ECORailS:
Energy efficiency and environmental criteria in the awarding of regional rail transport vehicles and services

Additional recommendations for the inclusion of relevant technologies and operational measures in the awarding documents

resulting in a reduction of consumption, harmful emissions and life cycle costs of rolling stock and rail services

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0. Introduction

Within ECORailS project, 83 technologies have been identified (see *Annex 7 - 83 Technologies and operational measures*) whose application can result in the reduction of rolling stock- or rail transport services- related costs, consumptions, and emissions, respectively.
These technologies were exhaustively dealt with, from various points of view, in deliverables *D7 - Integration of technological feedback from the User Platform and the consortium into the guidelines* and *D10 - Integration of legal and economical feedback from the User Platform and the consortium into the guidelines,* as well as in the *D22 – Guidelines*.
Based on this, as well as on the tests performed, the present Annex aims at making a brief survey of some of the most applied or recommended technologies in order to provide examples or tips to those who are to elaborate the awarding documentation by applying ECORailS principles.
Further technologies, out of those selected in *Annex 7 – 83 Technologies and Operational Measures*, or other technologies can be similarly introduced into the awarding documentation as well.

The examples and recommendations in the present annex show various modalities of fostering those offers providing the most competitive solutions (also) for reducing consumptions, harmful missions and LCC.
These objectives are essential to transport sustainable development in keeping with the European Union strategies and policies (see Directive 2009/33/CE, 2004/26/EC - NRMM, 2006/66/EC - TSI Noise), Directive 2002/49/EC, UIC 345/2006, UIC330, etc).
At the same time, the examples and recommendations in this annex are in strict compliance with the basic principles in the awarding procedures (they should allow for free and equal access, they should not limit competition, they should be transparent, they should use efficiently the public funds) as per EU Directives 2004/17/EC and 2004/18/EC.

Mainly, the examples and recommendations in this annex will not bring about any delays in the delivery deadlines, nor considerable rises in the procurement costs; on the contrary, they will stimulate the rolling stock suppliers and end users to develop permanent policies meant to cut down on consumptions, emissions and LCC.

According to the new procedure, there will be specified the main terms and objectives aimed at by the end user, while the tenderer is free to come up with the technical concepts and solutions in order to best meet them.
Based on these procedures, there will be certain mandatory (or minimal) technical terms, while for the rest, the tenderer will be required to propose the version considered optimum, for which – through a description and by filling in the required forms – he is to define and advocate the advantages of the solutions proposed through the Specifications or as compared to a standard version) based on the following criteria (from now on referred to as “eco criteria”):

- Difference in terms of energy consumption during service [kWh, kWh/Skm, kWh/pkm]. The indicators are to be used according to the acquisition type (kWh – for locomotives, kWh/Skm – for multiple units, and kWh/pkm – for services)
- Differences in terms of harmful emissions levels [Emissions: g CO2 /pkm, g NOx /pkm, Noise etc.]
- Life Cycle Costs (LCC). For rolling stock, life cycle can be considered 30-40 years
- Technical advantages or advantages in terms of utilization (as well as the modality in which they influence the values above)
- Advantages in terms of fiability and reliability in service

- The difference in price (if any) an optional version (equipment / technology etc.) is likely to induce in the total purchase price as compared to the tenderer's standard version.

The awarding documentation shall include standardized forms which are to impose a unitary drafting style for the main data to be specified by the tenderer, as well as the modality in which these data will be test proven (production tests, acceptance tests at the supplier's, tests on a test line as specified by the end user and throughout the service life, respectively).

The parameters to be taken into consideration when evaluating the offers, as well as the modality of scoring the offer according to the parameters provided, shall be also specified. In the contract model in the awarding documentation there shall be specified that the tenderer shall bear full responsibility for the data provided in his offer, except for those cases in which the blame for failure to meet some of the parameters specified lies with the end user, as a result of his not having complied with certain operation- and maintenance instructions.

In what follows, the technologies / solutions to be required and evaluated within the awarding procedure will be described separately (in order to point out the specific elements), even if some of them overlap or influence one other.

In what follows, several technologies which are similarly dealt with were sometimes cumulated.

The elaboration example was primarily made for an awarding documentation for Diesel Multimple Units – DMUs (in order to include more technologies); the specifications can be useful also for documentations that provide for other types of rolling stock or railway services.

1. Rolling stock selection

Note: The main decision to start from in elaborating an awarding documentation refers to selecting and defining the rolling stock type. Implicitly, it will play a major role (also) in terms of costs, consumptions and harmful emissions. The recommendations / examples under this chapter have a more general character, while the provisions under the following chapters will provide the necessary completions to them.

The recommended rolling stock for regional passenger transport are multiple unit trains (Multiple Unit - MU) – namely electrical multiple units (EMU) for electrified routes, diesel multiple-unit trains (DMU) for non-electrified lines, or mixed electrical-diesel traction vehicles for highly circulated routes including both electrified- and non electrified sections.
Main advantages of MUs: variable configurations according to the traffic requirements, low axle load, low energy consumption and low emissions, higher accelerations at start-up / braking, higher fiability etc.
The general solutions proposed by the tenderer, considerably influence fuel consumptions, harmful emissions and operation costs.

1.1. Recommendations for inclusion into the awarding documentation:

a) The conditions for rolling stock service and testing shall be described according to *Annex 1 – Technical Parameters*.

b) The maximum, minimum and average number of passengers in service, as well as the basic necessary requirements (maximum speed, maximum acceleration, maximum deceleration at normal and emergency braking) shall be specified.

c) General conditions: the offer shall confirm compliance with the latest norms / recommendations referring to passengers' present requirements (comfort, design, ergonomy etc.), ECORailS criteria , operation prescriptions, the end user's trade objectives, traffic safety , fire prevention, passengers' safety, interoperability, use of allowed materials, ecologic and ergonomic design, facilities for disfavoured /disabled / low-mobility people etc., and shall describe the actual modality in which these requirements have been complied with, according to edge-cutting technology.

d) General conditions referring to comfort and traffic safety shall be specified

e) The main technical characteristics of the rolling stock supplied shall be centralized in a standard form to be filled in by the offerer. These parameters shall be proved against tests.
We are showing, in *Annex 2 – DMU Technical Characteristics*, an example for such a form recommended for a DMU.

f) The Specifications, through *Annex 1 – Technical Parameters* and further details, as well as through a reference to standards, shall specify the conditions and modality for data testing and measuring / checking.

g) The awarding documentation shall specify the parameters to be evaluated when comparing the offers, as well as the modality of scoring the data supplied for each of these parameters.

h) The contract form from the awarding documentation shall specify the tenderer's liability for the compliance with the data provided and the sanctions to be applied if these data are not proven by the tests.

1.2. Conclusions

- It is essential that the awarding documentation should not impose detailed solutions, but rather foresee requirements conducive of meeting the mandatory technical performances, as well as concrete requirements as to low consumptions and harmful emissions and minimum costs throughout the service life (LCC).
- „Rolling stock selection" can bring about considerable reductions in consumptions, harmful emissions, LCC, particularly by stimulating the tenderers to provide optimum solutions in order to:
  - Reduce the overall weight and the weight as related to the number of seats
  - Possibly configure the train in connection with the number of passengers as foreseen in various circumstances
  - Apply certain design and construction solutions able to lower consumptions (streamlined profile, thermal- and sound insulation, ventilation modality, lighting, control optimization etc.)
  - Selection of the main equipment based on the requirements leading to the vehicle best performances, inclusively from the point of view of these eco criteria.
- The technical sheets filled in by the tenderers (see also the example recommended in *Annex 2 – DMU Technical Characteristics*) shall have to be proven against the tests to be performed , as well as allow for the offers to be easily compared with one another and basically evaluated based on the criteria set up in the awarding documentation.

2. Selection of Diesel engine / Power Pack

2.1. Recommendations for inclusion into the awarding documentation.

According to the awarding documentation, the offer shall prove that the engine si properly selected so as to best meet the technical- and fiability requirements, as well as the lowest values in terms of:

- Fuel- and oil consumption
- Emissions in keeping with stage IIIB as per EU Directive 2004/26/EC – NRMM, UIC 330, UIC 345, UIC 624, etc.
- Noise level – as per EU Directives: 2006/66/EC (TSI Noise), 2002/49/EC, 2001/16/EC, 2005/735/EC, ISO 9613-2, C(2004) 1558

- Life Cycle Costs (LCC) – Directive 2009/33/CE, etc.
- Start-up capability at low temperatures and protection at low temperatures
- Higher fiability indicators resulted from similar applications.

The engine- specific documentation shall include the technical characteristics (test proven), the optimum consumption diagrams, the list of documentation to be supplied (the Engine Book, Operation- and Maintenance Instructions, Service Manual, Test Bulletins, diagnose- and maintenance software, List of consumable and wear parts, Spare Parts Catalogue, references from actual etc.) as well as any other documentations which may contribute to a higher appreciation of the offer and, consequently, to a better and more efficient operation and maintenance. The offer shall also refer to the related equipment items and installations (transmissions, cooling, start-up, parking mode, diagnose etc.).

