ECORailS

Energy Efficiency and Environmental Criteria in the Awarding of Regional Rail Transport Vehicles and Services

Guidelines for Public Transport Administrations in Europe

Supported by
INTELLIGENT ENERGY EUROPE

English

Credits and Disclaimer

The ECORailS consortium wishes to thank all stakeholders who have been involved in meetings or discussions for their commitment and valuable input. We also like to thank the European Commission and the Executive Agency for Competitiveness & Innovation (EACI) for their support which is an encouraging sign for the ecological and economical relevance of regional passenger train services.

This document has been elaborated basing on in-depth analysis of the legal, economical and technological situation. However, national and European law (as well as its interpretation by courts), and other relevant determinants may change. Furthermore, not every possible combination of criteria has been analysed. Therefore neither Allianz pro Schiene nor any other partner of the ECORailS consortium accept any liability for problems which may occur by using this version in real awarding projects or other circumstances.

The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EACI nor the European Commission are responsible for any use that may be made of the information contained therein.

ECORailS

Energy Efficiency and Environmental Criteria in the Awarding of Regional Rail Transport Vehicles and Services

Guidelines for Public Transport Administrations in Europe

Supported by
INTELLIGENT ENERGY EUROPE

English

Content

1. Introduction **6**

Part I - Guideline for the political and strategic level **9**

2. Political considerations **9**

2.1 Transport and environment policy integration on European and national level **9**

2.2 Why integrate energy efficiency and environmental aspects into awarding procedures? 10

2.3 Relations with general railway strategy developments 12

2.3.1 Basic considerations and decisions 13

2.3.2 Instruments to trigger mid-term innovation 15

3. Legal framework **17**

3.1 Key environmental legislation 17

3.2 Integration of EE/ENV aspects into public procurement of services and vehicles 18

Part II – Guideline for the operational level **21**

4. Contracting and awarding with EE/ENV issues **21**

4.1 Defining the award project 21

4.2 Instruments for including EE/ENV criteria 23

5. Application of EE/ENV criteria and specifications **26**

5.1 Main types of specifications 26

5.2 Assessing energy consumption 28

5.2.1 Selecting a direct performance indicator 28

5.2.2 Setting the reference 30

5.2.3 Defining service profiles 31

5.2.4 Evaluating rolling stock 32

5.2.5 Evaluating and monitoring operations 35

5.2.6 Evaluating the weight of rolling stock 37

5.3 Overview about priority technologies and operational measures 38

5.4 Lifecycle cost (LCC) analysis 41

5.5 Pollutants 45

5.6 Noise 46

Glossary **49**

Abbreviations **57**

Legal Annex **58**

Annex L-1: Relevant European law, norms and bodies 58

Technical Annex

Annex T-1: Background information on strategic issues
- Annex T-1.1: Timetable issues
- Annex T-1.2: Review of selected criteria

Annex T-2: Additional information on instruments of awarding
- Annex T-2.1: The monitoring system for evaluating the keeping of the contract
- Annex T-2.2: Options in case of non-compliance of rolling stock upon verification
- Annex T-2.3: Modernisation paths/phasing out

Annex T-3: Details on Technologies and operational measures
- Annex T-3.1: Control of comfort functions in parked train
- Annex T-3.2: On-board use of braking energy in diesel-electric stock
- Annex T-3.3: Braking energy recovery by super-capacitors on board equipment
- Annex T-3.4: Vehicle concepts
- Annex T-3.5: Multiple units (MUs) vs. loco-hauled trains
- Annex T-3.6: Re-engining of diesel stock
- Annex T-3.7: Optimisation of traction software
- Annex T-3.8: Energy-efficient driving
- Annex T-3.9: Energy meters/diesel flow meters
- Annex T-3.10: Specific indicators (monitoring parameters) for technologies and operational measures

Annex T-4: Details on LCC and CBA application
- Annex T-4.1: Overview of cost categories
- Annex T-4.2: List of necessary data
- Annex T-4.3: Technical data sheet - DMU Overall Life Cycle Costs

Annex T-5: Additional information on pollutants

Annex T-6: Additional information on noise

Annex M: Pilot applications

Annex M-1: Lombardy/Province of Brescia (Italy)

Annex M-2: Berlin-Brandenburg (Germany)

Annex M-3: Øresund (Denmark)

Annex M-4: Timişoara region (Romania)

The Technical Annex and Annex M (with the text modules of the ECORailS pilot applications) are published in English on www.ecorails.eu.

1. Introduction

Public Transport Administrations (PTAs) play a key role today when it comes to improving the quality and environmental performance of passenger rail transport. The main purpose of this document is to support decision makers in the process of including environmental criteria into the PTAs' awarding procedures and service contracts. This document will show how to create awarding criteria and awarding texts (for example public service contracts (PSC) or tender specifications) compliant with European law.

The railways are one of the most environment-friendly means of passenger transport. Modal shift towards rail transport can be an appropriate measure for reducing energy consumption, CO_2 emissions, pollutants and noise. The inherent advantages of rail transport are most prominent in terms of energy efficiency. However, the railways have not yet fully exploited their potential for increasing energy efficiency and reducing environmental impact.

Many PTAs already have experience in specifying service requirements, quality criteria and other forms of obligations in PSCs, calls for tender and tender specifications for regional rail services and rolling stock. However, criteria relating to energy efficiency and environmental effects (short: "EE/ENV criteria") have their own challenges and their application will improve the environmental impact and the efficiency of the contracted services.

This is the reason why the ECORailS consortium recommends using this document in order to further develop awarding procedures in the EU. A PTA that wants to award energy efficient railway services or to procure energy efficient railway tractive units (locomotives or multiple units) may use different kinds of criteria. ECORailS proposes direct indicators, indirect indicators, technologies (or technological clusters) and operational measures. These criteria will be described in detail, including text modules to be used in real-life awarding, and will reflect the legal situation for public bodies procuring services or rolling stock.

Due to the dynamics of technological developments, we recommend using additionally the most recent information in terms of energy efficiency potentials, new technologies and new modes of operation. The information given in the Guidelines is as of 2010.

The document is divided in two parts: **Part I ("Guideline for the political and strategic level")** with the chapters **"Political considerations"** and **"Legal framework"** addresses all persons with responsibility for the organisation of Public Passenger Transport, including management units, government officials and politicians. In contrast, the main target group for **Part II ("Guideline for the operational level")** is PTA employees who actually prepare, compile, and evaluate tender documents and contracts. Accordingly, Part II comprises the chapters **"Contracting and awarding with EE/ENV issues"** and **"Application of EE/ENV criteria and specifications"**.

In addition to PTAs, all stakeholders who usually take part in awarding processes, such as train operating companies (TOC) or manufacturers of rolling stock, will profit from using these Guidelines.

EE/ENV specifications should be embedded within a more general strategy for environmentally-aware awarding. Elements of such a strategy are presented in **chapter 2**, including the main political and economic arguments for having them integrated into the PTAs' awarding policy. This issue does not only affect the relationship between the PTA and the TOC, it also impacts on infrastructure managers and the manufacturers of rolling stock. It is not likely that major technological improvements will be achieved by simply adding some ambitious specifications to the tender documents. Therefore, complementary instruments to trigger the innovation process are provided as well.

Chapter 3 deals with the legal framework. EU immission law forces local governments under certain circumstances to take action on emissions from the railways. EU environmental law already regulates the authorisation of rolling stock in terms of noise and pollutant emissions. However, if a PTA intends to go further than required by authorisation procedures, it should understand and apply the methodology of the regulations for emissions. The European competition law is not an obstacle to including EE/ENV criteria as long as a few basic principles are respected.

Chapter 4 should be used in the definition phase of an award project. Decisions already taken in this phase can influence the energy efficiency of future operations substantially. Decisions should also be made on the principal instruments for including EE/ENV criteria such as binding requirements, weighting/scoring and incentives. For the objectives of ECORailS, all main types of awarding (competitive tendering, in-house provision, direct awarding) are equally relevant.

Chapter 5 is the most technical one and gives detailed advice on the definition and application of EE/ENV specifications. It is recommended to focus on **direct indicators for the energy consumption (e.g. kWh/seat km)** wherever appropriate to ensure that the discovery process for new solutions is not hindered. Using direct performance indicators provides some challenges. It is necessary to select the most appropriate indicator, to set a reference level and to define service profiles. Furthermore, the method of application differs depending on whether it is used for the evaluation of rolling stock or the evaluation and monitoring of operations.

The quality of services (including e.g. energy consumption) depends to a great extent on the quality of the rolling stock which is used. PTAs can influence the quality of the fleet directly (when procuring it themselves) or indirectly (by specifications for the Public Service Contract). PTAs may be confronted with the rolling stock procured for the intended contract for a period of more than 30 years and should therefore be aware of the long-term implications.

Although the Guidelines highlight indicators, it is advisable for certain purposes to analyse the availability of **technologies and operational measures** that could help to improve energy efficiency. Such features can either be encouraged directly within the awarding procedure or evaluated in order to estimate the potential for improvement. Additionally, LCC analysis, pollutants and noise are issues covered in the 5th chapter.

Chapters 2 – 5 provide an overview to help structure the awarding process in order to include EE/ENV considerations and to facilitate the selection of issues to be considered.

The **Legal Annex** comprises a list of regulations, norms and technical recommendations that were relevant for the ECORailS project and should be taken into account for the proposed awarding procedures.

The **Technical Annex** provides more detailed and background information, including a catalogue of particularly promising technologies and operational measures. It is available in English and will not been printed or translated into other languages. It is available online (www.ecorails.eu).

Annex M contains the text modules that have been developed as part of the four pilot applications of the ECORailS project (Lombardy/Italy, Berlin-Brandenburg/ Germany, Øresund/Denmark, Timişoara region/Romania). The text modules are considered to be feasible and appropriate by the regional partners and stakeholders and are available on the ECORailS website in order to provide ideas for other PTAs. However, PTAs in other regions and countries should check the appropriateness and feasibility for their own situation instead of purely copying the texts.

The content of the Guidelines is based on the detailed analyses carried out as part of the project. These are documented in numerous Deliverables, which are also available on www.ecorails.eu. Readers who are interested in a very detailed approach are advised to refer to these Deliverables, which also include comprehensive lists of references and literature.

The Guidelines benefit from both ECORailS' own research activities and the results of other technological projects like EVENT (www.railway-energy.org), PROSPER (resulting in UIC Leaflet 345 [1]), and Railenergy (www.railernergy.org). The intention is to enable and encourage the European PTAs to profit from results that are already available. It is not intended to invent competing standards.

The ECORailS consortium hopes that these Guidelines are easy to use and will become a significant step for the common objective of reducing the energy consumption and enhancing the environmental friendliness of passenger mobility in Europe.

[1] UIC, Environmental specifications for new rolling stock, Leaflet 345, 1st edition, Paris, June 2006

Part I - Guideline for the political and strategic level

2. Political considerations

2.1 Transport and environment policy integration on European and national level

The EU needs to continuously reduce CO_2 emissions substantially until 2050. In the White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" of 2011, the EU Commission sets the requirement of reducing the greenhouse gas emissions (including CO_2) of the transport sector by 60 % by 2050 compared to 1990. However, since the greenhouse gas emissions (GHG) continued to increase between 1990 and 2008, the target for 2050 would mean a reduction of 70 % compared to 2008. The Commission sets an intermediate goal of reducing the GHG of the transport sector by 20 % (compared to 2008) by 2030. The Commission states in the White Paper: "In practice, transport has to use less and cleaner energy, better exploit a modern infrastructure and reduce its negative impact on the environment..." [2]

Reducing CO_2 emissions is a challenge that cannot be met by only using legal requirements and regulation of emission levels. Instead, the initiative, including investments, of public bodies is necessary in order to re-direct the development of private investments and technology. In the case of passenger transport, the railways emit less CO_2 than, for example, private cars by a factor of between 2 and 4, depending on the concrete technology, the occupancy rate, and the energy mix in the catenary. Therefore, modal shift towards the railways is an important means of climate policy. But the railways themselves can also become more efficient in terms of energy consumption and CO_2 emissions. Reducing the CO_2 emissions of the railways directly contributes to climate protection. Although sometimes additional investments could be necessary, the railways can achieve substantial improvements by just changing modes of operations without considerable costs.

The exhaust emissions of diesel operations and the noise emissions of railway operations in general can become obstacles for improving railway services. Noise in particular encourages people living near existing or planned railway lines to oppose more intense traffic. It is not only increasing energy prices that pose a risk to public finances (and the budgets of PTAs) but also the noise abatement measures that need to be taken alongside railway tracks.

Public Transport Administrations (PTAs) play a strategic role in terms of both achieving modal shift towards the railways and the improvement of energy efficiency and environmental impact of the railways themselves.

[2] EU Commission, WHITE PAPER «Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system», COM(2011) 144 final, pp. 3 (par. 6), 6 (par. 17), http://ec.europa.eu/transport/strategies/2011_white_paper_en.htm.

2.2 Why integrate energy efficiency and environmental aspects into awarding procedures?

There are several reasons why energy efficiency and other environmental criteria are an important issue for PTAs.

(1) Risk for public finances

Regional passenger rail transport in all European countries is financed to a great degree by public budgets. Providing public transport services is an important duty of governments and administrations because such services are a prerequisite for keeping modern societies functioning. The following risks can be reduced or avoided by forcing the TOCs to procure more efficient, more silent and less polluting rolling stock, or to apply improved methods of operation:

- Rising prices for energy and CO_2 emission rights: Even if at first the TOCs pay for the energy consumption, depending on the contract and the institutional framework, at the end of the day the increased energy bill for train services will to a great extent be paid by public budgets.

- The Environmental Noise Directive (2002/49/EC) forces governments to develop and execute plans for the abatement of noise and may even encourage people living in the vicinity of roads and railways to take legal action for protective measures.

- Similarly, the Air Quality Directive (2008/50/EC) forces the governments to take measures to avoid exhaust emissions, which may affect diesel train operations. Citizens in polluted areas may demand protective measures.

(2) Insufficient price signals

There are several reasons that justify why PTAs should influence the energy consumption by stipulating additional requirements and creating incentives, even if this meant additional initial investment costs:

- In some networks of the European railway system, the consumption of electric traction energy is not charged according to actual consumption, or the costs are borne directly by the contracting PTA. Thus the risk of increasing energy prices is borne by public budgets while the inherent incentives for the TOC to save energy are limited.

