two itineraries are prorated (weighted) using the vehicle's electric range and average distance between two battery recharges to get a value that represents the fuel and electrical energy consumption of the hybrid vehicle (l/100km or Wh/km). Test sequences are composed of an urban cycle and an extra-urban cycle (repeated for two times).
Shortcomings	Talgo	The test conditions described in the annexes could be used as a reference but would need to be well defined for trains (standard itineraries, definition of auxiliary consumers that should be on during the test, initial state of energy storage systems, driving mode...). The method used to quantify the electrical energy consumption is the energy discharged from the battery, so this method cannot be used to measure the energy consumption of an electric train.

Table 8: SORT

	Reviewer	Norm:
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	Reviewer	Norm:
Title	-	Standardised on-road test cycles.
Relevance	Alstom	Not directly but indirect interest.
Maturity	Alstom	Level of standardisation and real use unknown.
Abstract	Alstom	Reports of project "SORT", 2 reports : Standardised on-road test cycles for buses and addendum for double deck vehicles
Useful findings	Alstom	It could be a source for urban, mainly tramway, reference document to develop a urban railway standard on: standard cycles construction, measurement conditions & method, hybrid vehicles, Test protocol (test conditions, vehicle set-up, standardised result report presentation) for standard and articulated single deck buses (parallel could be done with 20,30,40 m tramways).
Shortcomings	Alstom	Next step could be asked to UITP as the real use in the urban operator is not known.

Table 9: Euro VI

	Reviewer	Norm: Euro VI
Title	-	Regulation (EC) No 595/2009 of the european parliament and of the council of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC
Relevance	Bombardier, Alstom	No.
Maturity	Bombardier, Alstom	Existing and published
Abstract	Bombardier, Alstom	<p>Euro VI standard defines emissions permitted for combustion engines in g/kWh for truck and bus engines. Two test cycles are defined:</p> <p>1) World Harmonized Stationary Cycle: Working points (load, speed, duration) and weighting are defined. Running in town is relatively strong weighed (speed <= 55 % for 13 out of 14 modes).</p> <p>2) World Harmonized Transient Cycle: Speed and torque profile (% of max) of a 30 min drive are defined. Approx. 50 % urban traffic</p>

	Reviewer	Norm: Euro VI
		represented (rest is road and motorway).
Useful findings	Bombardier, Alstom	Repeatable boundary conditions.
Shortcomings	Bombardier, Alstom	<p>Standard dealing with pollution.</p> <p>Not directly applicable to energy consumption (indirectly over efficiency).</p> <p>Considered substances in exhaust gas can be filtered out, so that no clear picture about fuel efficiency can be deduced.</p> <p>Consideration of engine only, not vehicle level.</p> <p>Relatively high focus on urban traffic with stopping distance of approx. some hundred meters.</p> <p>Long distance busses / trucks with long term cruising speed (on motorway) insignificantly considered.</p>

Table 10: Aircraft energy consumption best practises

	Reviewer	Aircraft energy consumption best practises
Title	-	<ul style="list-style-type: none"> • “Getting to grips with the Cost Index” Issue II. May 1998. Flight Operations Support and Line Assistance. (Airbus). • “Getting to grips with Fuel Economy” Issue IV. October 2004. Flight Operations Support and Line Assistance. (Airbus). • “Getting to grips with Aircraft Performance”. January 2002. Flight Operations Support and Line Assistance. (Airbus). • “Getting to grips with Aircraft Performance Monitoring”. Flight Operations Support and Line Assistance. (Airbus). • Airline Fuel and Labour Cost Share. June 2007 (IATA). • Fuel Conservation Programme Presentation. May 2007 (IATA). • Fuel Efficiency Campaign Sept. 2006 (IATA).
Relevance	Talgo	Small.
Maturity	Talgo	Depending of the source.
Abstract	Talgo	Description of systems to efficiently control fuel consumption in

	Reviewer	Aircraft energy consumption best practises
		<p>aircrafts.</p> <p>The International Air Transport Association describes the best practices to minimize fuel consumption and emissions associated.</p> <p>The objective of the Flight Management System is to optimize fuel consumption and flight time.</p> <p>To minimize flight cost, the fuel cost and the cost derived from the flight time need to be reduced. A compromise is needed to determine the operational speed that achieves a balance between the fuel cost and the flight time.</p> <p>Most important factors that affect flight cost (and fuel consumption) are analysed and their effect on fuel consumption is described: the centre of gravity of the aircraft, number of motors turned on during ground operations and flaps' selection during taking on and landing, flying height, flying speed, selected route, carrying a surplus of fuel... Each flight phase is studied from the point of view of energy optimization. Costs related to flight time are described. Solutions to minimize aircraft weight are described.</p>
Useful findings	Talgo	Generic best practices to minimize energy consumption of aircrafts: optimization of ground operations such as avoiding having motors energized for too long before taking off and only having one motor on while moving on the ground (to prepare for take-off and after landing), using ground equipment for power supply and air conditioning during long stops and switching off air conditioning during take-off.
Shortcomings	Talgo	Application for railway industry.