In addition to the above, the Tenderer shall also fill in:

- Technical Data Sheet – as per *Annex 2 – DMU Technical Characteristics* – for technical characteristics
- Technical Data Sheet for the diesel engine / power pack LCC. Based on it, the technical data sheet shall be filled in according to the example in *Annex 5 – LCC* for overall costs throughout the vehicle service life. The requirement for a separate LCC Data Sheet for the diesel engine is accounted for by the fact that, within the vehicle, it is the diesel engine that requires the most complex operation and maintenance activity, which will entail, alongside fuel consumption, the main share in the vehicle LCC.

Mention can be made that innovative technical solutions can be provided with a view to an optimum performance related to the above requirements, if the criteria and demands under the awarding documentation are thus met.
Among the innovative solutions which could be provided or required, we mention as follows:

a) Non-conventional fuel diesel engines??
b) Application of the GenSet concept, namely equipping with several diesel engine / generator sets. The number of engines and the operation regimes shall be best adjusted according to the output necessary to meet the vehicle loading conditions, making it possible for a considerable reduction in fuel consumptions (even over 50% and still higher as far as emissions are concerned), wears etc. The control system shall allow coupling / uncoupling and operation time monitoring at any time. Thus, a reduction / optimization can be achieved with maintenance operations, wear parts etc. (cost reductions down to 35%). Moreover, the system ensures spectacular increases in the traction force as a result of a better adherence (even over 50%).
   The system is applicable to diesel electric locomotives, and the decision as to its actual application shall be reached by comparing its important benefits and savings it entails in service to the extra procurement costs.

The specifications and considerations under the present chapter are applicable, in principle, to the awarding documentation referring to both new vehicles, and to the refurbishment of vehicles involving repowering.

2.2. Conclusions

The drafting of the diesel engine- related requirements is very important, as the selection of a particular diesel engine can entail considerable reductions in consumptions, harmful emissions and LCC as a result of its optimum dimensioning and of the design and construction solutions.

The diesel engine-to-vehicle design correlation, as well as an evaluated concept of unitary management for overall LCC monitoring and optimization are determining factors of major importance.

Considering the above, the mandatory engine- related technical data shall be generally required (maximum consumptions, harmful emissions, noise level etc.), but the offers shall be

evaluated mainly based on general vehicle parameters (see para 1) which will include the engine characteristics, while also correlated with other parameters, so that the evaluation may best possibly mirror the benefits with the vehicle actual service.

So, when evaluating the offers, no score points shall be awarded for a particular technical solution, as edge-cutting as it may be, but for its effect upon the vehicle performance, as evaluated by comparing the consumptions, harmful emissions and LCC.

3. Regenerative braking solutions

3.1. Recommendations for inclusion into the awarding documentation

- Regenerative braking shall be dimensioned according to the rolling stock operation- and testing conditions, as per *Annex 1 – Technical Parameters*.

- If there are routes featuring long distances with downhill running, it will be generally required to brake a maximum load DMU on a maximum- declivity downhill. The technical parameters, as well as the operation condition, efficient and excess heating- free, shall be specified in the offer. The data in the technical data sheet shall be proven during the acceptance tests along a representative test track, according to *Annex 3 – Diesel Engine.*

- **Regenerative braking and re-using of the regenerated energy for the auxiliaries supply**
  The extent to which regeneration can be achieved (in % and in kWh, respectively), as well as the modality in which the regenerated energy can be used, shall be specified in the offer. The data in the technical sheet shall be proven during the acceptance tests.
  According to the clarifications required in the Specifications and in the Technical Data Sheet (as per the pattern shown in Annex 4 – Brake) and in the LCC Data Sheet (as per the pattern shown in Annex 5 - LCC), a comparison can be made among the offers, as well as between the ratio investments + maintenance costs to the benefits related to lower consumptions, harmful emissions (generally, it can be estimated that a 2-5 % energy and emissions economy can be reached).
  According to that, this option shall or shall not be foreseen at contract concluding.
  The technology is already proven and supplied by several suppliers, therefore we can presume there will not be any high extra costs, the deadline will remain the same, and there will be no impediments in operation and maintenance.

- **Braking with energy storing and re-using for the next DMU start-up**
  Energy shall be stored in DMU- fitted supercapacitors.
  The following shall be specified: whether this optional requirement will be provided, the design solutions, the degree of regeneration which may be reached (in % and in kWh, respectively), as well as the modality in which the regenerated energy can be re-used.
  The characteristics of the storage devices (volume, weight, location, operations and extra costs – procurement, maintenance, life cycle costs ets.) shall be also specified.
  The data in the technical sheet shall be proven during the acceptance tests.
  It is a relatively new technology which may have some drawbacks related to extra procurement costs, the supercapacitors volume, the technical solutions for diesel traction. In exchange, the energy saving may be quite remarkable (up to 35%), it may feature a better behaviour in actual service than batteries (10 – 12 years' service life, good efficiency, low maintenance, low toxicity etc.)
  According to the clarifications required in the Specifications and in the Technical Data Sheet (as per the pattern shown in Annex 4 – Brake) and in the LCC Data Sheet (as per the pattern shown in *Annex 5 -LCC*), a comparison can be made among the offers, as well as between the ratio investments-maintenance costs to the benefits related to lower consumptions, harmful emissions, etc.
  According to that, this option shall or shall not be foreseen at contract concluding.

The technologies are already proven and supplied by several suppliers, therefore we can presume there will not be any high extra costs, the deadline will remain the same, and there will be no impediments in operation and maintenance.

3.2. Conclusions

- The regenerative braking solutions may entail considerable reductions in fuel consumption / electric energy, harmful emissions, as well as in the life cycle costs (lower wears at braking etc.).
- The filling in of a technical data sheet similar to the pattern recommended in *Annex 4 – Braking*, alongside the technical tendering documentation will provide the necessary data for the evaluation of the offers and the technical solutions.
- The technical data sheets *Annex 1 – Technical Parameters* and *Annex 4 – Brake*, will allow for a comparison among the offers and for checking the technical performances during the acceptance test on the test track.

  According to the clarifications required in the Specifications and in the Technical Data Sheet (as per the pattern shown in *Annex 4 – Brake*) and in the LCC Data Sheet (as per the pattern shown in *Annex 5 - LCC*), a comparison can be made among the offers, as well as between the ratio investments-maintenance costs to the benefits related to lower consumptions, harmful emissions and life cycle costs.
  According to that, these options of regenerative braking shall or shall not be foreseen at contract concluding, and the comparison among the offers will be possible
  The technologies are already verified and supplied by more than one supplier, so we can estimate that there won't be any supplementary costs, the supply term will remain the same, and there won't be any impediments during exploitation and maintenance.

4. Fuel / energy consumption measuring- and recording system

4.1. Recommendations for the inclusion in the awarding documentation

- The system shall allow for total fuel consumption measuring, by measuring both the level in the tank, and the flow.
- The energy- intended system (locomotives / electrical multiple units) shall measure and record the energy consumption as received from the supply system. The same system shall also record the regenerated energy which is transferred from the vehicle to the supply system..
- Data recording shall be in correlation with the date and the moment of the consumption as well as with other related parameters (diesel engine speed / traction force, vehicle speed, auxiliaries consumptions (besides traction ones), exaggerated- or random consumptions warning etc.
- The system shall comply with the provisions under EN 50483-2 clause 2, homologated for rolling stock and metrologically certified.
- The system shall be vandalism- and mistuning-proof
- The system shall be able to communicate with the Train Control and Monitoring System (TCMS) centralized system in order to allow for data collecting and display, as well as for driver assistance.
- There shall be the possibility of transferring the recorded data so that they may be further taken over and analysed through the maintenance software (depot) either by real-time transmission (on line), or by taking over on a stick or a memory card only by an authorized operator.

4.2. Conclusions

- The fuel- or energy consumption measuring and recording system does not directly entail energy savings, yet consumption monitoring allows for their analysis in order to spot exaggerated consumptions (leaks, theft, unaccounted for consumptions, faults etc.) as well as to follow up the effects of all the other methods intended to reduce and optimize consumptions etc.
- Following the analyses above – to be made by a specialized diagnose- and maintenance software – failures, inadequate tunings, cases of carelessness etc. can be spotted out, and the necessary correction / remedy / optimization steps can be taken accordingly .
- The above data can be directly correlated with the responsibles for these consumptions (the driver, the mechanic in charge of performing and checking the adjustments, the mechanics in charge of maintenance etc), while also automatically setting up the incentive measures (penalties / awards).
- The fuel- and energy consumption measuring and recording systems have been applied on rolling stock for over 20 years, and in some countries, they are applied on all the locomotives / electric- or diesel multiple units in service. These systems need not be subject to an international standardization, yet they should be homologated with the vehicle end user and with the railway authority. A metrological authorization is also necessary, according to the local legislation and regulations.
- Consequently, we consider that equipping the new vehicles or the vehicles subject to a modernization process with fuel- or energy consumption measuring and recording system is not only a recommendation, but it should become imposed under the awarding documentation.