  In these cases the PTA has an immediate interest in greater transparency about the actual energy consumption, and also in reducing the energy consumption in order to lower the costs for the services in the future. It should be checked whether there are options for improving the situation before the start of the new operation or at least during the contract period. The PTA should go for institutional changes so that billing systems (of the infrastructure manager or energy supplier) give an inherent and clear stimulus for the TOC to save energy.

- Current energy prices do not sufficiently reflect the urgency of climate protection or risk of future shortages of energy supplies. New railway vehicles will usually last for three or four decades. If their energy consumption is

high, this will result in future additional costs, either in the form of high operation costs or because of an early replacement of the fleet.

Although the later periods may seem to be out of the scope of a current Public Service Contract (PSC), the same or other PTAs will later have to deal with the sub-optimal rolling stock.

- Cost calculations of bidding TOCs focus on the first period of operations (usually not more than $^1/_3$ of the vehicle's lifetime). That means that increased investment costs for more energy-efficient technology are only accepted by the TOC if the costs can be balanced by savings made during the first period of operations.

  If the PTA gives additional stimulation such as a bonus per train km or additional scores at the assessment of bids, the amount of acceptable investment costs will be increased, with the PTAs and society in general gaining the revenues in later periods.

(3) Protection of the population

People living or working in agglomerations or in the neighbourhood of busy railway lines suffer from pollutant and noise immissions. The protection of the population is a responsibility on PTAs as part of the government's overall administrative duties. This is a reason why PTAs should influence the pollutant and noise-related quality of rail passenger services. The respective EU regulations (TSI Noise and "Non-road directive"; *see chapters 3.1, 5.5 and 5.6*) are almost only valid for the authorisation of new vehicles and may therefore not suffice in meeting the requirements of air and noise protection. It is questionable to what extent stricter authorisation requirements will be technically or economically feasible, but there is room for decisions like modernisation of existing vehicles, allocation of "better" vehicles to lines with the most serious environmental burdens, and an integrated approach for vehicles, operations, superstructure and infrastructure.

(4) Renewable energies

With respect to climate protection the reduction of CO_2 emissions should be a prominent objective of PTAs when awarding passenger train services. The electric traction can allow the use of energy from renewable sources such as water, wind and solar. Using electricity from renewable sources would be an important signal in favour of the positive role that the railways can play in climate protection.

PTAs (and TOCs) can push forward the use of renewable sources when they are able to achieve contracts for the traction energy supply with a high share (up to 100 %) of "green power". The bargaining power depends on how supplies of energy for the railways is organised, the national energy market and the availability of "green energy" in the respective country. Such contracts already exist, e.g. in Denmark and parts of Germany, and might be achieved in other countries as well. Within regional networks it might be easier to achieve direct contracts between TOCs or PTAs and a provider of eco-electricity.

(5) Innovation and backing for the railways

By using EE/ENV criteria, the PTAs can trigger the railways' innovation process. This would be very helpful backing for the railways with regard to their reputation, modernisation and prominent role in transportation policy. The PTAs may help to overcome market barriers for new technologies and positively influence the future innovation process in terms of energy efficiency and environmental effects.

(6) Ease of infrastructure development

In some areas new or improved railway infrastructure is not welcomed by the residents because of the expected noise immission levels. If more silent vehicles are used, such problems can be defused. Costly investments for noise protection can be reduced or completely avoided. Thus more silent passenger trains facilitate the way towards modal shift.

The relevance of the aspects given above may differ from region to region. But these outcomes clearly show that the application of environmental and energy efficiency criteria will reduce political, social and financial risks. In some cases solutions are available that do not only address environmental problems, but lead to economic benefits as well (*see chapter 5.4*). The ECORailS consortium, which includes a number of PTAs, is convinced that financial, and also technological and legal obstacles can be overcome by clearly analysing the technical potential, carefully defining the requirements and incentives and embedding all tenders in a more long-term oriented and coordinated environmental strategy. The analysis of the state of the art shows that solutions are available for the railways that will allow the reduction of energy consumption and of negative environmental impacts with affordable efforts.[3]

There are already some examples of good-practice in terms of making regional passenger transport in Europe more energy-efficient and environment-friendly. Such efforts affect e.g. noise emission limits for vehicles that were prescribed by the PTA, enhanced standards for emissions from diesel operation, the use of renewable energy or calculations of the life-cycle energy consumption of rolling stock.[4]

2.3 Relations with general railway strategy developments

Besides the criteria that are presented in the 5th chapter of these Guidelines, the PTAs should consider that the energy efficiency of railways depends to a considerable extent on the infrastructure, timetable general innovation strategies, the institutional situation and the quality of the existing rolling stock. The PTA's award policy should be embedded in a more long-term oriented strategy. The definition and review of strategy and strategic targets is a permanent challenge. Therefore, strategic decision making within government and an ongoing dialogue with TOCs, manufacturers and academics are all necessary. The forecasts of energy prices and supply, as well as the consequences of noise action planning, air quality planning, and other immission laws and targets, should be considered. A transport development plan is an instrument where, among others, environmental targets (such as 20 % energy efficiency improvements or share of renewable energies for a long-term time frame as 2020/2030) can be included.

[3] Further information is also given in the Deliverables 6, 7 and 8 of the ECORailS project (see www.ecorails.eu).
[4] Some examples are given in the Deliverables 9, 10 and 11 of the ECORailS project (see www.ecorails.eu).

2.3.1 Basic considerations and decisions

There are at least nine main issues to be considered that can have a major influence on the energy efficiency and the environmental performance of rail passenger services:

(1) Overall transport policy including targets for modal shift and environmental targets for the transport sector of the area

This is relevant for fleet strategy, infrastructure investments and identification of main environmental problems to be addressed.

(2) Clear financial relations between government (PTA) and the railway companies; sufficient duration of contracts

Investments are necessary for the application of new technologies including those for improved energy efficiency and the reduction of noise and pollutants. Therefore, the TOCs need a reliable financial basis, including a sufficient duration of the contract as a basis for amortisation. The latter is especially relevant when rolling stock is designed to specific needs of the respective network or when advanced technology shall be used. In general, reliable financial relations between governments and TOCs are a prerequisite for good service quality and attracting passengers.

The PTA enjoys flexibility as regulation 1370/2007 defines maximum contract lengths between 10 and 22.5 years, depending on the award procedure and the necessary investments in contract-specific rolling stock.[5]

(3) Quality of infrastructure (speed restrictions, level crossings, management of operations)

Braking and accelerating for slow orders and stops that are not necessary for taking on or releasing passengers have a negative impact on the energy efficiency. Investments in infrastructure quality can significantly reduce energy consumption, while simultaneously increasing travelling speed. The improvement of infrastructure and operations as described above has also a positive influence on the emission of pollutants and noise.

(4) Quality of energy supply infrastructure

Especially on DC-operated networks the efficiency of recuperating braking energy can be improved by new technology in fixed installations. One option is super-capacitors which would be an alternative to vehicle based equipment. Certain investments would be necessary. The combination of on-board super-capacitors and super-capacitors in fixed installations is not recommended. However, other combinations of onboard equipment and fixed installations could be viable and should be subject to a CBA analysis.

Reversible sub-stations, which transform the recuperated DC to 50 Hz AC of the national electricity grid, seem to be a good option, too. Like super-capacitors in fixed installations, reversible sub-stations could be introduced in cooperation with the infrastructure manager and the PTA.

[5] See art. 4 clauses 3 and 4 of Regulation (EC) No 1370/2007. In case of exceptional infrastructure the duration may even be longer if competitive tendering is applied.

(5) Electrification

Electrification has several inherent advantages compared to diesel operations and thus a positive impact on all kinds of environmental effects (energy efficiency, CO_2, pollutants, noise). Among the inherent advantages there exist, at least for the foreseeable future, improved possibilities for using recovered energy or for using electricity from renewable sources.

If traffic is not too scarce, the electrification of lines might be a good alternative to the procurement of, for example, low-pollution diesel vehicles. On the other hand, if electrification of a line or network is considered, this has implications for awarding projects, for example, length of the contract, vehicle specifications, fleet strategy etc.

(6) Timetable

Usually the PTA has a big influence on the timetables of regional trains within its scope. The timetable has a big influence on the potential for saving energy. The main timetable-related potentials lie in buffer time that can be used for eco-driving and in the adaptation to energy-efficient vehicle concepts.

Energy-aware timetabling is mainly an issue for the definition of an award project (*see chapter 4.2*), but there are relevant connections to more long-term oriented timetable strategies of the PTA.

(7) Integrated strategy for noise protection (silent vehicles instead of, for example, noise protection walls)

Investments in noise protection walls, protecting windows and similar measures can in some cases be reduced when silent trains are procured. The additional costs for silent vehicles or having vehicles retrofitted are often lower than the comprehensive construction of noise protection walls, especially when the infrastructure is almost only used by regional passenger trains. In addition, measures carried out to the superstructure (e.g. dampers, regular grinding) should be considered. Due to specific financing conditions (typically investments for protection walls financed by the national budget and silent rolling stock financed by regional PTAs), new arrangements with the infrastructure manager (IM) and other TOCs might be necessary in order to make rail noise abatement more economical for the society. Such arrangements could be part of noise action planning.

(8) Fleet strategy

Even if a PTA does not own the rolling stock for its services and wants to widely use competitive tendering, it should analyse whether and for how long old, modernised or new trains should be used. New rolling stock has usually the greatest potentials for EE/ENV improvements. On the other hand, it might not be economical to scrap vehicles that have not yet reached the end of their technical lives. Apart from exceptional cases it is not advisable to replace rolling stock only for environmental reasons. The potentials and risks of later replacement or of modernisation should be analysed. Modernisation usually can have significant although limited positive effects in terms of energy efficiency and emissions, but may result in individual solutions, relatively high costs and problems with authorisation. The fleet strategy in terms of new/old/modernised rolling stock may have strong implications for the potential of environment-related improvements and for the definition and weighting of criteria.

(9) A cost-benefit analysis (CBA) is an instrument to support the PTA in estimating the impact of additional quality criteria on additional costs, cost reduction, risk reduction, fare income, etc. A CBA can help to decide on the relative weighting of criteria and to evaluate offers. The basic principle of a CBA is similar to an LCC-analysis (*see chapter 5.4*), but the CBA focuses on the monetary effects from the point of view of a specific involved party, for example the PTA, during a given period, e.g. the duration of a contract.

2.3.2 Instruments to trigger mid-term innovation

If the PTA wants to achieve substantial improvements in terms of EE/ENV quality compared to existing or currently available rolling stock, the TOC and the manufacturer need time for development, authorisation, testing and calculating. The PTA should announce well in advance what environmental standards it is going to require or to encourage. In order to give manufacturers the confidence that their efforts will be rewarded, the PTA should follow the announced strategy consistently. Announcements should be given between 0.5 and 2 years before the Invitation to Tender (ITT). If advanced solutions are desired that are not yet available on the market, a long period of time may be required for developing, testing, manufacturing and the authorisation of new designs of railway vehicles, which would take up to 4 years, depending on the number of vehicles and previous efforts of the manufacturer and the TOC. Even evolutionary improvements need sufficient time for the incorporation in the vehicle design, testing and authorisation.

In order to achieve advanced results and to trigger a continuous innovation process, one or more of the following instruments may be used:

(1) Clear environmental strategy

Clear environmental strategies by the PTAs or public announcements about EE/ENV criteria to be included in the next tender(s) give orientation for TOCs and manufacturers on which innovations and achievements will be honoured in future awarding projects. This can work as stimulation for their research and development activities, provided the announcements are reliable in the eyes of the manufacturers.

(2) Coordinated action with other PTAs

Since the size of a series is a crucial aspect for manufacturers who want to develop vehicles with new technologies at reasonable prices, coordinated action by more than one PTA may help to trigger the innovation process.

(3) Stimulation instead of binding requirements

If it is not sure that a certain performance value or emission limit can be achieved at reasonable costs within the given timeframe, weighting/scoring schemes or incentives should be applied instead of strict requirements.

(4) “Postponed” requirements

In case of long contract durations for services, the PTA may, after an analysis of the state of the art and technologies under development, require certain performance values or technology for a later date, e.g. five years after start of operations. The TOC would have to modernise or replace its fleet if it is not able to fulfil the requirements at the beginning of its operations. A “postponed requirement” is thus only appropriate if it is clear that the technologies will be

available at a certain time in the short or mid-term future. Furthermore, the refurbishment of the existing fleet using the new technologies must be reasonable, or the replacement of the existing fleet must be economical within the considered timeframe if modernisation does not seem to be appropriate.

(5) Incentives for later modernisation

If the development or even the nature of desired new technologies, their applicability to the modernisation of existing vehicles, costs and reliability are not certain, it would be better to choose incentives for future modernisation rather than having “postponed” requirements. Such incentives could also encourage the replacement of the existing fleet with new rolling stock with advanced standards.

(6) Modernisation paths

If the existing fleet is to be replaced by the TOC within the first years of the contract, a timeframe for the delivery of new vehicles could be foreseen. For these future deliveries more advanced EE/ENV standards might be required or encouraged (by a weighting/scoring scheme) than those available at the date of tendering.

3. Legal framework

3.1 Key environmental legislation

National environmental law with relevance for railway operations has until recently focused on pollutant and noise immissions. Later on, regulations for noise emissions from railway vehicles were added in certain member states but are now being superseded by EU regulations. Additionally, more recent EU immission directives force member states to take action on noise abatement and air quality.

Energy consumption regulations governing the authorisation or procurement of railway rolling stock do not yet exist. However, the urgency of climate protection has led to binding political targets on European, national and local levels. The reduction of energy consumption and CO_2 emissions is more a matter of political action than of legislation, at least as far as the railways are concerned.[6]

Pollutants

For new vehicles or replacement engines the requirements defined by **Directive 2004/26/EC of 21 April 2004**, OJ I 146/1 (NRMM = Non-road mobile machinery) are compulsory (*see chapter 5.5*).

A first stage of the NRMM-directive ("Stage IIIA") has been in force since 2006/2008/2009 (differentiated for different classes of diesel tractive units). A more ambitious stage ("Stage IIIB") will be applied to all new motors for railway operations (railcar and locomotive engines) that come into service from 1 January 2012 onwards.