4. ENERGY NORM PROPOSAL

The draft norm TS 50591 fulfills to the largest extent the requirements defined in chapter 2. Furthermore it already contains a structure and approach suitable for precise definition of boundary conditions for railway rolling stock energy considerations.

Therefore TS 50591 is recommended to be used as a basis for developing a future energy norm by enhancements of its content. Recommendations for this are given in the next chapter.

5. IDENTIFIED GAPS OF TS 50591

5.1 CORRECTION/AMENDMENT PROPOSAL

After reviewing TS 50591 some inconsistencies have been found throughout the text, as well as minor suggestions, for which amendments are presented below:

- Chapter 5.5: Location and length [m] of each tunnel along the selected route or reference track (ID I06). But Table A1 of Annex 1 specifies km for giving I06 “The exact locations and lengths of all tunnels along the selected route or reference track”. Same unit shall be in both places; suggestion to use [m].
- Chapter 6.2.3: Payload is indicated to be given in kg, while in Table A.3 of Annex A, parameters S04 and S05 are indicated in tons. Same unit shall be in both places; suggestion to use [kg].
- No clear accuracy in timetable verification:
 - Chapter 7.2.2 states that the precision for simulation is +- 0s.
 - Chapter 8.3 states that for timetable verification +-5 s is accepted.
 - Chapter 8.6 f) states that travel times for test performance shall reach 7.2.2 precision, which seems unrealistic. The precision shall be the same as 8.3 (test phase and no simulation).
 - Chapter 9.3 states that no post processing for deviations in travel times are allowed, except for extraordinary standstill times in freight services. The test shall be planned and carried out in a way that the tolerances specified in 7.2.2 can be met. The precision shall be at least the same as 8.3.
 - Standstill times can be corrected within the limits specified in 7.2.2 without further detailed analysis. Larger corrections can be tolerated, if an analysis shows that the train is still in sufficiently steady state thermal conditions during the next running phase.

5.2 GAP CLOSING PROPOSAL

To obtain an energy norm that covers all necessary aspects for energy simulations, measurements and saving potential studies useful findings and shortcomings documented in chapter 3 are summarized and reformulated into statements of gaps in TS 50591. Gaps and closing proposals are listed in Table 11.

Table 11: Gaps of TS 50591 and closing proposals

Chapter	Gap (The norm should ...)	Gap closing proposal
4	Provide / highlight the importance of repeatable boundary conditions	In chapter 4 "General" the importance of repeatable boundary conditions and the same boundary conditions in simulation and verification shall be highlighted narratively.
6	Advice how to deal with uncertainty of wind speed measurement	Add in chapter 6 the following recommendations concerning wind speed: <ul style="list-style-type: none"> • Train runs for measurement in different directions with wind speeds not exceeding 4 km/h (to be confirmed by EN 14067 working group 6)

Chapter	Gap (The norm should ...)	Gap closing proposal
		<ul style="list-style-type: none"> Evaluate meteorological data from points along track (as a measure of quality of the verification results)
6.2.3 and 7.2.3	Give a guideline on which load case (payload) has to be to use for determination of energy consumption	<p>Guideline according to chapters 6.2.3 and 7.2.3 (Payload):</p> <p>Recommend to calculate with a certain number of seats occupied depending on the service category. The values will be selected within work package 8.2 (current recommendation in TS 50591 will be revised to have considered values more realistically)</p>
6.2.4	Account both all-out mode and run according to schedule	In addition to the item concerning Annex A an all-out run shall be recommended to compare driving performance in chapter 6.2.4 in a new paragraph.
6.2.5	Recommend line receptivity for regenerative braking	<p>Guideline for regenerative braking according to chapter 6.2.5:</p> <ul style="list-style-type: none"> For AC lines braking with max. line current 2 different simulation runs for DC line with total recuperation and zero recuperation into the line Recommended addition to TS 50591: prediction of the average line receptivity by means of an availability factor of recuperation into the line (definition of the factor in Annex A.2). During measurements the energy dissipated in the brake resistor is measured as well to readjust measurement results to another receptivity factor. The factor will be proposed in WP 8.2.
6.4 and Annex A.5	Consider the same temperatures as EN 13129 for HVAC (air conditioning tests)	For ambient temperature (chapter 6.4 and Annex A.5) reference to EN 13129-1
8	Define which physical quantities to measure	<p>In chapter 8 "Verification" the following measured quantities shall be listed:</p> <ul style="list-style-type: none"> Line voltage Line current