5. Train Control and Management System (TCMS)

5.1. Recommendations for the inclusion into the awarding documentation

- DMU shall be equipped with a TCMS system with dynamic self-configuration according to the train (variable) composition, allowing for train coupling / uncoupling and multiple control.
- The tendering documentation shall meet the requirements under paragraph 0 and the provisions in the awarding documentation.
- The informatic system shall be developed by a supplier specialized in equipment and software intended for operation on rolling stock, in strict compliance with the efficiency-safety- and interoperability norms under the directives and normatives currently in force. It shall be specified the compliance with the interoperability prescriptions according to the Commission's Decision 2006/679/CE and to the other technical requirements, as per UIC 612 and other specific norms.
- TCMS shall achieve the interface with the driver, train crew and service personnel. The buttons, switches, indicators and other equipment items on the driver's desk shall be connected to the TCMS. The TCMS shall translate the operator's actions into control signals to various systems and report back to the operator by means of the indicators.

The requirements referring to the TCMS informatic system may be classified into several categories according to the objectives met, namely:

a) Informatic system for passenger information and communication to passenger cabs.

b) Driving informatic system
The informatic system shall perform the following main functions:
   - Communicate with the other controllers in the configuration of the various equipment items (diesel engine, electrical transmission, fuel consumption measuring and

recording system, transducers etc.), in order to take over and monitor the data of interest necessary for commands, decision making / display / depot data base

- With multiple control, it shall control and monitor both its own and the other units.
- In emergency cases or with abnormal operation, action shall be taken in real time in order to command the protections and take the necessary steps so that the travel may be continued under a running regime as adapted to the new circumstances.
- Moreover, command shall be given for having the information on the respective failure, the protections and the new operation regime, displayed. If necessary, or on demand, further instructions may be displayed as well.
- All the protections controlled (wheel slip /- skid control, over-temperatures etc.) shall operate so as to allow for the travel to be continued at the best possible parameters considering the situation arisen
- Control the display on the screen in the driving post, of the information necessary for the drive of the own- and the control unit, as well as for conveying the messages referring to failures, also allowing for the check up of certain parameters, on demand. The displays shall be visible, synthetic and suggestive in order to assist the driver with driving and decision making, yet without providing unimportant information which may divert his attention.
- Provide helpful indications for an optimum driving in terms of fuel / energy consumption.
- Store all the data characteristic of a running „session", as correlated with the data from the DMU driver and the related necessary ones (date, time, train composition, temperatures, route, occupancy level, location, engine speed / traction force, speed etc.)
- The start of the "session" shall be marked by inserting the DMU driver- related data (by inserting a personal card or by keying in a code on the display etc.)
- In the main, the stored data are recorded on a working storage, a long-duration memory and an event memory (this latter cyclically recording the data characteristic of safe running).
  The recorded data serve (also) as documents if an accident / event is to be analysed, therefore they cannot be deleted / modified, shall be complete and feature the degree of accuracy required for all the values measured.
- The TCMS data shall be periodically taken over by an authorized operator on a stick or personal memory card.
  These data will be taken over only by the authorized operator and will be recorded on his identification code.
- On demand, or as an optional solution, the on-board controller shall convey all the necessary data to a control centre in real time. In this case, the same communication system may be also applied for the communication among DMU units or for multiple control.
- The data for the maintenance software shall be provided through a protocol agreed upon which may allow for the data provided to be read and interpreted.
- The Tenderer shall specify the facilities he is to provide: licence, documentation, training, parameters –the sections for which the end-user may make certain modifications / adjustments etc.
- Specific requirements related to costs- and emissions reduction in operation
- Requirements for a friendly software to be further improvable in service, inclusively for the technical assistance necessary to the end user (documentation, training, assistance in case of emergency, collaboration throughout operation etc.).

c) Systems for equipment operation – and safety optimization and control
   - train safety systems (Dead man, Indusi, ATP, ETCS, ERTMS, APC etc.). The train safety and control system shall be required according to the national- and EU strategy referring to the safety and interoperability conditions, as defined in Directive 2008/57/EC, UIC 612-1 etc.)

d) Equipment control systems (auxiliaries, door controls, lavatories, batteries, lighting, ventilation, air conditioning, smoke- and fire detection etc.)

5.2. Conclusions

- The technical facilities provided by a Train Control and Management System (TCMS) as well as the benefits it entails are so important that rolling stock not being fitted with highly performing customized equipment can no longer be thought of.

  It is necessary that the end user should be able to make best direct use of the unlimited technical facilities a high performance informatic system provides in order to facilitate the operation- and maintenance activities, inclusively consumption- and LCC monitoring and optimization. The supplier is generally interested that the TCMS system should ensure the vehicle operation, and express requirements are necessary for the system to provide the end user such a considerable assistance.

- The above principles and the requirements under the Specifications have a tremendous potential in reducing operation- and maintenance costs. That will depend in a decisive way on:
  - the modality of setting forth the requirements addressed to the developer
  - the modality of meeting these requirements and the correlation between TCMS and the maintenance software
  - the end user's actual and permanent involvement in exploiting this potential (with possible support / assistance from the producer).

- To the extent to which the above conditions are met and according to the statistics and tests conducted, a reduction of more than 20% in the operation- and maintenance costs, as compared to the present figures, may be easily registered.

6. Maintenance- and Diagnose Software (depot)

6.1. Recommendations for inclusion in the awarding documentation

- The maintenance software shall be fitted in the user's PC network, make up a data base taken over from each on-board controller, and process all these data in order to:
  - Provide the diagnose data and statistics (failures, operating times and conditions, wear condition, failure to operate within the prescribed parameters etc.) for the multiple unit train and the main equipment in its units. The software shall also provide the necessary related prescriptions (checks, remedies, adjustments, parts replacements, consumables etc.).
  - Provide data and statistics related to the driving modality and to consumptions (for traction and the other consumptions, respectively), operation regimes etc.
  - The statistics shall include all the data base for all the vehicles in service; however, statistics selected according to various criteria (over a time period, a certain route), comparisons between DMUs and equipment items of the same type, or between consumptions (in terms of time periods, drivers, routes etc.), information aimed at the operation or maintenance, Life Cycle Costs (LCC), diagnose etc. can be also provided.
  - The statistics can be automatically sent, or interconnected to other data bases, at various levels: to inform the managing board, to decide on the necessary maintenance measures and have them taken, to reward / penalize the drivers according to the compliance with the economic- and safety criteria etc.

6.2. Conclusions

- The maintenance software is a modern requirement compulsory in order to allow for optimized efficient operation and maintenance, with important economic effects in terms of reliability in service.
- Considering this software complexity and the must of having it best correlated with the specific operation modality, it can be developed by a manufacturer specialized in such software types. In this case, this software may be required only optionally, yet the DMU supplier shall have to necessarily specify his availability to correlate / adapt the TCMS software to the requirements of the end user and of the maintenance software.
- In the concept described, the TCMS system is not only a system working out DMU driving- related technical issues, but – alongside with the maintenance software – it becomes a complete informatic system, in support of the end user's requirements, similar to a management informatic system of EPR type (Enterprise Resource Planning) applied in enterprises for management and costs reduction.
- Without a management to follow up the actual contribution of this complete system, the other measures and technologies will not have the expected effect on reducing consumptions, harmful emissions and LCC.

7. Driver Assistance System

7.1. Recommendations for inclusion in the awarding documentation

- Driver Assistance System is a very important resource for fuel / energy savings.
- Driver assistance system shall feature a minimum number of accelerations, as long as possible a period of coasting (inertial running, traction- free) and regenerative braking .
- The supplier shall provide detailed instructions with a view to the driver assistance
- The drivers shall be trained accordingly
- TCMS will also include a software aimed at providing the driver the necessary assistance with a view to an economically optimized driving, while also observing the safety conditions and the fulfilment of running times. The supplier shall recommend as economical and efficient as possible a system (or versions) in order to meet this requirement.
- Besides the (optional) indications on the display, the fuel / energy consumption diagrams as well as the consumption saved through regenerative braking shall be necessarily recorded on the vehicle.
- According to the recorded data, the software shall store the consumption achieved by the mechanic, by calculating the deviations from the optimum consumption and (based on certain coefficients / user's prescriptions), the penalties or the bonuses achieved. The important driving errors may be also displayed.
- The offer shall include the system (or the variants) description, specifications on the system accuracy and efficiency, and shall also specify the extra costs as compared to the equipping version which does not feature this system.

7.2. Conclusions.

- Driver assistance system is a very important resource for fuel / energy savings (consumption may be reduced by more than 20% of the present consumption).
- As we are talking about considerable savings otherwise unnecessarily wasted, the driver assistance system is compulsory.
- The driver assistance system version shall be selected following an analysis of the offers in terms of the extra procurement costs and the system efficiency.