The EU Air Quality Directive (**2008/50/EC of 21 May 2008**, OJ L 152/1) stipulates EU-wide limit values for the concentration of certain harmful pollutants.[7] The concentration of these pollutants should not exceed certain values or not more often than on a specified maximum number of days per year. Additionally, limits for yearly averages exist. Since 2005 such limits have already been valid for particulate matters (PM_{10}). From 2010 onwards similar limits for nitrogen oxides (NO_X) are in force. For particulate matters of very small size ($PM_{2.5}$) target and limit values (yearly averages) are defined for 2010, 2015 and 2020. If the local concentration of one or more of these pollutants exceeds the limit values, the authorities will have to take systematic measures for the permanent reduction of pollutants (air quality planning according to art. 23 of the Directive).

The emissions of nitrogen oxides (NO_X) and particulate matters (PM) are the main pollutant issues of railway diesel operations. Possibly therefore, the PTAs may not only play a role in carrying out the government's environmental policy, they may also be subject to that policy since they are, at least partially, responsible for the environmental performance of regional passenger services.

[6] For the road transport sector, including buses, Directive 2009/33/EC of 23 April 2009, OJ L 120/5, "on the promotion of clean and energy-efficient road transport vehicles" requires contracting authorities and operators to take into account lifetime energy and environmental impacts, including energy consumption and emissions of CO_2 and of certain pollutants, when purchasing road transport vehicles.

[7] The Directive 2008/50/EC replaces the Directive 1999/30/EC of 22 April 1999, OJ L 163/41. Some terms of the previous directive, including the limit values which have already been valid since 2005, are still valid for a transition period.

Noise
For new vehicles to be used on the Trans European Network the requirements defined by the TSI Noise (**2011/229/EU,** OJ L 99/1; TSI – Technical Specifications for Interoperability) are compulsory, also for regional trains. Manufacturers now provide standardised vehicle designs complying with TSI Noise limits so that differentiated criteria for different parts of the network are not recommended.[8] A 2nd stage of TSI Noise with stricter limits is envisaged for implementation in 2016/2018.

The Environmental Noise Directive (**2002/49/EC of 25 June 2002**, OJ L 189/12) requires authorities and member states in certain regions (e.g. agglomerations and along trunk roads and trunk railway lines) to measure and map noise pollution as a public service. Noise action plans are to be drawn up based on these assessments. The level above which noise action plans must be drawn up has to be decided upon by the member states. The railways (and the PTAs) should assume that where railway traffic significantly contributes to noise pollution, they will be required to limit the use of noisy railway vehicles or to take measures alongside the infrastructure. These requirements could be imposed in different ways, legal, political or regulatory. Noise-differentiated track access fees and noise ceilings, which might be introduced by the infrastructure manager because of noise action planning, could cause additional operational costs. Existing regulations for emissions by railway rolling stock do not guarantee yet that the immission limits are complied with.

Technical norms
In contrast to the regulations mentioned above, *norms* are not binding if they are not explicitly cited in a document of binding law. Where appropriate, references to norms are given in the technical chapter 5. (*For a compilation of relevant norms, bodies and EU regulations see Annex L-1.*)

3.2 Integration of EE/ENV aspects into public procurement of services and vehicles

European legislation allows (and explicitly encourages) ambitious ecological standards to be set and enforced by awarding procedures as long as the following four main principles are observed:

- non-discrimination
- proportionality
- transparency
- equal treatment

The European Court of Justice (ECJ) has already emphasized the permissibility of environmental assessment criteria in awarding, as long as they are non-discriminatory and they are associated with the subject of the contract.[9]

[8] Exceptions may apply to narrow gauge networks.
[9] See European Court of Justice, Case C-513/99 of 17 September 2002 – Concordia Bus Finland (published in OJ C 274, 09.11.2002, p. 4)

Awarding authorities are free to decide *what* to award and which quality criteria (including EE/ENV criteria) to apply. Regulation (EC) **No. 1370/2007 of 23 September 2007**, OJ L 315/1 [10], allows explicitly the inclusion of quality standards (thus including environmental criteria) into the contract (art. 4 par. 6):

"Where competent authorities, in accordance with national law, require public service operators to comply with certain quality standards, these standards shall be included in the tender documents and in the public service contracts."

PTAs must however respect certain rules on *how* to award, which are defined in European legislation (in particular: Regulation 1370/2007, also: fundamental freedoms of the European Treaty[11]). The EU regulation provides great flexibility (although not unlimited) for awarding railway services, with respect to the type of awarding procedure, the selection of the TOC, and the definition of criteria. National legislation on awarding and tendering may however limit the PTA's flexibility. EU law allows and defines the respective limitations for the following types of awarding procedures:

- competitive tenders
- in-house provision
- direct awarding[12]

Any criteria, requirements, weighting/scoring and incentive schemes which are used for the evaluation of tenders or during the contract period, must be defined in awarding documents as well as in public service contracts. This includes the method for calculation of compensation or penalty levels and how to monitor the compliance to the criteria.

When the PTA is intending to procure vehicles, the stricter EU Directive coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors (**2004/17/EC of 31 March 2004**, OJ L 134/1) and the Directive on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts (**2004/18/EC of 31 March 2004**, OJ L 134/114) must be respected. The latter regulations must also be considered in cases of awarding services where environmental criteria for rolling stock (to be provided by the TOC) are explicitly defined.

The EU regulations cited above basically allow freedom of manoeuvre to specify the subject of the award, e.g. considering energy efficiency or pollution. However, the requirements have to be non-discriminatory. For example, the specification of a particular pollution filter (in the sense of a specific producer) would not be allowed. On the other hand, the specification of a maximum level of pollution or a cleaning method would be permitted, even if these limits were stricter than required by European or national regulations on emission limits. Specific environmental evaluation criteria for the appraisal of the offers are possible, but

- should be associated with the subject of the contract;
- should not admit unlimited scope of action for the public authority;

[10] Regulation of the European Parliament and of the Council on public passenger transport services by rail and by road" (Regulation (EC) No. 1370/2007); in force since Dec. 2009.
[11] Treaty of Lisbon, in force since 1 Dec. 2009
[12] The option direct awarding is an exception for railway services (see Regulation (EC) No. 1370/2007 art. 5 par. 6).

- have to be mentioned explicitly in the contract notice (announcement of the tender) and the tender documents;
- have to be consistent with the basic principles of EU-legislation.

For the authorisation of new or refurbished railway vehicles the respective national and EU regulations need to be respected, especially those related to safety and interoperability. Key responsible bodies for these issues are the national rail safety agencies or governmental directorates. Such regulations are not corresponding in terms of environmental issues, but in some cases the technologies which are described in chapter 5.4 may have implications for authorisation procedures.

Part II – Guideline for the operational level

4. Contracting and awarding with EE/ENV issues

4.1 Defining the award project

In the definition phase of a specific award project, lines or networks to be awarded will be defined. Preliminary decisions must be made on service concept, quality standards and the duration of the contract. For the following steps or issues EE/ENV criteria should be considered (including draft decisions):

- **Identification of lines or networks; definition of lots**
  Main aspects for the definition of lines, networks and lots should be the needs of passengers, existing contracts, existing rolling stock and the need for renewal, infrastructure situation, the existence and ability of interested TOC. Nevertheless, environmental aspects should also be considered, e.g.:

  (1) Energy efficiency: Do the defined lots allow for sufficiently homogeneous occupancy rates (without too much operational effort)?

  (2) Noise: Can the less noisy rolling stock be concentrated on the lines which have the most serious noise problems?

  (3) Pollutants: analogous to noise.

  In any case a certain level of flexibility should be allowed for the modification of services during the contract duration.

- **Timetable and service concepts**
  Similarly timetable and service concepts should mainly respect the passengers' needs, e.g. in terms of travel time and good direct or corresponding connections. Spare time in the timetable provides better options for both punctuality and energy-efficient driving. 2 % spare time between stations is usually sufficient for eco-driving.

  The following issues are prominent with respect to energy efficiency (*for details please see Annex T-1.1*):
  - Spare time
  - Stops on request
  - Weakening and strengthening of trains
  - Vehicle concept
  - Avoiding idle train runs
  - Integral regular timetable (ITF)
  - Avoiding diesel operation on electrified lines

- **Identification of main environmental problems**
  Although the focus should be on energy efficiency and CO_2 emissions, noise and pollutants (the latter in case of diesel operation) should not be neglected. If the region faces serious noise or air quality problems alongside the lines in question, the respective criteria should be given a relatively high relevance in the awarding process. (*For details see chapters 5.5 and 5.6!)*

- **Analysis of energy prices, charging and supply system**
  If the traction energy is not charged according to real consumption, it should be checked whether this regime can be changed for the contract which is being prepared. Additionally: are there options for the procurement of "green" energy? (*For details see chapter 2.2!)*

- **Analysis of the actual situation in terms of energy consumption and CO_2 emissions**
  The analysis of the actual situation in terms of energy consumption is essential for the estimations of savings which can be achieved by operational measures or new rolling stock. If no sufficient data are available, a measurement campaign should be considered. Alternatively, simulations based on the current train configurations and traction technologies could be helpful. (*For details see chapters 5.2 and 5.3!)*

- **Draft definition of targets in terms of energy efficiency**
  Based on the As-Is analysis and additional analysis of available technologies as well as feasible operational measures, a first estimation of the saving potential for the next contract period can be made. Thus a target can be defined and used as a reference in tender or contract documents. (*For details see chapters 5.2 and 5.3!)*

- **Analysis of the actual situation in terms of pollutants; draft definition of targets for avoiding pollutants**
  The emission standards "Stage IIIA" and "Stage IIIB" are legally binding for new diesel locomotives, DMUs and replacement engines. "Stage IIIB" will be in force from 1 January 2012 onwards. A PTA may, however, require or encourage that even existing or modernised traction units fulfil one of these standards. In certain situations even older standards could be relevant as minimum requirements. From a PTA's point of view, the relevance of such specifications depends, among other things, on the air quality in the respective area. (*For details see chapter 5.5!)*

- **Analysis of the actual situation in terms of noise; draft definition of targets for avoiding noise**
  It should be checked whether measured emission values of the existing rolling stock are available. If not, information about the norms which are fulfilled (e.g. TSI Noise or national regulations) can be helpful. Be aware that values given in dB(A) cannot easily be compared if definitions and measurement conditions are not harmonised. The analysis can show whether existing noise problems can be solved by modernisation or procurement of new rolling stock. Based on these analyses it can also be decided whether more ambitious noise limits than required by TSI Noise should be aimed for in the present awarding. (*For details see chapter 5.6!)*

- **Decisions concerning new, refurbished or existing rolling stock**
  The fleet strategy should be concretised with respect to the current awarding project and the relevance of EE/ENV considerations. It should be decided whether e.g. new or refurbished material will be required or encouraged or whether it will be up to the bidders to decide which generation of rolling stock to offer. (*For details see chapter 2.3!)*

- **Vehicle concept and comfort for passengers**
  Conceptual decisions about the vehicles and the comfort standards should be reviewed with respect to environmental effects. It is a prominent question whether the train configurations can easily be adapted to actual demands. Articulated MUs compared to conventional MUs, double-deck trains compared to single-deck trains, and MUs in general compared to loco-hauled trains have advantages, but these advantages may be outweighed by specific conditions, sub-optimal design or the higher flexibility of loco-hauled trains. In case of awarding services, the PTA may require a specific fleet concept (e.g. multiple units instead of loco-hauled trains) or leave the decision to the bidding TOC. (*For details see chapter 5.3!)*

- **Locations for parked trains and maintenance facilities**
  Noise and pollutants at stabling or maintenance facilities may cause disturbance to the neighbourhood. Timetable concept, infrastructure situation and the bidders' maintenance concepts should be reviewed with respect to this problem.

4.2 Instruments for including EE/ENV criteria

Energy efficiency and other environmental criteria can be included in all main types of awarding procedures: competitive tendering or direct awarding. In the technical sense there are mainly four ways of using criteria:

(1) Requirements

(2) Weighting and scoring

(3) Penalties if a defined quality is not realised during the contract duration

(4) Incentives (bonus/malus) for good performance or improvements during the contract duration

Requirements
Requirements are criteria that the TOC or manufacturer needs to fulfill as minimum standards in order to be qualified for the contract. The fulfillment must be verified and monitored. Bidders who breach the minimum standards will face sanctions which need to be defined in the service contract in advance.

In case of long contract durations, requirements that apply at a specified time later in the contract period, may also be defined.

The requirement of ecological standards which exceed the current regulations can be accepted by the bidders if the tender documents give a clear and calculable picture of the assessment criteria and reflect the availability, reliability and costs of the respective technologies.

Weighting and scoring
There are two main types of criteria to be considered for a weighting or scoring scheme:

(1) Features which are either offered or not.

(2) Improved performance values; in this case, the better the performance values offered, the higher the scores received by the bidder. The evaluation could be done with mathematical functions or the definition of quality classes which represent certain ranges of values.

The intention of such a weighting scheme is (a) to encourage good solutions while not increasing the price too much, and (b) to find an algorithm for comparing (in a legally secure way) different quality and EE/ENV features. Many European PTAs already use such weighting schemes regularly. The schemes are often designed to specific needs and situations of the PTAs.

The relative weight of criteria depends on the PTA's priorities, availability on the market, and inherent incentives for the bidder. Technical details should be requested from the bidder in order to allow the "anomalous offer check" before the tender is awarded. The standards which the PTA and the successful bidder have agreed upon must be monitored, and the bidder will face sanctions if the offered standards are not met.

Incentives and/or penalties
The usual incentive/penalty schemes (e.g. for punctuality or reliability of services) can also be applied with regard to EE/ENV specifications. The schemes usually refer to an agreed level of performance. Incentives for good performance or improvements during the contract period can be used if the TOC has different options to improve e.g. the energetic performance. An incentive scheme may also encourage investments by the TOC during the contract period such as procurement of new vehicles or refurbishment of the existing fleet.

The conditions for the incentive scheme need to be announced or agreed upon in advance. Penalties and bonus/malus levels need to be proportionate.

The four ways of using EE/ENV criteria mentioned above should be considered for each single criterion. A combination of these tools is also possible (e.g. requirements for minimum standard and weighting for additional measures).

