Study on

Non-traction energy consumption

and related CO_2 emissions

from the European railway sector

Final report prepared and submitted for the UIC Network of energy efficiency experts

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1. Summary

This report contains the main results of the non-traction energy consumption study prepared for the UIC and its network of energy efficiency experts. Overall energy consumption for railways is typical split into traction (around 85%) and non-traction (around 15%) energy consumption. Non-traction energy consumption for railways is divided into five main areas of activity:

1. Commercial activities: Stations and concessions
2. Maintenance activities: Workshops, depots and service buildings
3. Heating of switches
4. Technical railway operation: Lighting of infrastructure, signalling, telecom, traffic control and data centres
5. Administration and offices (outside scope of study)

With respect to railway non-traction energy efficiency two EU Directives are relevant at European level: the Energy Efficiency Directive (Proposal for a Directive on energy efficiency COM(2011)370) and the Directive on Energy Performance of Buildings (Directive 2010/31/EU). It is the assessment so far that incumbent railways are seen as public bodies and that railway facilities in general such as stations and offices will be covered by these provisions whereas workshops and depots will not. When railways are building new or making major renovations, EU energy requirements will be in force. Similarly railways are likely to be covered by provisions for energy audits and improvement targets for existing buildings.

As part of this study an online survey and several interviews were performed analysing the current status and activities for non-traction energy efficiency at European UIC members. There is a broad spectrum of energy efficiency activities in European railway companies concerning non-traction energy efficiency – ranging from new lighting systems, management of heating, cooling and ventilation over intelligent control of energy efficient equipment, energy requirements for contractors to energetic overhaul of buildings.

Recommendations for indicators and benchmarking

Following the revision of the indicator proposal from SNCB Holding[1] it is likely that consistent, reliable and usable non-traction energy indicators for railway operation could be defined and applied successfully among the UIC members covering operators, infrastructure managers as well as integrated railway companies. It is therefore recommended to consider launching a targeted UIC project to discuss and agree upon the description and definition of the exact non-traction energy indicators relevant for railway operation. It is furthermore recommended to consider launching a targeted UIC project to collect, benchmark, and communicate among UIC members their non-traction energy efficiency and CO_2 performance according to agreed indicator definitions.

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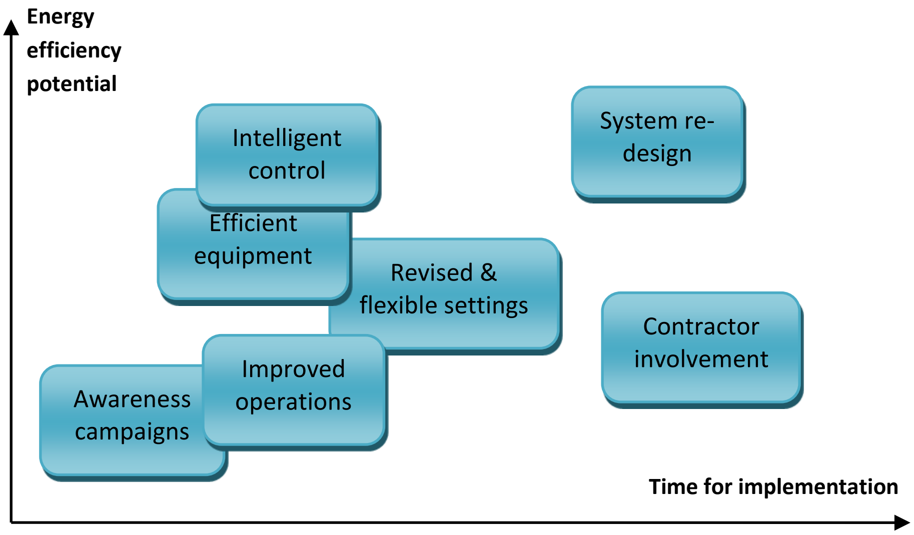
[1] Quoted in the Terms of Reference for this study

Recommendations for activity fields

The most promising technical and operational measures are listed together with the description of the main trends within each of the following five fields of railway activity: Commercial activities (station and concessions), maintenance activities (workshops, depots, and service buildings), heating of switches, technical railway operation (lighting of sidings and marshalling yards, signalling, telecom and data centres) as well as user behaviour and service quality.



The figure above illustrates “time for implementation” versus “energy efficiency potential” for different types of relevant measures. It is a generic picture applicable to all the fields of activity for non-traction energy efficiency in the railways. In the lower left corner are those measures which need little investment and short implementation times but also limited saving potential e.g. awareness campaigns and improved operations. Efficient equipment and optimised control require higher investments but also yield considerably higher energy savings.

Interesting saving potentials can also be exploited by revising settings for comfort and quality criteria e.g. temperature settings. Contractor involvement requires more time for implementation while offering interesting efficiency potentials with little investments needed. Finally system re-design based on current and future user needs offers significant savings but planning and implementation time could be extensive. Integration of energy efficiency aspects with existing planning is vital in all cases.

Commercial activities: Stations and concessions

The trend is that energy consumption generally is going up due to higher activity and comfort levels in this field. Legislation does exist for new buildings and major upgrades and future legislation will be even stricter.