We appreciate that the key element lending uttermost importance and efficiency to a method – to be applied together with the other specified ones – is the monitoring of the energy consumptions and of energy savings to be reused, referring to each driver, and the bonuses / penalties to be applied according to the results got. All that can be recorded on the driver's card (or on a separate form) which should also include the technical data referring to the driving modality.

8. Optimization of the heating- air conditioning- ventilation system (HVAC). Lighting. Doors actuation.

8.1. Recommendations for the inclusion into the awarding documentation

- The offer documentation shall meet the end user's requirements and the prescriptions under all the specific normatives in force regulating comfort conditions (UIC 553–2003, EN 13129-1:2004, etc.).
- The tenderer shall make sure to provide optimum heat insulation (of the passenger coaches and the driver's cab, respectively), so that the consumptions necessary for air conditioning, heating and ventilation may be minimum.
  There shall also be intelligent monitoring- and optimizing systems, both to provide the necessary comfort, and to optimize the consumptions according to the outdoor temperature, indoor temperature, air draughts, humidity, air quality, cars / compartments without passengers etc.
- Each coach and cab shall be provided with an adequately dimensioned heating system, making use of the diesel engine residual heat and / or a self-sufficient heating unit.
- All the heating units shall be provided with thermostat devices, thus allowing for the operation in automatic regime, and shall be protected when the heating agent reaches the minimum/maximum level. A system shall be provided for temperature control in the compartments of the multiple-unit train coaches, as well as for pre-heating programming.
- The heating units shall ensure the minimal parameters or the comfort parameters both at running and at standstill.
- The ventilation of confined spaces shall be made according to the actual demand (the seating capacity). The ventilation equipment has to allow for power variation according to an occupancy indicator and the indoor air quality (IAQ) (the level of this quality). (For instance, demand-operated ventilation based on CO2 sensors).
- The traction motor ventilation as well as the other technological ventilations shall make maximum use of technical solutions based on natural ventilations (self-ventilated traction motors, power electronic on optimized copper radiators, centralized / joint ventilations etc.). Forced ventilation shall be gradually controlled and adjusted according to heating, their gradient, and demands (draughts and their evolution in operation etc.).
- Lighting shall meet the end user's requirements and the provisions under the specific normatives in force regulating the general- and local lighting conditions (UIC 555, SR EN 13272:2001, etc.).
- The tenderer shall use the most efficient lighting systems in terms of efficiency, sight protection conditions, fiability and service life, as well as of environmental quality prescriptions.
- Interior materials shall also be selected so as to enhance lighting quality and its necessary consumption through their quality, colour, index- and modality of refraction.
- The location and material of the windows shall be selected so as to provide optimum lighting volume and quality.
- There shall also be provided intelligent monitoring- and optimization systems, in order both to ensure the necessary comfort, and to optimize the consumptions according to

natural lighting, the necessity of general and local lighting as determined by the presence and number of passengers etc.

- Door actuation control. The door actuation system shall control – monitor door opening and closing so as to ensure safety and protection, while also reducing the compressed air- and energy consumption.

8.2. Conclusions

By properly applying the above measures, consumptions may be reduced by 20 through 60%, and in principle such measures – applied during design phase- imply low extra costs.

9. Control of comfort functions in parked trains

9.1. Recommendations for the inclusion into the awarding documentation

The offer shall also include a solution to monitor and optimize the consumptions for the train at standstill.

Basically, it shall ensure that the train at standstill should be supplied at optimum consumptions, according to the requirements (actual temperature at the parching place, local temperatures, light conditions etc.), according to the specific- and operation data in *Annex 1 – Technical Parameters* and in the rest of the awarding documentation.

Reducing and optimizing consumptions at stabling shall meet the following requirements:

a) Diesel engine heating – only if the diesel engine pre-heating is foreseen before starting and if there is a freezing risk, respectively (cooling agent without antifreeze solution). That applies only if temperature drops below the prescribed temperatures and only for strictly as long as it is necessary for adequate temperatures to be maintained.
b) Heating of train at standstill – to be controlled only at a temperature below the minimum admitted limits (required by certain equipment, or by the conditions necessary for the cleaning / maintenance operations).
Minimum operation times and local heating (where necessary) shall be provided.
c) Train pre-heating before travel – to be provided for a minimum time before passengers' boarding – only if necessary in order to provide the prescribed conditions.
d) Lighting of train at standstill – to be provided only if needed, for the necessary time and area.

- The system shall ensure the optimum consumptions according to the prescriptions and the sensors provided values.
- The system shall allow for the adjustment of certain temperature parameters according to the end user's prescriptions.
- The supplier shall provide the necessary instructions and instruments for an easy and operative maintenance and cleaning of the trains at standstill, by specifying the required times and the related consumptions.
- The system shall record the consumptions, according to consumer types, as well as the operating times, thus allowing the user to monitor and optimize services / consumptions.
- The supplier shall indicate the potential of the energy saving for trains at standstill, reached through constructive measures (e.g. diesel engine with antifreeze solution and cold start-up) which reduces the situations / times requiring consumptions at standstill and / or through the optimized consumption control system, and of operation periods.
- The variant of the system providing on-line data on the services carried out and consumptions shall also be required.

- The supplier may provide optional versions, describing the system, its component parts, the operation modality, the consumption for each function, the efficiency in reducing consumptions and related extra costs.

9.2. Conclusions

- By deciding on the best measures and by monitoring the services and the consumptions, considerable energy savings can be reached (over 5% of the total consumption).
- As the optimization systems can be very different, the system shall be selected based on a comparison of the extra investment costs and the resulting efficiency from the reduction of consumptions and of life cycle costs.

10. LCC- driven procurement (entire life cycle costs)

10.1. Description

„LCC increased role in railway- related procurement decision making is one of the key factors vouching for a successful rapid application of innovative technologies intended for energy efficiency. At the same time, having in view a focus on the whole company, not only on departments or smaller companies, the wider and wider spread of LCC- driven procurement procedures can bring an important contribution to cost efficiency. In this respect, the bonus regulations in the procurement contracts and / or a better check of the guarantees and provisions under the penalty clauses in case of failure to meet the respective guarantees are key success factors."

LCC for rail vehicles. *(Source: * Trümpi 1998 ** Ernst 2001).*

	Locomotives for passengers transport *	Shunting Locomotives *	High speed trains (ICE 3)**
Investment	22,7 %	11,7 %	80,8 %
Energy	46,2 %	73,8 %	7,8 %
Maintenance	31,0 %	14,4 %	11,4 %

10.2. Principles and examples for LCC requirements implementation into the procurement documentation.

- Operation conditions. It is necessary to specify the operation conditions to be taken into consideration for LCC calculation, such as annual service (number of travel hours and number of km), infrastructure conditions, climatic conditions, modality of operation / maintenance, stabling conditions, service life for LCC, the costs (present / average estimated) to be considered for electric power, fuel , labour etc.
- There shall be specified the parameters to be proven at the acceptance test and during the tests along a track considered as representative for the service at the end user's. The test track characteristics and the parameters necessary for LCC calculation shall be defined in an annex to the Specifications, elaborated based on the prescriptions under UNIFE/UIC no. TECREC 100_001:2010..
  Here attached is the proposed form – *Annex 1 – Technical Parameters*– for these operation data and the data referring to the test track (profile, declivities, restrictions etc.) and to the timetable.

10.3. Modality of offer drafting

- It shall be indicated the modality in which the Tenderers shall meet the requirements in the Specifications, in a unitary form, so that the offers may be easily compared to one another. There is no imposed on or standardized form of an LCC concept for rail vehicles; the format is adapted to the scope and requirements.
  In *Annex 5 - LCC* we have proposed a form for LCC Data which may be included into an awarding documentation. The form was elaborated under the awarding documentation for DMU (ECORailS tests in Timişoara), in compliance with the provisions shown in normative EN 60300-3-3:2005, Part 3-3: Application Guide. Life cycle cost evaluation, and respectively with the model of Table E1 - Annex E of this norm.
  As it may be seen, the form will allow for a comparison of the offers in terms of the procurement price, consumptions and maintenance costs throughout service life.
  The possible extra costs for the procurement of a technology, as well as the benefits (in terms of costs) it entails, shall be also derived based on the form.
- The Tenderers shall specify the documentation they will supply, with a view to a proper implementation of their own concept of operation and maintenance, leading to minimum LCC.
- In compliance with these prescriptions and of the other instructions in the supplier's documentations, the costs specified in LCC + Data Sheet as per *Annex 5 – LCC*, shall correspond to the actual operation costs.
- An optional offer may be required, through which the suppliers shall bind themselves to provide maintenance or management / assistance for the delivered products, in order to have the maintenance concept properly applied in keeping with the minimum foreseen prices.