It is recommended to assess which standards and technologies are available at the time of starting the awarding project. In general a combination of binding requirements and incentives should be applied. The criteria and targets to be included need to be simple to verify, monitor and report. There should be room for the bidders' own suggestions on how to achieve better environmental performance. However, these suggestions have to be transparent and comprehensible for the PTA.

Where specific technology is concerned, the recommended approach is to specify the technology functionally (e.g. efficiency of energy storage or necessary functions of parked train control systems) and not proprietary solutions or products. The latter could even cause major legal problems while the functional approach is viable in almost all cases.

During the compilation of the tender or contract documents, each criterion should be checked in terms of practicability, appropriateness, legal security, and economical risks. However, a comprehensive survey should be done before finalisation in order to avoid unwanted consequences due to interactions between the criteria or their accumulation. A respective checklist is given in Annex T-2. It should also be reviewed if the final compilation of criteria is in line with the strategic considerations of the PTA (*see chapter 2.3*).

5. Application of EE/ENV criteria and specifications

5.1 Main types of specifications

Environmental criteria (specifications) can be classified according to their degree of quantification.[13] For a PTA, it is usually preferable to choose a functional approach instead of concrete design provisions. In a few cases, however, it is proposed to make provisions for the vehicle design or for modes of operation (*see chapter 5.3*). In those cases, specific quantifiable indicators may be applied which refer only to a specific component of the system. According to UIC Leaflet 345, four degrees of quantification can be distinguished:

(1) Target specification
The PTA can set target values for the energy consumption or types of emissions. These can be taken from regulations ("Non-Road Directive" or TSI Noise, *see chapters 5.5 and 5.6*). As an alternative, the PTA may choose more advanced values based on market analyses. No regulations exist at present for the energy consumption of railway rolling stock. Therefore any target values for the specific energy consumption would be based on market analysis. The PTA may use target values as compulsory requirements or as reference values for weighting or for incentive schemes.

(2) Performance specification
Performance specifications should be quantified by the bidder or the manufacturer. When used in awarding projects, the PTA needs to define the conditions and the calculation method. Performance specifications can be used when information about the achievable values is not sufficient or when the framework conditions are too complex or individual. A PTA may use performance specifications for the energy consumption. In the case of noise and pollutants, the PTA may use such specifications if (1) existing vehicles should be accepted for services that were set into service before the regulations were applied or (2) the PTA wants to encourage better performance than required by regulations. When referring to the same category or parameter, performance and target specifications should be described according to the same methodology.

(3) Compliance specification
Compliance specifications are not to be quantified. The bidder shall simply state whether the rolling stock, certain components or certain operational measures comply with the required standard (usually set by norm or legislation). Emission limits of TSI Noise and the "Non-Road Directive" are, however, considered as target values (see UIC Leaflet 345, p. 40).

(4) Design Provision
Design Provisions describe special equipment or a component with a specific function (e.g. provision of rolling stock with energy meters or on-board use of braking energy in diesel-electric stock). The bidder should provide technical information about the performance of these equipments.

[13] This section is based on UIC Leaflet 345 (1st edition, June 2006) mainly pp. 18, 38-39. The UIC Leaflet covers the procurement of railway rolling stock but can also be used for specifications of vehicles when awarding services.

Quantifiable specifications
In the context of ECORailS, quantifiable specifications (criteria, performance values) mainly refer to the following categories:

- Specific energy consumption (kWh per seat km and similar indicators)
- Mass per seat
- Emissions of pollutants, mainly PM, NO_X, CO and HC (g/kWh)
- Noise emission (dB(A))

All categories mentioned above are relevant for the assessment of vehicles. Specifications by the PTA for rolling stock are relevant in the following business cases:

(1) Awarding of services, rolling stock provided by the TOC

(2) Procurement of rolling stock by the PTA

The indicators for analysing the specific energy consumption can also be used for monitoring operations during the contract period, but the way they are applied differs from the evaluation of rolling stock. Monitoring operations is relevant when services are awarded by the PTA (with rolling stock provided either by the PTA or by the TOC).

Technologies
Despite the advantages of quantifiable indicators, it may be helpful to also use technological criteria, which usually means requiring special equipment for the rolling stock (design provisions). The purpose would be, among other things, (1) to assure that a certain degree of energy efficiency will be reached, (2) to bring forward the development of certain technologies (e.g. energy recuperation on diesel trains), or (3) to be in accordance with specific situations in terms of infrastructure. Furthermore, knowledge about the available technology helps the PTA to forecast, or at least assume, the results that can be achieved by using energy efficiency criteria in the awarding process. Some information will be given in chapter 5.3 and in the annexes but for a more detailed analysis please use the technical documents of the ECORailS project, provided on the website www.ecorails.eu.[14]

Operational measures
Operational measures can be applied independently of the type and age of the rolling stock, although the actual effects may differ, depending on the technical level of the fleet. Operational measures aim at achieving a more energy efficient use of the vehicles. The most prominent example is “energy efficient driving”. Operational measures may require the fitting of additional features to the rolling stock, e. g. energy meters, and certain control functions, but these can usually be fitted without major changes to the vehicles. Operational measures provide considerable potential for saving energy and can be required by a PTA, although TOCs themselves may also be motivated to use such measures. The latter can be the case because of the energy prices or because of incentives set in the PSC. Since some pre-conditions in terms of timetabling, quality of infrastructure or training are usually necessary for operational measures, respective considerations by the PTA are advisable even if no specific incentives are set.

[14] Please see especially the Deliverables 8 (“Technological overview with regard to energy efficiency and environmental performance, ready to be integrated into the final guidelines version”), 6 (“Technological overview with regard to energy efficiency and environmental performance, ready to be integrated into the guidelines”), and 7 (“Integration of technological feedback from the User Platform and the consortium into the guidelines”).

Fig. 5-1 illustrates the different degrees of quantification:

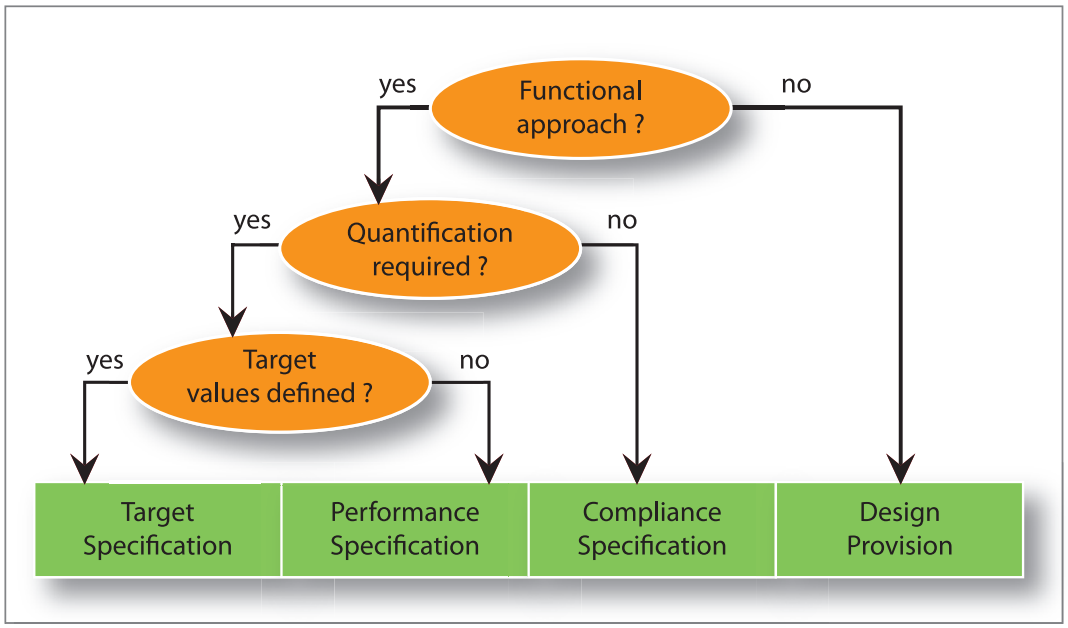

Fig. 5-1: Quantification process for environmental specifications (Source: UIC Leaflet 345, June 2006, p. 38)

5.2 Assessing energy consumption

5.2.1 Selecting a direct performance indicator

Direct performance indicators focus directly on the aim of reducing the energy consumption of a traction unit (or operations in general) in relation to a unit of measurement that refers to transport performance or operational performance. In the field of energy efficiency, it is not yet clear which solutions will prove to be the best ones in the medium to long-term. The big advantage of using direct indicators in awarding procedures is to leave the decision about which technologies or solutions they want to use for reducing energy consumption to the TOC or the vehicle supplier. Such direct indicators show the interdependent result of an ensemble of aggregates, technologies and solutions of the fleet while the positive result of a specific solution could be balanced by a less intelligent combination with other features.

The following list shows the most relevant direct indicators when it comes to awarding procedures for rail passenger services. The unit “kWh” is used for electric traction and is usually replaced by “litres” (of diesel fuel) when looking at diesel traction (see below). For further information about environmental performance indicators see also UIC Leaflet 330.

The indicator ***“kWh per seat km”*** will be the most appropriate one for most applications in the context of awarding rail passenger services or vehicles, since it can be applied to the comparison of different types of trains and operational concepts. However, the calculation, simulation and verification of “kWh per seat km” will usually be based on the value “kWh per train km”, to be re-calculated according to the number of seats etc.

The indicator ***"kWh per train km"*** can be used if class and configuration of the train compositions are defined very clearly. It may typically be used if the PTA has very clear specifications about the train capacity. It should be considered that a train may consist of two or even more multiple units or loco-hauled compositions. With respect to these cases the supplier should guarantee that multiple traction does not cause disproportionate increases of energy consumption due to inappropriate control functions.

The indicator ***"kWh per gross tonne km"*** is appropriate when comparing very different train concepts like locomotives vs. multiple units. It could also be used when locomotives are to be procured independently from carriages. "Gross tonne km" describes the weight of the train either including the locomotive (gross tonnes worked) or without the locomotive (gross tonnes hauled), multiplied with the distance the train is hauled. By using "gross tonnes worked" it is possible to directly compare an offer based on MUs with one based on locos and coaches. If fixed compositions of loco-hauled trains are compared with each other or with multiple units, the indicator "kWh per seat km" should be used additionally.

"kWh per passenger km" is the most relevant indicator in terms of climate protection and in the political discussion about transport modes. The responsibilities and the levers for improvements are very different for increasing occupancy on the one hand and improving technological efficiency on the other hand. The PTA may set incentives to encourage the TOC to improve occupancy, but it seems to be more efficient to clearly distinguish between action for increasing occupancy and action for improving technological efficiency.

In order to get meaningful results when comparing the energy consumption of different types of trains, the PTA must make some effort, and some methodological restraints should be respected:

- Clear definition of train configuration and interior design; this has to be made anyway, based on realistic comfort requirements and independently of energy consumption matters when a PTA is asking for bids.
- For the simulation and verification of the energy consumption, all relevant secondary conditions and parameters have to be clearly described. These variables are not to be neglected because differing definitions of secondary conditions in a simulation may lead to bigger differences in the calculated energy consumption than the actual, real-life difference between the energy consumptions of two different classes of traction units.
- It should be checked whether the values offered and the simulations provided by TOCs or vehicle suppliers are really comparable and use the correct methodology.
- The PTA needs to select and sufficiently describe the stretch of the network which will be the reference for comparing or verifying the energy consumption of the rolling stock.
- The technology that is necessary for monitoring the energy consumption should be specified and required (e.g. energy meters).
- Trains also consume energy when parked for some time between services. This energy consumption is not negligible, but has to be analysed separately from the traction energy (*see chapter 5.3*).

In the case of diesel operation the amount of fuel is usually measured in litres. This may be sufficient for many purposes, but the volume of diesel fuel may differ by up to 5 % because of differences in temperature. As some of the technologies and operational measures result in differences in consumption of only 2 to 6 %, the measurement by volume of fuel (litres) may lead to wrong evaluations if the result is not re-calculated to a standard temperature.

Using the mass of diesel fuel as the basis (kg) for measurement and calculations is recommended when the diesel flow in the engine, sometimes under high pressure, is to be measured.

When comparing diesel traction with electric traction or other transport modes, it is necessary to recalculate the mass of fuel to its energy content (in kJ). The actual factor may differ depending on the quality of the fuel.

5.2.2 Setting the reference

When requiring a certain maximum level of energy consumption, overly ambitious requirements should be avoided. For the application of direct performance indicators, a reference value (or reference consumption level) is usually needed. The reference value can be used for defining

- a maximum level of energy consumption;
- a reference level for weighting/scoring schemes;
- a reference level for incentive schemes (bonus/malus);
- standard costs for energy consumption.

Depending on its function in the award procedure or contract, it can take the shape of

- a maximum value;
- a target value; or
- an average value.

In other words: Reference values help to define an interval of plausible energy consumption values/reduction potentials.

The main methods and instruments for analysing the energy consumption on a particular line or network are:

- Monitoring the energy consumption by using energy meters on all tractive units.
- Collecting consumption data by using energy meters on one or a selection of tractive units as examples for each type.
- Test runs.
- Simulations.

A PTA that wants simulations to be conducted needs to follow the new energy standard defined by UIC/UNIFE TECREC 100_001[15] and provide some basic data according to the following steps:

[15] UIC/UNIFE, TEC REC 100 001, Specification and verification of energy consumption for railway rolling stock, 2010; download on: http://www.tecrec-rail.org/100_001.

1) Select a line.

2) Collect information about the infrastructure.

3) Define timetable and driving styles.

4) Select a reference class and train configuration of rolling stock.

5) Conduct the simulation.

Reference levels can either be defined with or without comfort functions for the passengers. It is recommended to use them without comfort functions when the analysis is focused on the quality of the rolling stock (*see chapter 5.2.4*). When the focus lies on the real operations (or overall energy costs), the comfort functions should be included *(see chapter 5.2.5)*.

5.2.3 Defining service profiles

The definition of service profiles is an indispensable prerequisite for calculating the energy consumption and the energy costs of railway operations in advance. Service profiles are relevant when procuring new vehicles (for assessing the vehicles), when awarding services (for assessing timetable concepts, vehicles and operational measures). Additionally, service profiles can be used for calculating standard costs of energy consumption. Service profiles are the basis for simulation, calculation and verification.