Chapter	Gap (The norm should ...)	Gap closing proposal
		<ul style="list-style-type: none"> • Line active power • Traction power • Comfort systems energy • Fuel volume at begin and end (for diesel rail vehicles) • Energy storage charge status at begin and end • Energy storage power • Brake resistor power • Onboard network battery charging power • Speed • Time • Exterior temperature • Wind speed & direction • Payload (passenger or freight) • Stopping time with doors open
8	Explain different simulation / measurement methodologies including their applicability (e.g. Consumption of one train run, Annual consumption)	<p>In chapter 8 "Verification" different verification methods should be explained and benchmarked / recommended with respect to accuracy and applicability:</p> <ul style="list-style-type: none"> • Test train runs on special test tracks with the service profile defined in Annex B, if the test track allows maximum speed of service profile • Test train runs on a real line • Regular train runs on a real line (revenue service) • Simulation according to service profiles from annex B with measured characteristics of modules (e.g. losses of traction system depending on force and speed) • Verification of energy consumption of comfort systems (heating, cooling, lighting) -> EN

Chapter	Gap (The norm should ...)	Gap closing proposal
		<p>13129</p> <ul style="list-style-type: none"> • Verification of energy consumption in parked mode
8	Define the charge status of energy storage / fuel volume at beginning (if applicable also at the end) of a train run	<p>Additional recommendations for performance of tests (chapter 8):</p> <p>Measurement of fuel level and battery charge status at the beginning and at the end of the train run</p>
Annex A	<p>Consider the following input data:</p> <ul style="list-style-type: none"> • Infrastructure • Driving style (to level of detail like “schedule mode” or “all-out mode”) • Train model 	<p>Additional physical simulation parameters shall be defined in Annex A:</p> <ul style="list-style-type: none"> • Line current limit (Annex A.2) • Rolling stock parameters within a new Annex A.7 (weight, max. speed, payload, driving resistance curves, traction and braking force curves, efficiency curves of traction modules, door opening times...)
Annex B	<p>Take into account the following train / operation types:</p> <ul style="list-style-type: none"> • Light rail vehicle (Tram) • Metro • Suburban (Commuter) • Freight • Regional • Intercity • High speed 	<p>In annex B the track data and schedules with 5 ... 10 % time reserve, which will be part of the result of Roll2Rail work package 8.2, shall be added. The schedule times in annex B shall be checked and respectively revised whether there is enough time given so that the train does not have to run in all-out mode to achieve the scheduled time.</p>
Annex C	Include reference scenarios with input data and reference results for tool validation	<p>A new annex C shall be created with reference scenarios including input data and reference simulation results / measurement results for tool validation. The scenarios shall be defined for all train / operation types listed above and shall be taken over from Roll2Rail work package 8.2 result.</p>

6. APPLICATION GUIDE

For the energy saving potential quantification that shall be shown in ITDs (Integrated Technical Demonstrators) and STDs (System Platform Demonstrators) the following points should be used as an application guide. Because TS 50591 is the only norm which is valued applicable for usage in ITDs and SPDs it is not necessary to explain which excerpts of other norms shall be combined.

For quantification and demonstration of energy saving potentials the actions below should be executed:

- Refer to TS 50591
- Use reference data for the respective operation profile (regional, high speed etc.) mentioned in Table 11, use also the revised recommendations for payload and schedule
- Use a methodology (e.g. simulation, measurement) recommended in Table 11
- For simulations use a tool that is validated against the expected results from reference cases mentioned in Table 11
- Refer to other items from gap list (Table 11) which are not highlighted in this application guide as well

7. CONCLUSION

In the course of task 8.1 of Roll2Rail TS 50591 has been chosen as the most suitable norm for railway rolling stock energy considerations. For those aspects which should be included or revised, gaps are identified and gap closing proposals are prepared. Other norms found in the database search are presented as well.

The application guide presents the way forward that should be used for energy saving potential calculation as well as experimental demonstration within the projects Roll2Rail and Shift2Rail.