10.4. Principles and examples referring to the modality of checking LCC offers.

- Besides the LCC Technical Data Sheet, the offers shall also include documents / documentations / references / explanations necessary in order to back up / account for the data in the technical sheet and the innovative solutions proposed as well as prove their efficiency in reducing consumptions and LCC.
- The consumptions shall be checked by measurements (during the acceptance tests and the tests on the test track – as defined in the procurement documentation and *Annex 1 – Technical Parameters*). Both the consumptions in normal operation and their reduction following the application of various technologies (regenerative braking, driver assistance system, systems of reducing consumptions in service / at standstill etc.).
- The checks and measurements shall be performed according to the Specifications, the recommendations in UNIFE/UIC TecRec 100_001:2010, EN50463 and in other specific normatives.
- The other costs in the LCC Data Sheet (spares / wear parts, foreseen maintenance, overhauls etc.) shall be checked in the long run, during the guarantee period and throughout the service life, respectively.

10.5. Modalities of offer evaluation

The procurement data sheet shall clearly and unequivocally include the criteria and modalities for evaluating and scoring the offers. Only those offers having met the minimal mandatory conditions shall be evaluated. The LCC Data Sheet can be considered as providing complete information on all the costs (investment, consumptions, maintenance etc.). Consequently, the LCC Data Sheet shall play a very important role in evaluating the offers.
We are suggesting in what follows several examples of evaluation, leaving it for PTAs / TOCs to decide on the actual drafting in the Procurement Data Sheet:

a) the decision shall be based only on the LCC Data Sheet, therefore the winning offer shall feature the lowest LCC.
b) only the first ….. offers featuring the lowest LCC shall be selected, or there shall be selected only the offers with costs by maximum …….% higher that the minimum cost offered. In these cases, the offer on the first place will be awarded 80 score points, for instance, while the rest of the offers will get a lower score by the percentage by which they exceed the minimum cost. Maximum 20 score points (for instance) shall be added to the final evaluation, in a differentiated way, according to the extent to which other criteria to be foreseen in the Procurement Data Sheet are met.
c) According to the above table „LCC for rail vehicles – passengers transport ”+ point 10.1. the score awarded can be: 100 points, proportionally with the statistic percentages in the table (approx. 25 points for the minimum acquisition price, 45 points for minimum consumptions and 30 points for minimum maintenance costs). The other offers shall get lower scores, proportionally with the percentage by which the minimum threshold at each of the 3 criteria is exceeded).
d) If, through calculations, or other evaluations, o share of the various technologies or criteria can be estimated, there can be foreseen an evaluation modality as based on these shares. Please find here attached an example of evaluation as proposed based on the calculations, simulations and analyses conducted during the ECORailS Timişoara test (*Annex 6 – Example of point rating grid*).

10.6. Contract conclusion

The Contract Form is part of the procurement documentation and will be known to the tenderers the moment the call for proposals is released. According to the tender calendar, there will be a period of time in which questions or intimations referring to the possible inadvertencies etc. may be submitted. After all these claims have been dealt with and possible modifications have been made in the procurement documentation, inclusively in the contract form, the documentation becomes binding for all the participants in the tender. The contract form shall foresee:

a) The modality in which the data in the offer shall be proven against the acceptance tests at the supplier's, the tests on the test track at the tenderer's, the checks during the guarantee period, and checks throughout the service life.
b) The tenderer's liability for the data in the offer, based on which the offer was declared winning, and the sanctions (loss / shortening of the guarantee period, penalties etc.), respectively, in case the checks show non compliance with certain data.
c) Bonus / malus awarded when certain data (particularly referring to consumptions / costs) are proven to be reduced or exceeded during the tests or in current service.
d) The supplier's liability of supporting his maintenance concept in order to achieve minimum costs, through IT (equipment and software) able to record the consumptions and related data on the operation conditions, the vehicle driver, DMU / EMU configuration and loading, temperatures, times, location etc., respectively to assist and optimize the maintenance according to the concept described in the offer.
e) Trainings, technical assistance, as well as the know-how transfer necessary for the optimum application of the operation- and maintenance concept shall be stipulated through the contract and the procurement documentation. The end user shall in turn be liable for the compliance with the provisions in the supplier- submitted documentation.
f) It is preferable that the provisions under paragraphs „c,d,e" above should be met under a partnership through which the supplier may be interested in following up / checking the operation- and maintenance modality.
During the guarantee period, and throughout the service life, respectively, periodical checks and analyses shall be foreseen, so that the reduction in consumptions and costs may be permanently monitored to the benefit of both parties under the contract and in the view of a long term partnership.

10.7. Conclusions referring to LCC.

- With a view to optimizing costs, energy consumptions and emissions throughout the service life – a fundamental condition for sustainable transport development – it is compulsory to include these requirements not only into the procurement documentation and procedures, but also in the permanent basic activities of the PTAs and TOCs.
- A permanent cost monitoring can make it possible for these objectives to be met. This can be achieved by:
  - Elaboration of strategies and policies for a sustainable transport development;
  - An advanced and active management that imposes the organization and continuous improvement of the activities related to the operation and maintenance of the rolling stock for passengers transport, based on permanent analyses of costs, energy consumptions and emissions with a view to their reducing.

- Directive 2009/33/CE from 23 of April 2009 stipulates that:
  "The biggest impact on the market, together with the best cost/benefit result, is obtained through mandatory inclusion of lifetime costs for energy consumption, CO2 emissions, and pollutant emissions as award criteria in the procurement of vehicles for public transport services".

11. ANNEXES:

11.1. Annex 1 – Technical Parameters

Standard parameters defining the operation conditions for the rolling stock

ID	Parameter	M.U.	Values	Definition
I	**Infrastructure characteristics**			
I 01	Route length	km		Total distance of selected route or reference track from selected origin station to selected destination station
I 02	Altitude profile (height)	m		The total height profile in meters above sea level along the selected route or reference track
I 03	Altitude profile (gradient)	‰		The gradient profile (slope) along the selected route or reference track
I 04	Track speed profile	km/h		The maximum speed profile at every location along the selected route or reference track
I 05	Curve radius	m		The exact locations and radii of all curves along the selected route or reference track
I 06	Tunnel profile (length)	km		The exact locations and lengths of all tunnels along the selected route or reference track
I 07	Tunnel profile (cross section area)	m^2		The exact locations and cross section areas of all tunnels along the selected route or reference track
E	**Electric supply**			**System characteristics**
E01	Nominal voltage	Volts		Choice of the different standard electrification systems (750 V DC, 1.5 kV DC, 3 kV DC, 15 kV AC, 1x25 kV AC,2x25 kV AC)
E02	Nominal frequency	Hz		Choice of the different standard electrification systems (DC, 16.7 Hz, 50 Hz)
E03	Mean voltage at pantograph	Volts		Mean voltage measured at pantograph during operation of the train according to existing standard measurement protocol (EN 50163)
E04	Neutral sections	m		The exact locations and lenghts of all neutral/phase separation sections along the selected route or reference track
S	**In-service operation mode**			
S01	Stops/stations	Integer		Number and exact location of stations with planned stops (except departure and arrival station)
S02	Stand still time on the route	hh:mm:ss		The total time elapsed for stopping time at stations (wheels not in motion)
S03	Journey duration	hh:mm:ss		Total time elapsed (from wheels rolling at departure station to wheels stopped at arrival station) e.g. from time table
S04	Load conditions in passenger service (multiple units)	tons		Total pay load of passengers e.g. average or all seats occupied (total weight of persons, average weight per person per service type)
S05	Load conditions in service (locomotives)	tons		Total pay load (total weight hauled by locomotive): weight of wagons in service plus passengers according to S08
S06	Passenger load conditions - occupancy according to number of seats (or standing capacity if applicable)	%		Total passenger occupancy rate e.g. average or all seats occupied
S07	Comfort function duration in-service operation	hh:mm:ss	Summer: Winter:	Duration for the total package of comfort functions in service operation: Heating, ventilation, Aircondition, lighting, entertainment

				and info panels (during summer and winter) per 24 hours
S08	Comfort function profile for in-service operation (load)	%	Summer: Winter:	Cumulated load profile for the total package of comfort functions in service operation: Heating, ventilation, Aircondition, lighting, entertainment and info panels (during summer and winter) per 24 hours
P	**Out of service mode (parking)**			
P01	Pre-heating and pre-cooling duration	hh:mm:ss		Total average duration of the pre-heating or pre-cooling period before each "in service" period begins per 24 hours
P02	Pre-heating and pre-cooling load profile	%		Load profile for pre-heating or pre-cooling before each "in service" period
P03	Cleaning period duration	hh:mm:ss		Total average duration of the "cleaning mode" period per 24 hours
P04	Cleaning period load profile	%		Load profile for "cleaning mode" period
P05	Parking period duration (hibernating)	hh:mm:ss		Total average duration of the "parking mode" per 24 hours
P06	Parking period load profile (hibernating)	%		Load profile for "parking mode" period
A	**Ambient conditions**			**with seasonal changes**
A01	Temperature	° Celsius	10.6	All year round average temperature
A02	Humidity	%	78	All year round average humidity
A03	Sunlight	W/m^2	736	Intensity of sunlight
A04	Head wind	m/s	2.2	Average head wind conditions in service operation
*A05**	Ambient air pressure	hPa	1005	International standard atmosphere
*A06**	Minimum temperature (winter conditions)	° Celsius	- 35,3	Winter minimum temperature
*A07**	Humidity at winter conditions	%	85	Winter mean humidity
*A08**	Maximum temperature (summer conditions)	° Celsius	40,0	Summer maximum temperature
*A09**	Humidity at summer conditions	%	72	Summer mean humidity

* *Parametrii optionali.* Consumuril specifice (%) se raportează la consumul nominal definit pentru toate funcțiile care asigură confortul.