As a PTA usually has sufficient information about the infrastructure, the environmental conditions and the planned timetable, it is recommended to define a specific service profile ("defined infrastructure under defined operational conditions"), either exactly for the line to be operated or a simplified version (typical for the relevant network) if this would facilitate verification. For this purpose the standardised methodology according to the UIC/UINFE TECREC 100_001 should be used. According to this methodology, the following parameters have to be defined clearly for the operation of the train *("in-service mode"; "out of service mode" ("parked-train mode"); please see chapter 5.3)*:

Infrastructure: longitudinal profile, speed profile, curves, tunnels, electric power supply system.

Diesel fuel: diesel fuel specifications[16].

Operational requirements: train and propulsion system, timetable, pay-load, driving style, regenerative braking, comfort functions (in-service).

Environmental (ambient) conditions: ambient temperature, humidity, intensity of sunlight, average head wind.

Standard Service Profiles (SSP) can be used to describe the energetic performance of a traction unit or a train independently from a specific network or operation. The SSPs are a proposed standard, applicable for the specification and verification of energy consumption of new rolling stock, or for the improvement of exist-

[16] In the Railenergy papers the „Diesel fuel specifications" are part of the infrastructure description.

ing rolling stock. The criterion used for the energy consumption is the total net energy consumed at pantograph over a predefined operational profile. Five SSPs have been agreed upon which can be used for the procurement of vehicles or the contracting out of services. Three of them are relevant for regional passenger rail transport:

(a) “Suburban”

(b) “Regional”

(c) “Intercity”[17]

The definitions of the three Standard Service Profiles with instructions for the description of the secondary conditions can be found in the Technical Recommendations 100 001 (UIC/UNIFE).

5.2.4 Evaluating rolling stock

Vehicle design is one of the most decisive determinants for the energy consumption of passenger railway operations.

When procuring rolling stock, the PTA should ask for the energy consumption of the vehicles (locomotives, multiple units, or train sets consisting of loco and carriages). Since the manufacturer is not responsible for the operation of the rolling stock, its energy efficiency must be understood as a quality feature of the vehicle class. The energy consumption can best be offered and verified according to one or more defined test cycles.

In addition, when the PTA wants to award services and the TOC is to provide the rolling stock, the PTA can ask for data about the energy consumption of the vehicles to be used. These should be evaluated separately from the operational performance, which is also influenced by other factors. The methodology is the same as when procuring rolling stock.

The approach presented in this chapter can be applied to both newly procured and existing/second-hand rolling stock. If existing rolling stock is to be accepted the concrete values will be different from those for new vehicles and the calculation of scores must refer to a broader range of performance levels.

How to evaluate the energy consumption of rolling stock in the awarding procedure

1) Analyse the data situation.
   a) Energy consumption on the services to be awarded/relevant for the vehicles to be procured; collect data if possible.
   b) Standardised information about vehicle performances.

2) Decide whether new vehicles will be required or existing ones will be accepted. In the latter case, decide upon which consumption levels (or technical levels) should be accepted.

3) Decide upon approach.
   a) Requirement (maximum value for kWh per e.g. seat km); *or*

[17] Although the brand “Intercity” is used in most countries for long-distance trains that are run without state subsidies or Public Service Contracts, train services with similar service profiles are awarded by PTAs in many cases (e.g. in Germany, Denmark, Sweden or France).

b) weighting and scoring with/without reference value; *or*
c) combination

4) Select the relevant indicator (e.g. kWh per seat km); define a factor for the calculation of multi-purpose areas, restrooms etc.

5) Define maximum and/or reference levels; define scoring method.

6) Decide upon service profile.
a) The relevant Standard Service Profile; *or*
b) the real service profile for the line in question; *or*
c) a simplified version of the real service profile.

7) Describe the selected service profile(s) according to the standardised methodology.

8) Require declaration of traction energy consumption from the manufacturer according to the defined methodology.

9) Define requirements for verification.

10) Integrate text modules and documents in the tender documents.

Related actions

- Define comfort parameters (interior design, heating, air conditioning).
- Require on-board energy meters or monitoring devices for fuel consumption (*see also chapter 5.3*).
- Require advice for the most appropriate energy-efficient driving styles, as part of the manufacturer's manual (*see also chapter 5.3*).

Instruments

When procuring vehicles or awarding services, the instruments in both cases are:

- Requirements
- Weighting and scoring

In the following examples the reference value is kWh per seat km, but the instruments can be applied in the same way also for kWh per train km or kWh per gross tonne km.

Requirement

"The energy consumption must not exceed *x* kWh per seat km (litres of diesel per seat km) when used on the specified test cycle" (usually specified in the technical annex of the tender documents).

Weighting and scoring

In case of weighting and scoring it is recommended to use a reference level for the calculation of scores. The reference level does not need to be the same as the maximum level of the binding requirement but can be chosen a certain (usually one-digit) percentage lower.

“The reference consumption level according to the specified test cycle is *x* kWh per seat km. Offered fleets with a higher energy consumption will get zero points in the category ‘consumption of traction energy’. A fleet with a consumption better than the reference level will get additional points.”

(It should be considered to not give the scores in direct proportion to the offered savings but to reflect which reductions are assumed to be available with reasonable costs and sufficient availability.)

Weighting and scoring can be combined with a binding requirement for maximum consumption. In both cases, the PTA needs to know which level of energy consumption can be expected by using rolling stock with modern standards. Sources for this information can be (1) present and recent monitoring of operations; (2) simulations; (3) databases for energy consumption values for existing rolling stock. In all cases, the PTA must provide sufficient information about the service profiles that the award documents refer to.

Per definition (according to the standardised Railenergy methodology), the indicators to be used in the procedure described above should not include comfort functions for the passengers. These have to be defined and analysed separately (*see chapter 5.3*).

Verification
The level of energy consumption that is determinate by the vehicle design should be verified before operations start. The driving styles that are recommended by the manufacturer should be applied in both simulations and test runs. The following are the main options for verification:

(1) Simulation by the manufacturer
Simulations by the manufacturer should be required in order to enable the PTA to make plausibility checks. The simulations must be compatible with the methodology used in the service profiles that have been defined by the PTA. The methodology of the simulations must be checked when evaluating the tenders.

(2) Certified documentation of test runs performed on behalf of the manufacturer
If the PTA refers mainly to one of the Standard Service Profiles defined by TECREC 100_001, test results could already be available. In this case the test results should be validated by an independent certified organisation.

(3) Test runs under the auspices of the PTA
The simulations of the successful bidder should be verified by test runs. Test runs can be done:

(a) on the real line (or one of the real lines) which the rolling stock is intended for;

(b) on another line or dedicated test facilities according to the defined service profile;

(c) on another line or dedicated test facilities, using operational cycles and extrapolate the results to the defined service profile.

It should be stated in advance who will bear the costs of the test campaign.

If the verification fails, which would mean that the rolling stock is not compliant with the requirements or agreements, the PTA needs to react appropriately, not only with respect to its own objectives but also with regard to the competing bidders. Several options are explained in Annex T-2.2.

In certain situations, the PTA may allow some flexibility in the sense that the TOC is encouraged or requested to introduce more efficient rolling stock at a later time than at the beginning of its operations. Binding requirements at a defined date in the future, and other, more flexible stimulations can both be used. The main options are described in Annex T-2.3. Such instruments can also be applied when the PTA intends to have the rolling stock modernised during the contract period.

5.2.5 Evaluating and monitoring operations

Evaluation and monitoring of operations is relevant if services are awarded (rolling stock provided by TOC or PTA). Monitoring the real consumption is a prerequisite for the application of an incentive system to motivate the TOC to apply all feasible operational measures in order to save energy. In some cases modernisation investments may even be induced.

The intention of including an incentive system is to complement the price signals from the energy market. A revision of the incentive scheme, especially for long-lasting contracts, should be considered if changes of the supply and market conditions are expected (e.g. reform of track access fees, increasing energy prices etc.).

Additionally, an appropriate monitoring system provides the necessary data for

- identifying potentials for improvement (joint effort of PTA, TOC and IM);
- better calculations of reference values, including standard costs for energy consumption, for future tenders or contracts;
- reporting about the environmental effects of the railways (including CO_2 emission).

How to integrate the monitoring of operations in the awarding procedure

1) Analyse the data situation: energy consumption on the services to be awarded; collect data if possible.

2) Define the required precision and other parameters of the monitoring system.

3) Decide whether to use an incentive system.

4) Describe the relevant line(s) as concrete service profile(s) according to the standardised methodology.

5) Define the reference level.

6) Integrate data and assumptions about the energy consumption for comfort functions.

7) Define the values for bonus/malus (considering relevance of energy prices for the TOC; basing also on estimations about the value of the contract – € per train km).

8) Follow, if available, the PTA's usual method for establishing incentives for quality requirements (e.g. punctuality).

9) Analyse whether the combination of criteria for the assessment of rolling stock (*see chapter 5.2.4*) and the incentives for low energy consumption based on monitoring the real operations is viable.

10) Integrate text modules and documents in the tender documents.

Related actions

- Define comfort parameters (interior design, heating, air condition).
- Require energy meters or monitoring devices for fuel consumption.

Instruments

The main instruments for the integration of such a monitoring and incentive system in the award procedure are requirements and incentives.

Requirement

"The TOC must accept a monitoring system for the traction energy consumption and provide the necessary equipment and database." (If the rolling stock is provided by the PTA, the PTA should provide the vehicle equipment.)

It should be defined how exact the monitoring system should be. On bigger networks or if the vehicles are often also used on other lines than on the contract under consideration, the monitoring system should allow the analysis of the energy consumption for every train (according to train number) and day. In other cases it might be sufficient to analyse more aggregated data.

Incentive

An incentive system implies that bonus or malus payments will be applied, related to a better or worse performance compared to the reference value.

"The reference level for energy consumption on the requested services is *x* kWh per seat km. If the real consumption exceeds this level by *y* % or more, the compensation will be shortened by *a* ct per train km. If the real consumption is at least *z* % lower than the reference level, an additional compensation of *b* ct per train km will be paid." (Differentiated schemes with additional thresholds are possible.)

Setting a reference value

If the PTA provides the rolling stock, it can test the energy consumption, extrapolate the results and thus define a reference value (usually in kWh per seat km). The reference level should be higher by about 5 % per seat km as test runs would usually be done under laboratory conditions, using the recommended driving style. It is recommended to calculate separately the traction energy consumption and the energy consumption for comfort functions. If the TOC provides the rolling stock,

the reference level can be based on the offered energy consumption of this rolling stock. A third option is to calculate a reference level based on a reference class of rolling stock. In the latter case, this incentive system would additionally motivate the TOC to offer rolling stock with low consumption levels.

The methodology for calculating the reference level needs to be consistent with the calculation method for the energy consumption of the rolling stock (if applied). When defining an incentive scheme, the calculation of the service profile must, however, be more detailed and very close to the real situation and timetable of the line(s) in question. Methods for monitoring need to be identified and described in the tender and contract documents. The same applies to the incentive scheme itself.

Critical issues
There are several critical issues to be considered when applying incentive schemes, mainly:

- Unstable infrastructure and operating conditions usually lead to increased energy consumption. A contract clause should clarify that an incentive scheme may be revised or temporarily suspended in case of severe disturbances lasting for more than a few days (usually due to construction works or force majeure). If a monitoring and incentive scheme for punctuality is applied, the definitions from this scheme may be used or adapted.
- Improved infrastructure and operating conditions usually lead to lower energy consumption. In order to avoid over-compensation, a revision clause should be included in the case of long-lasting contracts. In contracts with a short duration, investments may already have been sufficiently planned so that necessary amendments to the incentive scheme can already be defined in advance.
- Incentives for low energy consumption must not outweigh penalties for bad punctuality.

The legal obligation of penalties may especially be questioned if the PTA intends to apply such a scheme in situations that cannot be influenced by the TOC.

5.2.6 Evaluating the weight of rolling stock

The mass of a vehicle is decisive in regional passenger transport with its frequent stops and a high share of energy consumption for acceleration.

This criterion is obviously the most outstanding one (in terms of traction energy consumption) when passenger carriages for loco-hauled trains are to be procured independently from the locomotives or with the future perspective of being operated with other locomotives.

When using the indirect indicator “mass per seat”, the compliance to the required or offered value needs to be tested when the vehicles are delivered. The text modules for the inclusion of the direct indicators for assessing the quality of the rolling stock can also be used, in a simplified way, for the indirect indicator “mass per seat”.

How to include mass per seat in the awarding procedure

1) Define the relevant parameters of the vehicle concept, including vehicle configurations (1st class, 2nd class, multi-purpose areas, driving cab for push-pull train).

2) Decide whether to use fixed requirements or weighting and scoring (or combination).

3) Collect benchmark information about rolling stock which is available on the market.

4) Integrate text modules and documents in the tender documents.

Related action:

- Define comfort parameters (interior design, heating, air conditioning).

5.3 Overview about priority technologies and operational measures

The ECORailS project has analysed 83 clusters of technologies and operational measures, with reference to the state of the art in 2010. Nine of them are highlighted in this chapter.

“Technologies” refers to the equipment of vehicles and the infrastructure. These technologies typically require considerable investment costs while saving operation costs during the lifetime of the equipment or of the vehicles. In contrast, “operational measures” can usually be applied to existing vehicles and infrastructure. Although in some cases investments are necessary (like energy meters or driver training), these initial costs are relatively low and there is no need to condemn existing vehicles. The most promising operational measure is energy-efficient driving. It has therefore a prominent role in the following descriptions.

The analysis of promising technologies and operational measures is relevant for PTAs for the following purposes:

- Estimation of potentials for reducing energy consumption;
- Knowledge about costs, reliability and implementation time;
- Decisions about timetables and infrastructure investments that may be related to the analysed technologies or operational measures;
- Inclusion in award procedures in certain cases.

Despite the prominent relevance of direct performance indicators it might be reasonable to require or encourage specific technologies or operational measures in the following cases:

- If the effects of the respective technology/operational measure are not covered by the direct indicator (e.g. kWh/seat km);
- To ensure a certain level of energy efficiency;

- Because of interdependence with the infrastructure;
- To boost the innovation process.

It is in compliance with the European legislation to require a specific technology if it is described functionally, and the decision on how to achieve the required or preferred performance values is left to the TOC or the manufacturer (*see chapter 3.2*).

Quality and performance of technologies can be described by specific performance indicators. These indicators must be defined individually for each technology and can refer to its specific contribution and efficiency in terms of energy consumption, noise or exhaust emissions.

The economic and technological potentials of the highlighted technologies and measures are described based upon the impact on implementation, operational, maintenance and disposal cost, which could serve as guidance for selection and assessment. The estimations of the potential for reducing energy consumption are based on the evaluations already available in technical literature, on partners' expert judgements and on evaluations made in previous and ongoing projects (EVENT, TRAINER, Railenergy[18]). A simulation tool, based on the Railenergy guidelines, has also been used.

In general, (innovative) technologies, the reliability of which is still to be examined, should not be required but could be encouraged by a weighting scheme or incentives. A precondition is that the manufacturer agrees to guarantee a high level of reliability and a reasonable maximum level of maintenance and operational costs.

A short description of the nine priority technologies (concerning rolling stock) and operational measures is given here. *(For further details please refer to Annex T-3 and Deliverable 8 of the ECORailS project "Technological overview with regard to energy efficiency and environmental performance, ready to be integrated into the final guidelines version")*.

Control of comfort functions in parked train
Instead of heating parked passenger trains all night, control systems for the comfort functions can be used which may reduce the respective energy consumption by 3-9 %. The technology is available. The costs for implementation are low. However, individual solutions are necessary depending on the vehicle design, stabling facilities, climate conditions, cleaning procedures etc.

On-board use of braking energy in diesel-electric stock
With modern diesel locos or DMUs with electric power transmission it is possible to recover energy when braking and use this energy for auxiliaries (compressors, ventilation etc.) or comfort functions in passenger trains. The saving potential is about 2-5 %. The technology is available for new rolling stock. Additional costs are low provided that new tractive units are going to be procured anyway. The effects of this technology can best be evaluated by direct performance indicators (kWh per seat km etc.). There are even several concepts under consideration for re-using the energy for traction purposes but only prototype power packs are currently available.

[18] Please refer to the project websites:
EVENT: www.railway-energy.org
TRAINER: www.iee-trainer.eu
Railenergy: www.railenergy.eu

Braking energy recovery by super-capacitors on-board equipment
On-board storage of energy with super-capacitors is an option if the receptivity of the grid for the recovered energy is limited. In electric (DC) light rail systems, 20-30 % energy savings have already been realised, thus allowing an amortisation period of less than 10 years. Additional advantages are that investments in the energy supply system can, in some cases, be reduced and that operations without overhead wire are possible on short distances. The results of the technology can be evaluated by direct performance indicators (kWh per seat km etc.).

Vehicle concepts
There is a potential for saving energy (estimated to 5-10 %) if the most appropriate type of rolling stock is used. Which vehicle concept should be chosen depends on the types of operation and on the necessary patterns of flexibility with respect to capacity. Some of the vehicle concepts have also some advantages in terms of noise emissions. Details about the following concepts are discussed in Annexes T-3.4 and T-3.5:

- railcars/multiple units vs. loco-hauled trains
- double-deck trains vs. single deck trains
- single (steering) axles vs. two-axle bogies

Multiple units (MUs) vs. loco-hauled trains
Multiple units have two basic advantages in terms of energy consumption: (1) decentralised traction, thus allowing a high rate of recuperated energy when braking, and (2) lower weight per seat. The relevance of these advantages compared to specific advantages of loco-hauled trains depends on the type of operation (e.g. frequency of stops) and on the flexibility patterns with respect to capacity. If other considerations are not decisive, individual train designs of both types can be compared by direct indicators (kWh per seat km etc.).

Re-engining of diesel stock
Compared to engines from 15-30 years ago, modern engines allow for substantial reductions of toxic exhaust pollutants and of energy consumption as well as improved control and monitoring facilities. Compared to procuring new locomotives or MUs, re-engining can, in some cases, be more economical. The results of the technology in terms of energy consumption can be evaluated by the direct performance indicators (kWh per seat km etc.). The results in terms of pollutant emissions are at least as important and should be analysed with reference to emission standards.

Optimisation of traction software
The software of the on-board computers that regulate the traction equipment is usually fixed by the manufacturer and not adapted to the specific operation conditions of the TOC. The potential for optimising this software is about 1-3 % while the costs are low. However, individual solutions are necessary and the entity (e.g. TOC or PTA) that is procuring or improving the vehicle should be involved in the development process.

Energy-efficient driving
Energy-efficient driving can reduce energy consumption by usually 5-10 %, provided that there is some buffer time in the timetable and that the reliability of operations allows its regular use. Coasting, reducing maximum speed, using valleys and

hills are the main elements of energy-efficient driving styles. Eco-driving can be implemented by low-tech measures and training programmes. Assistance systems can help to realise the reduction potential. When awarding services the PTA may require or encourage assistance devices and a training concept as well as specific performance values for the training programme. *(See Annex T-3.8 and also Annex T-1.1)*

Energy meters/diesel flow meters
Energy meters are required by an increasing number of infrastructure managers in order to calculate the energy bill according to the actual consumption of each TOC. Energy meters provide helpful information for drivers when applying eco-driving styles. Both PTAs and TOCs may use the collected information in order to set incentives and to identify potentials for reducing the energy consumption of specific operations. Diesel flow meters provide real time information on fuel consumption and can thus be used for driver advice systems and for identifying saving potentials.

Energy and diesel flow meters do not automatically reduce the energy consumption but can be a very helpful instrument.

5.4 Lifecycle cost (LCC) analysis

The basic idea of the LCC concept is that the costs of a product, for example a railway vehicle, are not only determined by the initial investment costs (purchasing price) but also by all other costs that occur during the product's lifetime, especially operational and maintenance costs. This means that higher initial investment costs can be justified by reduced operational costs during the entire lifetime of the vehicle. In general, lifecycle cost analysis is the calculation of all possible costs of a product during its lifecycle. The LCC concept is especially relevant for railway rolling stock because of the usually long technical and economic lifetime (25-40 years or even longer).

The method of LCC analysis can also be a helpful instrument for introducing more energy-efficient railway rolling stock. The relevant cost categories for an LCC analysis are:

- investment costs
- capital costs
- energy costs (part of the operational costs)
- other operational costs
- maintenance costs
- recycling and disposal costs

(*For further details see also Annex T-4.1.*)

Although these Guidelines focus on energy costs, it should be considered that new or additional equipment for saving energy can cause relevant changes for other operational costs, maintenance costs as well as for recycling and disposal costs. LCC analyses can be applied when procuring rolling stock or, although with reservations, when awarding rail services. The following business cases are relevant:

(1) Procurement of rolling stock by the PTA:

If the PTA is procuring rolling stock itself, it is highly recommended to make an LCC analysis, and therefore the relevant calculations and cost elements have to be requested from the participating suppliers.

For analysing the LCC of rolling stock any costs for the vehicles are added up. The total sum of all accrued costs during the lifetime of a specific product is the relevant parameter for comparison purposes with other products. In the end, the net present value (NPV) for the product must be generated. This means that all costs, also including future costs, are discounted on the cash value. This method enables the decision maker to compare different products in relation to their LCC. Estimates of future cost development (e.g. interest rates) should be included in the tender documents as basis for the calculations of the bidders. Since energy prices are expected to rise, assumptions on their development are especially relevant and can be decisive for the award procedure.

The LCC methodology for procuring rolling stock can also be applied in business cases (2) and (3) (*see below*).

(2) Public Service Contract (PSC) with guaranteed re-use of rolling stock:

In certain cases the PTA may offer a guarantee to re-use the rolling stock after the contract period even if the current TOC does not win the follow-up contract. This lowers the risk for the bidding TOCs, and the PTA can also benefit from lower costs. This approach is especially advisable if non-standardised rolling stock will be operated on the network (e.g. innovative features, specific network conditions or small national networks).

If the fleet is going to be transferred to another TOC after the first PSC, the fair value must be calculated. This depends to a considerable extent on the observed operational costs. If the TOC intends to take up the guarantee of re-use, the LCC calculations for the respective fleet cannot be considered as an industrial secret.[19] The following information flows are essential:

a) The bidding TOCs need information and data of the prospective rail service from the PTA in order to calculate the LCC of the required rolling stock. This calculation is included in the bid price. Information regarding the specific conditions and the operation modalities help the bidders to check or to enhance the products/services they provide as well as their costs according to these conditions.

b) The PTA should do a sample accounting in order to get an expected value for the rail service. The procedure for doing this is quite similar to the one when the PTA is procuring rolling stock itself, even if some of the data are more uncertain. The results of the sample calculation can be used for determining the values and the relative weighting of direct performance indicators (like kWh/seat km) in the tender.

[19] The general conditions regarding transferring the vehicles etc. will be agreed at the beginning of the initial contract. It should be clear that the use of the respective vehicles is binding for the TOC which is to win the follow-up service contract.

c) The PTA should require the actual consumption data (permanent monitoring system) of the rolling stock. The actual energy consumption has a major influence on the life cycle costs and the fair value of the fleet at the end of the contract period.

For defining and structuring these information flows the methodology can be used that is described in chapters 5.1 and 5.2.

(3) PSC without guaranteed re-use:
If the rolling stock is to be provided by the winning TOC and the PTA does not guarantee to re-use the rolling stock in the follow-up PSC, the factoring is more complicated for the TOC. This may result in higher costs for the PTA. The PTA should, however, provide all relevant information regarding the service profile and other determinants of the energy consumption (*see chapter 5.2*). This broadens the calculation basis of the TOC and allows a tighter cost and risk calculation to be made. In general, the information basis provided by the PTA to potential bidders should be the same as if the PTA was procuring the rolling stock by itself. In this business case the PTA would rather focus directly on the energy consumption of the fleet than on the LCC data.

(4) Economic assessment of components:
Independently of the ownership of rolling stock, the PTA may try to evaluate the costs for certain components. For instance, a reduction of energy consumption is possible by many different means. An LCC analysis could determine the cost differences for the different technologies. This could be the basis for the decision regarding a technology or component. A cost benefit analysis (CBA) is preferable if costs for components with different impacts are calculated. The LCC analysis of components could be an economic criterion for the PTA when evaluating specific technologies. Sample data sheets for some relevant technologies are provided in Annex T-4 (*see also chapter 5.3 and Annex T-3*).

The operational costs, and to a lesser degree the maintenance costs, are variable and strongly depend on the operating program. Therefore, the calculation should be made for specific operating scenarios. The important operational characteristics (e.g. mileage per vehicle, service profile, etc.) should be collected for the respective scenario, so that common indicators (e.g. time-dependent and mileage-dependent maintenance cycle, operational costs per train-km, etc.) can be used. As far as the operational costs are concerned, the assumptions about the energy consumption can be based on the analyses of direct indicators. With regard to LCC analysis, it is mainly kWh per train km or gross tkm that are relevant. In addition the definitions and assumptions about stand-by and comfort functions as well as operational measures should be consulted (*see chapters 5.2 and 5.3*).

A practical problem is that today, the suppliers are the main source for the necessary data. For technologies that are already in use, the individual operators should have the relevant data for their specific use cases. A PTA compiling awarding documents should be aware of this situation and challenge the bidders to commit themselves to specifications concerning LCC components. However, in case of new vehicles, especially when using new technologies, clear statements regarding life cycle costs are harder to obtain.

Verification
LCC calculations are based on assumptions about the development of upcoming costs. The actual costs depend largely on the maintenance quality and the actual operations. That means that the more we look into the future, the stronger the responsibility of the PTA or the TOC will be and the higher the risk that the operational patterns will have changed. The following main options of verification and/or binding agreements can be proposed (also as combination):

- Assumptions on the energy costs (consumption) can be verified by testing the vehicles (*see chapter 5.2)*.

- The manufacturer may guarantee the offered cost limits for a certain period. The usual guarantee period is two years, but this could be extended to e.g. five years. However, the purchasing price may rise if a prolonged guarantee period is requested.

- Maintenance could be defined as the manufacturer's duty for a certain period. In this case the PTA (or the vehicle operator) would pay a package price. That would reduce the risk of unexpectedly high maintenance costs for the vehicle operator but the manufacturer would let the TOC or PTA pay for its own increased risk. Such a package contract is not advisable for a period longer than 5-10 years (in any case not longer than an awarded service contract), since operating conditions could change considerably after such a period.

- The energy consumption could again be verified at the end of the period for which the manufacturer gives guarantees for the maintenance. Since the quality of maintenance cannot be assessed by type tests, the most appropriate way seems to be a permanent monitoring system, optionally combined with test runs of randomly selected vehicles.

Awarding documentation
If LCC data are required by the PTA for the procurement or assessment of a series of vehicles, the LCC calculation needs to be part of the awarding documentation (tender, contract). The form should be designed according to the definitions mentioned above and provide clear options for the comparison of the offers.

The awarding documentation will stipulate the verification modalities; the testing conditions must be specified in the awarding documentation. The contract will stipulate the responsibilities of the bidders for the fulfillment of the provided data.

Norms
Methods and forms for LCC calculation requirements can be based on the specifications of EN 60300-3-3 (Application guide LCC). Further norms with relevance for LCC analyses are:

- IEC 60050-191. International Electrotechnical Vocabulary. Chapter 191: Dependability and quality of service;
- IEC 62198. Project risk management – Application guidelines;
- EN 61703. Mathematical expressions for reliability, maintainability and maintenance support terms;

5.5 Pollutants

When a PTA is preparing an awarding procedure which includes non-electrified lines, the relevance of exhaust pollutants (mainly particulate matters and nitrogen oxides (PM and NO_x)), the present situation, and the potentials for improvement should be assessed (*see chapter 3.1*). Pollutants from diesel operations should be given a relatively high weighting in the awarding project, if one or more of the following circumstances are prevalent:

- The operations serve a densely populated area or an area with a lot of pollution caused by industrial production, ports or road transport.
- The operations serve an area with high air quality and this is to be protected.
- There are covered stations or stations in tunnels which are served by diesel trains.
- There are railway lines or marshalling yards which are heavily used and operated by diesel locomotives.
- The area to be served is subject to air quality planning because of exceeded immission limits.