Defining the standard profile for the test track for verifying the rolling stock's consumption and parameters

Station	km	Altitude [m]	Speed restriction [km / h]	Arrival time	Stopping time	Departure time	Travel time / interstation	Observations
Station A	0,000		40		3:00	0:00:00		
	1,000		80					
	3,000		120					
Station B	15,000		120	0:11:00	2:00	13:00:00	11:00	
	25,000		90					
	27,000		140					
Station C	40,000		160	0:28:00	2:00	30:00:00	15:00	
Station D								

Note:
The tables above are in keeping with **UIC Standard** / **UNIFE TecRec 100_001** /11.03.2010, annexes included:

- Annex A - in which the parameters required in order to describe the rolling stock operations conditions (para 1) are identified and defined
- Annex B, in which the standard values are defined for the profile of a test line on which the vehicle consumptions and other parameters (accelerations, decelerations, noise level etc.) are to be measured according to the requirements in the Specifications

The data in the table, para 2, are given merely by way of example .

In order to use the forms under paragraphs 1 and 2, it is necessary to refer to the recommendations in the standard „TecRec 100_001 / 2010" regarding the parameters definition and the modality of conducting the check tests for the rolling stock energy- / fuel consumption etc.
In order to have all the parameters required under the technical data sheets proven, several tests shall be performed, such as:

a) by observing the running times specified under para 2
b) route covering in a minimum time (by checking maximum start-up acceleration and maximum braking deceleration)
c) optimized driving in order to get minimum consumption (with and without regenerative braking options, respectively)
d) in DMU configuration for 100% passengers and DMU configuration for approx. 60% and 20% passengers (for instance)

According to the requirements, tests may be performed along two or several test lines, in order to check under the most severe operation conditions (for instance, in order to check maximum speed, traction / braking on maxim declivity ramp-gradient, curve negotiation, protection operation or consumption optimization controls etc.
For each test line, all the data shall be defined according to the table, para 2, possibly through additional attached documentations referring to the track constructive profile and characteristics (curves, super-elevation of rails, declivities, points, restrictions etc.).
All the conditions of each type of test shall be clearly defined in the Specifications.
Based on the above (possibly on the remarks to be made on site), the tenderers shall have the necessary data in order to calculate and simulate the technical data they will fill in in the technical data sheets, inclusively in the data sheet referring to the costs throughout the service life (Annex 5 - LCC)

11.2 Annex 2 – DMU Technical Characteristics

TECHICAL SHEET - EE and Env features of DMU

No.	Denomination	MU	To be filled-in by Tenderer		Observations for tenderers
			Values	Detailed/explanatory docs from the Offer	
1	Train forming				
2	Weight of DMU	kg			
3	Specific weight of DMU	kg/S			
4	Maximum speed	km/h			
5	Total installed power	kW			
6	Specific installed power	kW/S			
7	Traction power	kW			
8	Power for traction auxiliary services	kW			
9	Installed power - train heating	kW			
10	Installed power - train air conditioning	kW			
11	Installed power - lighting	kW			
12	Number of seats [S]				
13	Maximum acceleration at start-up	m/s2			
14	Maximum deceleration at breaking	m/s2			
15	Energy consumption at field test with all auxiliary consumers	l/S km			
16	Duration (minimum)	s			
17	CO2 emissions	g CO_2 / S km			
18	Exhaust emissions	g NO_x / S km			
19	Interior noise, V=0	dB			
20	Exterior noise (7,5 m), V=0 and n=$n_{max.}$	dB			
21	Exterior noise (7,5 m), start-up with n=$n_{max.}$	dB			
22	Exterior noise (7,5 m), V=$V_{max.}$ and P_n	dB			
23	Energy consumption at field test without auxiliary consumers	l /S km			
24	Minimum DMU consumption (optimized driving mode)	l/S km kW/Skm			
25	Minimum DMU consumption through optimized driving and recuperative braking	l/S km kW/Skm			
26	Minimum DMU consumption 60% S_{CS} configuration optimized driving and recuperative braking	l/S km kW/Skm			
27	Minimum DMU consumption 60% S_{CS} configuration optimized driving and recuperative braking	l/S km kW/Skm			
	Parked DMU consumption for:				
28	−Anti-freeze protection of engine under $T1_{minimum}$	kWh			
29	−Preliminary pre-heating consumption under $T2_{minimum}$	kWh			
30	−Preliminary cooling consumption	kWh			
31	−Consumption for cleaning period	kWh			
32	−Consumption during parking	kWh			

Note:

- All values are to be filled-in by each tenderer, referring to the requirement from the technical specification and respectively to a field test that is going to take place on a line detaining the characteristics defined through the Technical Specification.
- The tenderers shall respect the format of the technical sheet. Possible supplementary details ca be provided in an informative annex, with explicative role, but which can not justify the divergence from the values from the table.
- The values of the parking consumption will take into consideration the data from Annex 1 of the Technical Specification
- The offer will also include a table with the weights (kg) of the motor carriage, trailer carriage, as well as for the primary equipments (bogies, power pack, fuel tank, compressor, heating/air conditioning/ventilations, couplings, etc.)
- The data from the Technical Sheet are to be correlated with the ones from the Offer and for each of the component equipments/technologies, as well as with the data from the checking/measuring sheets on stand and at acceptance.

11.3 Annex 3 – Diesel Engine

TECHNICAL SHEET - Diesel Engine Characteristics Tenderer: …….

No.	Denomination	MU	Values	Description, observations, benefits from the point of view of economy, consumption, emissions, noise, monitoring	Norms, references, documentations (to be validated and filled-in by tenderer)
1	Type of Diesel Engine - manufacturer				
2	Production year				
3	Dimensions	mm			
4	Volume	m^3			
5	Weight of DMU	kg			
6	Specific fuel consumption	g/kWh			
7	Nominal power for heating+air cond.	kW			
8	Maximum speed	rpm		`	
9	Traction power at $n_{max.}$	kW			
10	Fuel consumption at $n_{max.}$	l/h			
11	CO2 emissions at nominal power	g CO_2/h			
12	Exhaust emissions at nominal power	g Nox/h			
13	Noise at nominal power	dB			
14	Idling speed	rpm			
15	Power at $n_{min.}$	kW			
16	Fuel consumption at $n_{min.}$	l/h			
17	Hourly consumption	l/h			
18	Electronic control of injection				
19	Oil consumption	l/h			
20	Minimum start-up temperature	° C			
21	Consumption for pre-heating and keeping warm	l/h kW/h			
22	Fuel consumption recording				
23	Diagnosis, display and recording system				
24	Computer assisted maintenance				
25	Download possibility for diagnosis and maintenance data				
26	Communication possibility with on-board computer				
27	Reliability-Availability-Safety				
28	Life cycle	Years			
29	Time period befor general overhaul	Years			
30	Detailed documentation for operation and maintenance				

Note:

- The values are to be filled-in by each tenderer, in accordance with the requirement from the Specification and respectively with the on-stand and acceptance tests
- The tenderers shall respect the layout of the Technical Sheet. Supplementary details can be given in informative annexes and in the specific documentation for the diesel engine (fuel tank, compressor, heating/air conditioning/ventilation, coupling, etc.)
- The data from the Technical Sheet are to be correlated with the ones from the offer, as well as with the data from the checking/measuring sheets on stand and at acceptance
- Separately, a detailed sheet with the life cycle costs of the diesel engine (or power pack) is going to be supplied.

11.4 Annex 4 - Brake

Tenderer: .....