The specification of limit values for exhaust emissions is relevant when awarding services (rolling stock provided by the TOC) or when vehicles are procured by the PTA. There is no legal obstacle to exhaust-related requirements as the criteria can be described functionally, with reference to standards.

From 1 January 2012 onwards, all newly procured diesel locomotives and DMUs within the EU must fulfil the limit values of Stage IIIB of the Directive 2004/26/EC. The same applies to new motors which are used for re-engining. Due to certain transition rules it is likely that motors fulfilling only the previous Stage IIIA may still come into operation in 2012.

If exhaust pollutants are relevant for the PTA, it must find an appropriate balance between requiring very high standards and allowing existing vehicles with lower standards to be used. The PTA should consider using one or more of the following options:

Requiring (or encouraging by additional scores) Stage IIIB (according to Dir. 2004/26/EC)

That would ensure that engines with the best available standards are used, but would imply that new rolling stock must be used or that existing rolling stock must be re-engined with new motors.

Requiring (or encouraging) Stage IIIA (according to Dir. 2004/26/EC)
This stage of limit values has been in force since 2006 (for DMUs) and respectively 2009 (for diesel locomotives with a rated power of more than 560 kW). Requiring Stage IIIA might be more appropriate than Stage IIIB for economic reasons (option to use existing tractive units) but still excluding engines with poor standards. If Stage IIIA is accepted, it is advisable to demand guarantees from the manufacturer that the later retrofit with a particle filter will be possible without major problems in terms of space, weight, decreased seat capacity, decreased performance, or authorisation.

Requiring (or encouraging) Stage IIIA but the PM limits of Stage IIIB to be fulfilled
In most cases Stage IIIA engines can be retrofitted with particle filters so that the PM values of Stage IIIB are achieved. This can be the appropriate option if there is a relevant PM immission problem and a fairly modern diesel fleet exists.

Excluding locomotives or DMUs with very out-dated standards
Already in 2002, engines were available that fulfilled the PM limit of Stage IIIA although not the NO_X values. Therefore this value could be the least ambitious requirement with reference to an emission norm for locomotives. For DMUs with motors based on lorry technology, the EURO 3 norm may alternatively be used as a meaningful minimum reference for rolling stock older than 2006. However, the "EURO" norm refers to road transport. The test cycles and load collectives differ substantially from those relevant for railway operations. The values cannot consistently be compared to the values according to Stage IIIA/Stage IIIB.

Modernisation of the fleet
If the PTA is to accept rolling stock that does not fulfil the desired values for exhaust emissions, requirements or incentives can be defined in order to stimulate modernisation during the contract period. The modernisation can comprise

- replacement by existing vehicles with better standards;
- replacement by entirely new vehicles;
- re-engining.

Intensified use of better vehicles
The intensified operation of rolling stock with better exhaust emission values may be stimulated by

- additional compensation for «better» tractive units, calculated per train km;
- reduced compensation for «worse» tractive units, calculated by train km;
- restricted use of old vehicles (e.g. only during rush hour or as spare stock).

Maintenance quality
The exhaust emissions depend on the maintenance quality of the engine itself, the exhaust after-treatment devices (esp. particle filters), and other auxiliaries. The PTA may require

- a maintenance concept by the TOC (to be assessed qualitatively);
- that the exhaust gases are analysed regularly (e.g. with each revision) and that the documentation can be produced to the PTA on request.

5.6 Noise

The actual relevance and definition of noise-related criteria will usually depend on the relevance of noise immissions in the region and on the age and the availability of rolling stock (*see chapter 3.1*). Noise emissions (external noise) should be given a relatively strong weighting in the awarding project if one or more of the following circumstances are prevalent:

- The relevant railway lines have dense traffic and cross densely populated areas.
- Areas along the railway lines and stations are subject to noise action planning.
- The existing fleet which is relevant for the awarded services does not comply with TSI Noise values but has still a fairly long remaining technical lifetime.
- New rolling stock is to be procured, but it is unclear whether complying with the TSI Noise limits will be sufficient for solving the existing noise problems.
- The PTA or the TOC have already been confronted with major complaints about railway noise emissions (but be aware that such complaints often refer to specific problems like curve squeal, braking noise etc. which are not regulated by the TSI – *see Annex T-5.6)*.

Most relevant regulation: TSI Noise

The emission limits of the TSI Noise (**2011/229/EU of 4 April 2011**, OJ L 99/1; TSI = Technical Specifications for Interoperability) have been in force since 2006[20]. According to this regulation, new railway vehicles which are used on the Trans-European network (TEN) must comply with specified noise emission limits. That also includes regional trains even if they are only partially operated on TEN tracks. Some member states extend the scope of the TSI Noise to the whole national standard gauge railway network. Refurbishment of existing vehicles is not required by TSI Noise but it has to be proved that noise emissions have not been amplified when refurbishment is done.

The TSI Noise define noise emission values, differentiated as start-up noise, pass-by noise and noise at standstill, and also define a methodology for measuring these values. The TSI Noise deal with the external noise of railway vehicles. It is strictly recommended that PTAs use the TSI Noise methodology even if the required actual values are not identical to the TSI limits.

National emission limits

In some countries (Austria, Switzerland, Italy) national regulations for emission limits of railway vehicles exist. Due to differences in definitions and measurement methods, the limit values must not directly be compared with TSI values. However, the PTAs may, for a transitory period, use national methodologies and limits if existing vehicles are to be accepted and emission data only exist according to the national methodology.

How to include noise criteria in the awarding procedure

1) Analyse the relevance of noise emissions by regional trains on your network.

2) Analyse available data about noise emissions of the relevant rolling stock.

3) Require that newly procured vehicles fulfil the emission limits of TSI Noise.

[20] The new Decision of the Commission 2011/229/EU replaces the former version 2006/66/EG. Scope and limit values have not been changed.

4) Decide whether stricter emission limits shall be required or encouraged by weighting & scoring or by incentive systems (before stricter values are set as a binding requirement, evidence should exist that such vehicles will be available at reasonable prices and reliability when starting operations).

5) If existing vehicles are going to be accepted, decide
   - which emission limits they should fulfil;
   - whether noise remediation will be required and which noise emission targets to set;
   - whether and how modernisation or replacement should be stimulated by incentives to be applied during the operation period;
   - whether and how to define incentive schemes in favour of a more intense use of silent vehicles;
   - which method of verification will be required.

6) Require documentation of type-approvals in terms of noise emission.

7) Require a monitoring system which allows for the application of the defined incentive system.

Verification and maintenance
Noise emission values according to TSI Noise definitions should be available since test runs for measuring noise emissions are compulsory for all new vehicles to be used on the Trans European Network. In this case additional verification is not necessary, but the actual emission values should be asked for and not only the compliance with TSI regulations.

The preservation of the acoustical quality of a vehicle depends on the maintenance procedures. Monitoring the noise-related maintenance quality comprehensively is complex. It is therefore recommended that the PTA requires a maintenance concept from the TOC and assesses it qualitatively. Additionally, trackside monitoring devices could be considered in certain cases. *(See also Annex T-5.6 for additional information on TSI Noise and further options and considerations!)*

Glossary

Air Quality Directive
The Air Quality Directive 2008/50/EC of 21 May 2008 sets limit values for the concentration of some toxic matters. The most relevant of them for railway transport are particulate matters (PM) and nitrogen oxides (NO_x). If the concentration of the regulated pollutant matters exceeds the limits on too many days of a year, the authorities are obliged to develop and execute Air Quality Plans.

Auxiliaries
Equipment needed to operate the traction equipment, but not producing tractive or dynamic braking efforts themselves (e.g. cooling fans, oil and water pumps, and compressor). In the context of this standard, heating and/or air conditioning of the leading driver's cab is included in the auxiliaries (see UIC/UNIFE TEC REC 100 001).

Awarding, Awarding procedure
Procedure in which the right or the contract to operate public passenger transport services on a particular route, network or in a particular area, is given to a transport company by a competent authority (PTA). It is also the procedure used by a competent authority to buy investments goods (like rolling stock). Awarding can be done through either competitive tendering, direct awarding or through in-house provision, although in certain cases legal restrictions by European or national law apply when choosing the awarding method.

Cluster
A cluster is a group of technologies or operational measures that are developed or used with the same or similar objective in terms of reduction of energy consumption. The definition of clusters is a heuristic method to analyse objectives and potentials of different approaches. The technologies and operational measures that are grouped in a specific cluster may be competing or co-acting with each other. A cluster may consist of many elements (technologies/measures) while other clusters may consist only of one element.

One example for a cluster is the recuperation of "braking energy" which might be done with different methods, especially when it comes to diesel operation. Another example for a cluster is "Eco-driving/driver training" to which several, partially co-acting elements belong.

Comfort systems
All equipment that consumes energy, but belonging neither to the traction equipment nor to its auxiliaries, mainly in passenger cars: heating, air conditioning, toilets, information and entertainment systems, laptop supplies etc. (see UIC/UNIFE TEC REC 100 001).

Compensation
Any benefit, particularly financial, granted, directly or indirectly, by a competent authority from public funds to a transport operator who signs a public service contract with the PTA. The compensation usually covers the net financial effect on costs incurred for the transport operator in complying with the public service obligations or the tariff (fare) obligations plus a reasonable profit. Any overcompensation is not in compliance with European law.

Competitive tendering
Awarding procedure where the competent authority (PTA) may evaluate the offers of a number of interested transport operators or rolling stock providers in a public and transparent way. According to the EU law, three different procedures may be used: *open*, *restricted* or *negotiated with publication of a contract notice*. In the *open procedure* an invitation to tender is published and every interested company may take part and submit offers; in a *restricted procedure* tenders may only be submitted by the operators selected and invited by the PTA following pre-defined criteria; in a *negotiated procedure with publication of a contract notice*, the PTA chooses the companies to negotiate the awarding from among those that have answered to a public invitation.

Contracting out
The decision by a PTA to provide a public transport service through an external operator. A public service contract has to be signed between the PTA and this operator. The operator can be chosen by competitive tendering or directly.

Decibel (dB, dB(A))
Analyses of railway noise usually refer to sound pressure levels. The physical unit of measurement for sound pressure levels is “Pascal”. Human sound sensitivity acts approximately in a logarithmical manner. “Decibel” (dB) is a mathematical unit that is used in order to describe noise pressure according to the logarithmical manner of perception. An important characteristic of the logarithm is that difference values occur as follows:

- $\Delta L = 3$ dB → the original physical quantity is doubled or halved respectively. A 3 dB sound pressure difference level can typically not be identified by humans;
- $\Delta L = 10$ dB → the original physical quantity is decupled or reduced by a tenth respectively. This difference is perceived by humans as a (subjective) doubling or halving of the sound level respectively.

Acoustic signals are always composed of dynamic signals made up of (usually) many frequencies. The human ear has the highest sensitivity in the frequency range from approx. 200 Hz to approx. 10 kHz. Therefore, the originally measured signal must be ‘frequency-weighted’ when the effect on humans is to be described. Usually the so called “A-function” is used for this purpose and the weighted signals are marked as dB(A).

In railway acoustics, an important sound level is the $L_{pAeq,T}$. It means an A-weighted sound pressure, equalized at the complete pass-by Time of a train. For example, the European sound limits for train pass-by measures given in the TSI Noise are quantified in this level. Further common levels are maximum levels, L_{Amax}. Noise values given in dB(A) can only be compared if they refer to the same definition of sound levels and if they are measured under the same conditions (for example height, number and distance of measurement points, pass-by speed).

Direct awarding, direct contracting
Awarding procedure where the PTA awards the public transport services to an operator without competitive tendering. The details are negotiated directly between the PTA and the TOC. Even for this procedure the PTA is requested to publish a contract notice. Unless prohibited by national law, the use of direct awarding is an optional choice for the competent authorities for rail services (other than metro and tram) while for other passenger transport modes this is only allowed under special circumstances (see EU regulation 1370/2007). All compensation, of whatever nature, connected with a public service contract awarded directly shall also comply with the provisions laid down in the Annex of EU regulation 1370/2007.

Direct indicator, direct performance indicator
In the context of ECORailS, a direct indicator shows directly the energy consumption of a traction unit in relation to a unit of measurement that refers to transport or operational performance. The unit of the enumerator is “kWh” (kilowatt hours) while the denominator is given as:

- pkm (passenger kilometre); *or*
- seat km; *or*
- train km; *or*
- gross tkm (gross tonne kilometre).

In order to get meaningful results when comparing the energy consumption of, for example, different types of trains, it is essential to make sure that the secondary conditions are harmonised to a sufficient extent. Among other things, the following secondary conditions may be considered: timetable, gradients, ambient conditions, curves, occupancy, comfort functions and passenger comfort definitions.

EE/ENV criteria
Energy efficiency and environmental criteria are key elements for a sustainable transport policy. These criteria in awarding processes force bidders or directly contracted TOCs to propose means or services with less energy consumption or less emissions. Binding or encouraged inclusion of such actions reduces the specific energy consumption or provides better performance for the same energy input, cuts specific energy supply costs, increases competitiveness, reduces greenhouse gas emissions, the local air pollution and noise nuisance. Because of their considerable relevance, the ECORailS project focuses on energy efficiency, CO_2 emissions, exhaust pollutants and noise although further dimensions of EE/ENV criteria might be considered.

Electric power supply
Generation and distribution of electric energy to the train: power stations, high voltage transmission lines, substations and their switchgear, catenary lines (see UIC/UNIFE TEC REC 100 001).

Environmental Noise Directive (END)
The directive 2002/49/EC from 25 July 2002 requires authorities and member states in certain regions to measure and map noise pollution as a public service. Noise action plans are to be drawn up, based on these assessments, if certain immission limits are exceeded. The directive currently specifies which information is to be provided about noise pollution.

Gross tonne kilometre (gross tkm)
It is obtained by multiplying the gross tonnage of a train by the number of kilometres covered. The weight is generally determined by adding the weight of the load to the actual weight of each vehicle. If the train consist is modified during the journey this must be reflected in the calculation. In case of passenger transport a notional weight for the “payload” should be used *(See also UIC Leaflet 410!)*

Guarantee of re-use (of rolling stock)
Guarantee of re-use is an option for dealing with the issue of rolling stock in different contract periods. The PTA guarantees the TOC the re-use of its vehicles in upcoming contract periods even if the respective TOC does not win the follow-up contract for rail services. Thus the risk of re-use is removed from the TOC, with benefit for the vehicle factoring. At the end of the period the vehicles will be assigned to the winning TOC and the “old” TOC will receive compensation, usually the fair value of the vehicles at the end of the first contract period.