TECHNICAL SHEET - Pneumatic installation and braking for DMU

No.	Denomination	MU	Values	Description, comments, EE and Env advantages	Norms, annexes, doc.	Obs.
1.	**Equipment for the production of compressed air**					
1.1	Type compressor (without greasing)					
1.2	Power	kW				
1.3	Filtration, air drainage					
1.4	Duration for the complete filling of the installation	min.				
1.5	Noise maximum level	dB				
1.6	Weight					
2.	**DMU braking**					
2.1	Composition, description of electro-pneumatic braking					
2.2	Anti-skid control					
2.3	Emergency brake					
2.4	Filling time					
2.5	Way length for normal braking - loaded DMU	m				
2.6	Way length for emergency braking - loaded DMU	m				
2.7	Maximum deceleration	m/s^2				
3.	**Parking brake**					
3.1	Description					
3.2	Indicators, signals, protections					
3.3	Pinning test, DMU at maximum load	35‰				
4.	**Electro-dynamic brake**					
4.1	Sizing power	kW				
4.2	Braking test - loaded DMU, from $V_{max.}$	25‰				
4.3	Way length for braking - loaded DMU V max.- 10km/h	m				on the test line
4.4	Verification of heating, protections, signaling					
5.	**Energy recovery braking**					optional
5.1	Design solutions, recovery mode					
5.2	Maximum recovery power	kWh				field test FT_01
6.	**Energy storage braking**					optional
6.1	Design solutions, storage mode, recovery					
6.2	Additional weight	kg				
6.3	Maximum recovered power at one braking	kWh				field test
6.4	Duration of energy storage					
7.	**Annex documentations**					annex docs are to be specified

Notă:

- All values are to be filled-in by each tenderer, referring to the requirement from the technical specification and respectively to a field test that is going to take place on a line detaining the characteristics defined through the technical specification.
- Possible supplementary detailes ca be provided in an informative annex, with explicative role, but which can not justify the divergence from the values from the table.
- The tenderer can offer a standard version and an optional versions, respectively versions for different design, equippment, technologies, etc. In this case the tenderer will fill-in FT04-standard and FT04-a for a different version. The versions will be explained through descriptive annexes, the possible price difference from the standard variant being indicated. For each version, all the other Technical Sheet that suffer modifications form the standard one, are to be completed.
- In the technical sheet FT_09-LCC and in the annexed sheets, the optional versions (for points 4,5,6) are to be filled-in separately, specifying the possible savings and also if there are any suplementary costs or late deliveries compared to the standard version.

11.5 Annex 5 - LCC

Technical Sheet - Life cycle costs for DMU Tenderer…….

No.	System name	Procurement costs	Energy consumption & costs / year			Spare parts	Wear parts, consumables	Planned maintenance	Repairs	General / capital overhauls			Total costs (€) after:					Total LCC	Obs.
		€	Consumption /year	MU	€	€	€	€	€	type	months	€	1 year	5 years	10 years	15 years	30 years (LCC)	%	
	DMU			kWh															
1	Car body																		
2	Bogies and undercarriage																		
3	Diesel engine			l															
4	Generator principal			kWh															
5	Traction control and adjustment																		
6	Traction engines			kWh															
7	Ventilation systems for cooling			kWh															
8	Energy source for auxiliaries			kWh															
9	Accumulator batteries																		
10	Compressor			kWh															
11	Pneumatic installation																		
12	DMU Braking																		
	–Braking energy recovery and utlization for aux. services																		optional
	–Braking energy recovery and storage																		optional
13	Electric installation																		
14	Computer system																		
15	Air conditioning			kWh															
16	Heating			kWh															
17	Lighting			kWh															
18	Communication and information system																		
19	Information system																		
20	Interiors, information displays, etc.			kWh															
21	Control of energy consumption for parked trains			kWh															
22	Doors' actuating																		
23	Train control optimization system																		
	TOTAL (€)																	100	total, without optional versions
	TOTAL (%)																100		

Note:

- A period of service of 5000 hours / year, or 200.000 km shall be considered. Out of that, 1400 hours are considered at low temperatures (requiring train heating) and 1000 hours at high temperatures (over 28°C.)
- Parking shall be considered for 3500 hours / year, out of which 2000 hours at night, 800 hours at temperatures below 0 °C and 400 hurs below -10°C.
- Under energy consumptions, there shall be filled in only the costs for the consumption from sources external to the train (fuel, exterior electrical energy). The other consumptions shall be given for the comparative analysis related to other offers and the percentage value of the total.
- For regenerative braking versions, the values for the regenerated consumptions shall be signed minus.
- The tenderers shall comply with the technical data sheet format. Any further explanations or details shall be given in an explanatory annex to the technical data sheet. It is also there that specifications shall be made - with references to the technical documentation referring to train equipping with devices for consumptions measuring and recording, as correlated with the on-site conditions. The format of the present Technical Data Sheet is according to the European Standard EN 60300-3-3 : 2005.
- The tenderer may offer a standard version and optional ones, namely referring to the design, equipping, technologies etc. In this case, FT05 (standard) and FT 05 - a, b, c (for the various versions) shall be filled in. The versions shall be explained in descriptive annexes, by also specifying the possible differences in prices as compared to the standard version. For each version, there shall be filed in the other Technical Data Sheets, too, which will be modified as to the standard version.
- RK at 60 months is given for information purpose, as an example of how to fill in the document. The RG, RK overhaul schedules shall be filled in by the tenderer.
- When evaluating the offers, a comparative analysis shall be made between the total acquisition value and the total LCC value (the yellow cells), values which do not include the costs in the lines related to the versions required as optional versions.
- The optional versions shall be analyzed according to the data in the table, by comparison with the other offers. The optional versions can be contracted accordingly, and in this case, all the offers shall be scored according to the data provided.

11.6 Annex 6 – Example of point rating grid

Nr	Analysis criteria	Eval points	Comments
1	**Variable and optimized DMU configuration**	9 6 3	The maximum score shall be awarded to the offer featuring the best KPI2 [kWh / seat km] filled in in Technical Data Sheet FT_01-DMU for the running test, consumption calculated for the 3 versions of occupancy (300, 200, 60 seats, namely maximum / average / minimum number of passengers) and of MU configuration, respectively. The other offers shall be awarded lower scores proportionally with the extent to which KPI2 is exceeded.
2	**Performant diesel engine**	0	The harmful emissions level stage IIIB shall be mandatory. The same with the noise maximum level. The tenderers are interested in providing the best engine, so we propose that no special score points be awarded for the engine. The input of the engine shall be referred to in KPI2 under para 1 and in LCC - where the engine maintenance and consumptions play an important role.
3	**Braking energy recovery and utilization for start-up**	14	Maximum score shall be awarded the offer featuring the biggest energy saving [kWh] to be achieved through the system proposed. The data shall be filled in in the Technical Data Sheets, as per the annexes in the Specifications and shall be checked during the acceptance- and the running tests, respectively. The other offers shall be awarded lower scores, proportionally with the energy saving achieved as compared to the offer with the maximum score.
4	**Assistance for optimized driving**	2	
9	**Optimized consumption for parked train**	3	
10	**Optimization of HVAC system (Heating, Air conditioning, Ventilation)**	2	
11	**Train Control and Management System TCMS**	4	Score points shall be awarded for totally meeting each optional requirement in the Specifications. These requirements, inclusively the evaluation modality and the maximum score to be awarded shall be enlarged upon in the Technical Data Sheet.
12	**Measurement and recording of fuel consumption**	0	Although it shall not to be scored, it will be a mandatory requirement according to the Specifications
13	**LCC analysis**	22	The offer featuring minimum LCCs, according to the technical data sheet FT-LCC, annex to the Specifications. The other offers shall be awarded lower scores, proportionally to the extend to which they exceed the costs specified in the offer having been awarded maximum score.
14	**Total DMU price**	35	The maximum score shall be awarded to the offer with the minimum price. The other offers shall be awarded lower scores, proportionally with the prices.
Total		100	

Notes:

- We have chosen a cost- oriented score, assuming that the rest of the requirements in the Specifications are mandatory (eliminatory).
- We have proposed a 100 point score, awarded as follows: 35 points for the minimum price and 65 points for the parts in the offer determining energy- and maintenance costs, respectively, to a larger extent. It is a proportion approximately similar with the one in the Technology Catalogue (22,7%, 46,2% and 31%), increasing only the percentage awarded to the initial price (currently having a much bigger share, up to 100%), to be closer to the present practice.
- We have considered the main technologies / ECORailS requirements applied in the Timişoara zone test, giving examples of score awarding. The scores were awarded considering the effect of these technologies (their estimated share within the energy- and maintenance costs), but also in an attempt to getting the tenderers to provide the best solutions, where we have considered it important, and where we think that the offers can differ more to one another (it is no use awarding many special points for those technologies in terms of which we consider that the offers will be close to one another, or where characteristics imposed by mandatory norms are requested).
- With actual offers, points can be also scored for their compliance with requirements for quality, deadlines etc. having a major interest for the purchaser. In this example, we have focused only on ECORailS requirements, to provide an example of procedure and drafting.

11.7 Annex 7 – 83 Technologies and Operational Measures

No	Technologies and operational measures (short name)	Technology/ Operational Measure	Technical Annex
1	Database of traction consumption	O	x
2	Multiple units (MUs) vs. loco-hauled trains	T	x
3	Re-engining of diesel stock / Upgrading of engines	T	x
4	LCC-driven procurement	O	x
5	Optimisation of traction software	T	x
6	Automatic train control	T	x
7	Braking energy recovering by supercapacitors in fixed installation	T	x
8	Braking energy recovering by supercapacitors on board equipment	T	x
9	On-board use of braking energy in diesel-electric stock	T	x
10	Control of comfort functions in parked trains	T	x
11	Energy efficient driving by low-tech measures	O	x
12	Thermo Efficient Climatisation System	T	x
13	Energy measurement and record documentation	T	x
14	Diesel flow meters	T	x
15	Future developments in diesel technology	T	x
16	Bonus / penalty rules	O	x
17	Improved operation control for air-conditioning	T	x
18	Modernisation of the braking system	T	
19	Optimisation of traction technologies with HTSC transformer	T	
20	Energetic optimisation of timetable	T	
21	Braking energy recovering by heating a fluid in fixed installation	T	
22	Braking energy recovering by batteries (storage technology)	T	
23	Revision of limit value for longitudinal forces in the train	O	
24	Heat exchangers to use waste heat in MUs	T	
25	Coach insulation	T	
26	Automatic door closing system during a stop	T	
27	Modification of target temperature in passenger coaches	O	
28	Ventilation control (retrofit)	T	
29	Energy-saving by magnets used on injector pipes	T	
30	Developing lighter, higher-output brake assemblies and discs	T	
31	Reducing noise by taking action on brake systems	T	
32	Reducing noise by taking action on wheels	T	
33	Ventilation control (in new stock)	T	
34	Use of solar panels - PVTrain EU project	O	
35	Optimisation of traction technologies by switch-off of traction group	T	
36	Optimisation of traction technologies by Diesel-mechanic transmission	T	
37	Mass reduction by fibre-reinforced polymers	T	
38	Mass reduction by sandwich structure	T	
39	Mass reduction by aluminium car bodies	T	

40	Mass reduction by light interior coach equipment	T	
41	Fly-wheels (storage technology)	T	
42	Lubrication of wheels and tracks	T	
43	Preheaters for diesel locomotives	T	
44	Magnetic levitation technology (maglev)	T	
45	Mass reduction by single-axle bogies	T	
46	Mass reduction with mechatronic innovations for future running gear	T	
47	Mass reduction by articulated train	T	
48	Double-decked stock	T	
49	Modular train sets	T	
50	Training programs to raise awareness of personnel	O	
51	Identification of noise and wheel flats by trackside check points	T	
52	Train with particulate filters and emission optimisation within engine	T	
53	Noise-based track access fee concept	O	
54	Noise-driven procurement	O	
55	Incentives for drivers	O	
56	Energy efficient driving strategies	O	
58	Optimisation of train operation by control center	O	
59	Energy efficient driving with passenger information systems to reduce boarding time at stations	T	
60	Regenerative electric braking	T	
61	Management and organisation in reference cycle for energy efficiency	O	
62	Loss reduction by optimised power intake	T	
63	Common Rail	T	
64	Optimisation of traction technologies with Insulated Gate Bipolar Transistors (IGBT)	T	
65	Wide-body stock	T	
66	Transversal flux motor	T	
67	Wheel-mounted permanent magnet synchronous motor	T	
68	Medium-frequency transformer	T	
69	Systematic train delays	O	
70	Smart windows	T	
71	ORC technology to use waste heat in MUs	T	
72	Coupling of parked trains for common energy supply	T	
73	PEM fuel cells	T	
74	Liquefied-gas engine	T	
75	Natural gas engine	T	
76	Hydrogen engine	T	
77	Modular system for doors electrically operated	T	
78	Diesel-electric vehicles with energy storage	T	
79	Gas turbine	T	
80	Modernisation of the lighting systems	T	
81	Modernisation of doors and windows, fillers and insulation	T	
82	Heat pump in coaches for heating and cooling	T	
83	Fly-by-wire controls	T	

12. Related Documentation:

I. ECORailS

- D22: ECORailS Guidelines
- D7: Integration of technological feedback from the User Platform and the consortium into the guidelines
- D10: Integration of legal and economical feedback from the User Platform and the consortium into the guidelines
- D14: Report on Pilot Applications
- W25: Pilot Catalogue of 10 Technologies and Operational Measures

II. Legislation

1.1. Directive 2002/49/EC relating to the assessment and management of environmental noise – transposed into Government Decision no. 674/2007)
1.2. Directive 2004/17/CE coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors
1.3. Directive 2004/18/CE on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts
1.4. Directive 2004/26/CE of the European Parliament and of the Council of 21 April 2004 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery
1.5. Directive 2009/33/CE on the promotion of clean and energy-efficient road transport vehicles
1.6. Commission Decision of 29 April 2004 specifying the basic parameters of the 'Noise', 'Freight Wagons' and 'Telematic applications for freight' Technical Specifications for Interoperability referred to in Directive 2001/16/EC (2004/446/CE)
1.7. Commission Decision of 23 December 2005 concerning the technical specification for interoperability relating to the subsystem 'rolling stock — noise' of the trans-European conventional rail system (2006/66/EC)

1.8. UIC 176 - Specifications for passenger information displayed electronically in trains
1.9. UIC 330 Railway specific environmental performance indicators
1.10. UIC 345 Environmental specifications for new rolling stock
1.11. UIC 410 - Composition and calculation of the weight and braking of passenger trains
1.12. UIC 440 Sonorization of RIC passenger coaches
1.13. UIC 542 Brake parts - Interchangeability
1.14. UIC 544 Brakes - Braking power
1.15. UIC 546 Brakes - High power brakes for passenger trains
1.16. UIC 547 Brakes - Air brake - Standard programme of tests
1.17. UIC 553 - Heating, ventilation and air-conditioning in coaches
1.18. UIC 555 - Electric lighting in passenger rolling stock
1.19. UIC 564-1– Coaches - Windows made from safety glass
1.20. UIC 576 - Wagon doors and securing devices (Interchangeability)
1.21. UIC 612-1 - Rolling stock configurations and main activated functions for EMU/DMU, locomotives and driving coaches
1.22. UIC 624 - Exhaust emission tests for diesel traction engines
1.23. UIC 625-2 - Fitting of front windows, side windows and other windows installed in drivers' cabs of motive power units with internal combustion engines, and in driving trailers (with a view to ensuring protection for the staff)

1.24. UIC 651 – Layout of driver's cabs in locomotives, railcars, multiple-unit trains and driving trailers
1.25. EN ISO 3095:2006 “Railway applications - Acoustics - Measurement of noise emitted by rail bound vehicles”,
1.26. EN ISO 3381:2006 “Acoustics – Measurement of noise inside rail bound vehicles”,
1.27. EN 13129-1:2004 Railway applications — Air conditioning for main line rolling stock Part 1: Comfort parameters
1.28. EN 13272:2001 Railway applications — Electrical lighting for rolling stock in public transport systems
1.29. EN 13452:2004 Railway applications – Braking; Mass transit brake systems
1.30. EN 14813-1:2006 Railway applications. Air conditioning for driving cabs. Comfort parameters
1.31. EN 15020:2007 Railway applications. Rescue coupler. Performance requirements, specific interface geometry and test methods
1.32. EN 15152:2007 Railway applications. Front windscreens for train cabs
1.33. EN 50121-2:2007 Railway applications. Electromagnetic compatibility. Emissions of the whole railway system to the outside world
1.34. EN 50125-1:2003 Railway applications - Environmental conditions for equipment - Part 1: Equipment on board rolling stock
1.35. EN 50126:2003 Railway applications. The specification and demonstration of reliability, availability, maintainability and safety (RAMS).
1.36. EN 50128:2003 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems.
1.37. EN 61377:2003/2006 Railway applications. Rolling stock. Combined testing of inverter-fed alternating current motors and their control system.

III. Related projects

1. **Railenergy** (Innovative Integrated Energy Efficiency Solutions for Railway Rolling Stock, Rail Infrastructure and Train Operation)
1.1. SP1_Results_Final Report_draft_14.09.2007 (KPIs)
1.2. TecRec (Specification and verification of energy consumption for railway rolling stock)
1.3. Energy efficiency strategies for rolling stock and train operation (Catalogue of EE tech.)
1.4. Railenergy calculator

2. **Event** (Energy Efficiency Technologies for Railways)

http://www.railway-energy.org/tfee/index.php?ID=200
2.1 Energy efficiency strategies for rolling stock and train operation
2.2 Final Report, March 2003

3. **Prosper** (Harmonized Environmental Specifications for new Rolling Stock)
3.1 UIC 345 (Procedures for Rolling Stock Procurement with Environmental Requirements)
3.2 Final report, September 2005
3.3 Deliverable II: Documentation of Legal Aspects, July 2005

4. **Ravel** (Rail Vehicle Design for Environment for the entire Product Life Cycle)
4.1 Integrating Eco-design into business environments, by Wim Dewulf, Joust R. Duflou

5. **Repid** (Rail sector framework and tools for standardizing and improving usability of Environmental Performance Indicators and Data formats)

6. **Trainer** (Cooperation in the improvement of energy-efficiency on railways)