Indirect indicator
In the context of ECORailS, an indirect indicator describes a parameter that has a major or substantial influence on the energy consumption of a train but does not describe the energy consumption itself. The most prominent example is “mass per seat” which can be used for the procurement or description of passenger carriages for loco-hauled trains.

Infrastructure
Fixed installations of the railway: tracks, power supply, signalling, communication etc. (see UIC/UNIFE TEC REC 100 001)

In-house provision
It is a special case of direct awarding where the public transport services are awarded to an internal operator. An internal operator is a legally distinct entity over which a competent local authority, or in the case of a group of authorities, at least one competent local authority, exercises control similar to that exercised over its own departments.

Integral regular timetable (ITF)
Regular timetable with the additional quality that at all major nodes of the railway network trains from all directions arrive at a short time before minutes 00 or 30 of every hour and depart a short time after. Thus optimal connections are provided for passengers from and to all directions.

Loco-hauled train
The traditional passenger train comprises a collection of coaches with suitable motive power attached in the form of a locomotive. As long as the train weight remains within the capacity of the locomotive(s), any number of vehicles can be attached, although limits will be imposed by platform or siding lengths. Locomotives themselves can also be used flexibly, many being designed to cover a range of duties. In spite of that, multiple units may be more appropriate for a range of passenger operations, depending on the kind of flexibility needed.
Source: www.railway-technical.com/tr-ops.shtml#LocomotiveHauledTrains

Multiple unit (MU)
A powered train (or part of the train) of fixed consist (group of vehicles coupled together). The fixed consist of a multiple unit comprises both passenger compartments and propulsion aggregates. Depending on the type of services and the actual design, MUs may have advantages in terms of flexibility, better acceleration and more efficient recuperation of energy when braking.

Net present value (NPV)
Net present value (also present value) is used for dynamic cash-flow statements in order to compare capital costs during different time periods. The comparison is enabled by discounting upcoming cash-flows on the starting point of the capital investment.

Operational measure
Operational measures aim at achieving a more energy efficient use of existing vehicles and infrastructure. Operational measures can be applied independently of the type and age of the rolling stock, although the actual effects may differ. The most prominent example is “energy efficient driving”. Operational measures may require the fitting of additional features to the rolling stock, e.g. energy meters, or certain control functions, but these can usually be fitted without major changes to the vehicles.

Operational performance
In case of passenger railway operations: Figures to describe quantitatively the services that are provided, but independent of the occupancy rate. Main parameters: seat km, train km, gross tonne km.

Public service contract (PSC)
The PSC is the legally binding act that confirms the agreement for a specific rail service between the two contractors, PTA and TOC, and in which the competent authority requires the public service operator to comply with quality standards and technical specifications. The PSC must be in accordance to national law, but the actual standards and requirements may be stricter, e.g. in terms of environmental effects, than required by national or European legislations. The requirement concerning standards and techniques also has to be included in the tender documents.

Regular timetable (or clock face timetable)
A timetable in which trains that belong to the same route are scheduled with fixed, periodic time intervals between their train paths.
(Source: www.joernpachl.de/glossary)

This timetable is based on two fundamental elements:

- Standardisation of routes, stops and running times
- Repetitive schedules (trains follow each other at regular intervals).

Requirements
Criteria that the TOC or the manufacturer needs to fulfil as minimum standards in order to be qualified for the contract. The fulfilment must be verified and monitored. Bidders that breach the minimum standards will face sanctions that need to be fixed in the tender documents or in the service contract in advance.

Rolling stock
All sorts of railway vehicles, with or without propulsion system, including vehicles for passenger or freight transportation (definition by Railenergy)

Solution
Suppliers may develop different solutions for the application of the same technology. One example is that more than one supplier offers super-capacitors for the on-board storage of energy. Asking for a specific solution can be very close to asking for a specific product and thus cause legal problems for a PTA issuing a tender.

Specific indicator
Different technologies or solutions that are implemented for the same purposes may be compared by specific indicators. These indicators must be defined individually for each cluster or technology. For example, if different technologies for recuperative braking are to be compared, the recuperation rate (recuperated energy compared to the overall traction energy) may be used. Operational, ambient and infrastructural conditions should be harmonised for this purpose.

Specific service profile
A specific service profile describes the characteristics of a real line or network, such as gradients, curves, distances between stations, timetable and maximum track velocity. The more exactly these characteristics are described the more precisely the energy consumption needed for traction effort when driving on this line or network (see also “standard service profile”) can be calculated.

Standard costs
An estimated or predetermined cost level of performing an operation or offering a service, under normal conditions. Standard costs are used as target costs (or the basis for comparison with the actual costs), and are developed from the analysis of historical data or from time and motion studies. The standard costs of energy consumption of regional train operations may be analysed separately from other types of costs. Standard energy costs can be used, for example, as a calculation basis when compensation for cost increases is concerned.

Standard service profile (SSP)
A standard service profile describes the characteristics of a virtual line. The UIC/UNIFE Technical Recommendation 100 001 (www.tecrec-rail.org/100_001) defines such service profiles. The SSPs “Suburban”, “Regional”, and “Intercity” are relevant for awarding regional passenger services or the respective rolling stock. Due to the fact that the calculated energy consumption of a train on these virtual lines is not to be directly compared to the energy consumption of a train on a specific line, the standard service profiles should only be used to compare different vehicle designs on a standardised basis, independently from a concrete network. This approach is similar to standardised test cycles in the automotive industry.

Technology
Equipment of vehicles or the infrastructure. Technologies for reducing energy consumption typically require investment costs while saving operation costs during the lifetime of the equipment or the vehicles. The analysis of promising technologies and operational measures is relevant for PTAs in order to estimate reference levels or reduction potentials. Additionally, it may be appropriate to require or to encourage certain technologies in awarding procedures under certain circumstances.

The quality and performance of technologies can be described by specific performance indicators. These indicators must be defined individually for each technology and can refer to its specific contribution and efficiency in terms of energy consumption, noise or exhaust emissions.

Tender
A proposal made by a transport operator in response to a call published by a PTA in case of competitive awarding. The tender must follow the requirements that are given in the call and in its annexed documents. The time limits enclosed in the awarding documents must not be exceeded.

Tendering
Short for competitive tendering

Traction equipment
Equipment directly needed to produce tractive or dynamic braking effort (e.g. transformer, converters, motors, gearboxes) (see UIC/UNIFE TEC REC 100 001)

Traction unit, tractive unit
One or several railway vehicles with a propulsion system (definition by Railenergy)

Train
Consist of one or more vehicles, including at least one traction unit, all coupled and running together.

Transport performance
The transport performance of passenger services is the number of passengers multiplied with the distance over which every passenger has been transported. The unit of measurement for the passenger transport performance is “passenger kilometre” (pkm).

Abbreviations

CO – Carbon monoxide

CO_2 – Carbon dioxide

dB, dB(A) – Decibel, Decibel A-weighted

DMU – Diesel multiple unit

EACI – Executive Agency for Competitiveness and Innovation

EE – Energy efficiency, energy-efficient

EE/ENV – Energy-efficiency and environment-related (criteria)

EMU – Electric multiple unit

ENV – Environment-…

GHG - Greenhouse gases

HC - Hydrocarbons

IM – Infrastructure manager

ITT – Invitation to tender

kJ – Kilojoule

KPI – Key performance indicator

kWh – Kilowatt hour(s)

MU – Multiple unit

NO_x – Nitrogen oxide(s)

NPV – Net present value

NRMM – Non-road mobile machinery

pkm – Passenger kilometre

PM – Particulate matter

PSC – Public service contract

PTA – Public transport administration

SSP – Standard service profile

tkm – Tonne kilometre

TOC – Train operating company

TSI – Technical Specifications for Interoperability

UIC – International Union of Railways

UNIFE - The European Rail Industry

Legal Annex

Annex L-1: Relevant European law, norms and bodies

EU regulations
(as of 13 April 2011)

Consolidated versions of the **Treaty on European Union and the Treaty on the functioning of the European Union**, OJ C 83/1, especially basic principles

Directive 2001/14/EC of 26 February 2001, OJ L 75/29, on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification

Regulation (EC) No 761/2001 of 19 March 2001, OJ L 114/1, allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)

Directive 2002/49/EC of 25 June 2002, OJ L 189/12, relating to the assessment and management of environmental noise ("Environmental Noise Directive")

European Court of Justice, Case C-513/99 of 17 September 2002 – Concordia Bus Finland, OJ C 274/4

Directive 2004/17/EC of 31 March 2004, OJ L 134/1, coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors

Directive 2004/18/EC of 31 March 2004, OJ L 134/114, on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts

Directive 2004/26/EC of 21 April 2004, OJ L 146/1, 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 ("NRMM = Non-road mobile machinery").

Commission Interpretative Communication on the Community law applicable to contract awards not or not fully subject to the provisions of the Public Procurement Directives (2006/C 179/02), OJ C 197/2

Regulation (EC) No 1370/2007 of 23 October 2007, OJ L 315/1, on public passenger transport services by rail and by road and repealing Council Regulations (EEC) Nos. 1191/69 and 1107/70

Directive 2008/50/EC of 21 May 2008, OJ L 152/1, on ambient air quality and cleaner air for Europe ("Air Quality Directive")

Directive 2009/33/EC of 23 April 2009, OJ L 120/5, on the promotion of clean and energy-efficient road transport vehicles

Commission Decision 2011/229/EU of 4 April 2011, OJ L 99/1, concerning the technical specifications of interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system

Norms and recommendations

EN ISO 3095: Measurement of noise emitted by railbound vehicles

EN ISO 3381: Measurement of noise inside railbound vehicles

EN 16258: Methodology for calculation and declaration on energy consumptions and GHG emissions in transport services (good and passengers transport)

IEC 60050-191: International Electrotechnical Vocabulary. Chapter 191: Dependability and quality of service

IEC 60300-3-3: Dependability management – Part 3-3: Application guide – Life cycle costing

EN 61703: Mathematical expressions for reliability, maintainability and maintenance support terms

IEC 62198: Project risk management – Application guidelines

UIC Leaflet 330: Railway specific environmental performance indicators, Paris (UIC), 2008

UIC Leaflet 345: Environmental Specifications for new rolling stock, Paris (UIC), 2006

UIC Leaflet 410: Composition and calculation of the weight and braking of passenger trains, Paris (UIC), 6th edition, 2006

UIC/UNIFE, TEC REC 100 001, Specification and verification of energy consumption for railway rolling stock, 2010; download on:
http://www.tecrec-rail.org/100_001

VDV 154: Geräusche von Nahverkehrs-Schienenfahrzeugen nach BOStrab, Verband Deutscher Verkehrsunternehmen, VDV-Schriftenreihe, 2002
(This document is not available in English.)

Bodies

Community of European Railway and Infrastructure Companies (CER)
www.cer.be

European Committee for Electrotechnical Standardization (CENELEC)
www.cenelec.eu

European Court of Justice (ECJ)
http://curia.europa.eu/

European Rail Infrastructure Managers (EIM)
www.eimrail.org

European Railway Agency (ERA)
www.era.europa.eu

International Union of Railways (UIC)
www.uic.org

The European Rail Industry (UNIFE)
www.unife.org

International Association of Public Transport (UITP)
www.uitp.org

The ECORailS Consortium

The project ECORailS consists of European PTAs, research institutes and consulting companies from six countries (Sweden, Denmark, Germany, Italy, Hungary and Romania).

- TSB FAV Berlin – Germany
- Senate Department for Urban Development Berlin – Germany
- Pro-Rail Alliance – Germany
- KCW GmbH – Germany
- Berlin University of Technology – Germany
- Trafikstyrelsen – Denmark
- Transportforskningsgruppen I Borlänge AB – Sweden
- Province of Brescia /
  ALOT – Agency of East Lombardy for Transports and Logistics – Italy
- Università Commerciale „L. Bocconi“ – Italy
- Università di Roma „La Sapienza“ – Italy
- Integral Consulting RD – Romania
- Universitatea POLITEHNICA din Timisoara – Romania
- CFR Timisoara – National Society of Railway Transport – Romania
- Budapest University of Technology and Economics – Hungary

Project coordinator

TSB Innovationsagentur Berlin GmbH
Department for Transport and Mobility
Fasanenstraße 85, D-10623 Berlin

www.fav.de

contact: Mr. Martin Schipper
phone: +49 (0)30 46 30 25 77
e-mail: schipper@tsb-berlin.de
web: www.ecorails.eu

Public Transport Administrations (PTAs) play a key role today when it comes to improving the quality and environmental performance of passenger rail transport. The main purpose of these Guidelines is to support decision makers in the process of including energy efficiency and environmental criteria into the PTAs' awarding procedures and service contracts.

The document addresses all persons with responsibility for the organisation of Public Passenger Transport, including management units, government officials and politicians as well as PTA employees who prepare, compile, and evaluate tender documents and contracts.

The project consortium of 15 partners from six European countries developed the Guidelines to help decision makers take energy efficiency improvements, noise and green house gases/exhaust gas reductions into account when awarding regional railway passenger transport services and rolling stock.

Key parts of the Guidelines have been evaluated in four European test regions (Lombardy, Berlin-Brandenburg, Øresund, Timişoara), which represent different situations in European regional rail passenger transport. Altogether, over 50 key actors and stakeholders of the project, including public transport administrations, train operating companies, infrastructure managers and suppliers, identified the different requirements, needs and expectations on environment-related awarding.

ECORailS

Imprint

Compilation of the Guidelines:
Matthias Pippert
Allianz pro Schiene e.V.

Published by:
Allianz pro Schiene e.V.
Reinhardtstraße 18
10117 Berlin, Germany

phone: +49 (0) 30 24 62 599-0
fax: +49 (0) 30 24 62 599-29
e-mail: info@allianz-pro-schiene.de

web: allianz-pro-schiene.de

Layout/Typesetting:
id praxis - Agentur für Werbung, Public Relations & New Media GmbH, Berlin

Photos: ARRIVA, DB AG/Axel Hartmann, Matthias Pippert (3 x)

Place of publication: Berlin, June 2011
V.i.S.d.P.: Matthias Pippert