Field of activity	Recommended efficiency measure	Subsystem saving potential
Lighting	• Intelligent control • Replacement of less efficient lighting	• 10-30% • 10-40%
Heating and cooling	• Intelligent control including temperature setting • Insulation of roof and wall • Renewal of installation • Modern heat pumps (A+)	• 10-20% • 10-30% • 20% • Up to 30%
Powered equipment	New efficient drives (A+) and intelligent control	10-40%
Concessions/shops	Targets and energy audits built into contracts	Up to 20% *

Maintenance activities: Workshops, depots and service buildings

Energy consumption in this area is going down due to the overall improvements of energy efficiency in buildings and the reduction in numbers of workshops and depots due to improved operations. This is mainly driven by building legislation and the need to reduce operational costs.

Field of activity	Recommended efficiency measure	Subsystem saving potential
Lighting	• Intelligent control • Replacement of less efficient lighting	• 10-30% • 10-40%
Heating and cooling	• Improved insulation of buildings • Intelligent control including temperature setting • Modern heat pumps (A+)	• 10-30% • 10-20% • Up to 30%
Powered equipment	New efficient drives and pumps (A+) plus intelligent control	10-40%
Lighting	• Intelligent control • Replacement of less efficient lighting	• 10-30% • 10-40%

Heating of switches

Energy consumption in this area is going down as the energy cost itself is a strong driver and efficiency measures have been implemented to a certain extent within the last decade. Furthermore the rail networks are getting more productive which means that the total amount of switches is going down despite of growing traffic. In this area no legislation exists neither is it foreseen.

Field of activity	Recommended efficiency measure	Subsystem saving potential
Number of switches	Planned and optimised network design with reduced number of switches	Up to 30%
Heating of switches	• Intelligent control including optimised temperature settings & accurate weather forecasting • Improved switch heating design	In total 20-50%

Technical railway operation

Energy consumption is going up due to higher activity and information levels in this field partly due to the technology shift in signalling and communication. The fast growing activity of mobile communication also contributes to rising energy consumption. No energy legislation exists but since most of the activities in this field are safety relevant, special care is needed for implementing energy efficient solutions.

Field of activity	Recommended efficiency measure	Subsystem saving potential
Lighting of marshalling yards	• Intelligent control • Replacement with low-pressure sodium or LED lamps	• 10-30% • 10-40%
Cooling of trackside equipment	• Intelligent control • Improved design including ambient air • Replacement of cooling agents and filters	• 10-30% • Up to 30% • Up to 15%
Number of signals	Planned and optimised network design with reduced number of signals in use	Up to 30%
Signal lights	LED based light systems (with built-in resistors due to safety)	20-30%
Data centres	"Green data centres" with intelligent control, efficient equipment and ambient air/soil cooling	25-50%

User behaviour and service quality

New innovative concepts are more focussed on assessment of real user needs and meeting adequate service quality for the railway customers. Rethinking e.g. levels for lighting, heating and ventilation and making use of ambient conditions and renewable energy sources all lead to significant energy savings on system level.

Field of activity	Recommended efficiency measure	Subsystem saving potential
Comfort levels and quality criteria	Revision of comfort levels and quality criteria with respect to energy efficiency and based on assessment of shifting needs	Up to 15%
Working procedures	Improved procedures with integration of energy efficiency aspects	Up to 10%
Awareness	Awareness campaigns focussing on energy efficient behaviour	5-10%

Next steps

For UIC and its members the most important next steps would be the following:

- Networking and exchange of experience and good practices between railway experts within the specific fields identified in this report.
- Facilitation of knowledge exchange within the sector as well as with rail manufacturers, research institutions and academia.
- Development of a targeted EU or UIC project. The aim of such project could be:
    - Knowledge transfer within the sector
    - Migration and adaptation of non-railway specific technologies
    - Development of a professional web-based dissemination platform like for the UIC project EVENT or as an E-learning system like for the UIC/SkillRail project for Railenergy outputs
    - Development of the framework for benchmarking non-traction energy efficiency activities

2. Introduction

Overall energy consumption for railways is typical split into traction (around 85%) and non-traction (around 15%) energy consumption. This split is a "rule of thumb" and is valid for most operators and integrated railways but is of course not applicable for infrastructure managers. This report focuses on the non-traction energy consumption breakdown and composition with the aim of providing an overview of the state of the art in the sector, legislation, good practise, indicators and by giving clear recommendations for lanes of actions and next steps to improve energy efficiency.

2.1 Scope

Table 1 below outlines the main activity fields with breakdown for each category for non-traction energy together with its relevance for operators, infrastructure managers and integrated railways. It is difficult to create a fixed split of relevance for infrastructure managers and operators – especially regarding stations and concessions – mainly due to the different implementation of EU Directive 91/440/EC. Read more about this in section 4.7.

Activity fields related to non-traction energy consumption for railways	**Operator**	**Infrastructure manager**	**Integrated railway**
1. Stations and concessions • Lighting of stations and platforms • Heating, cooling and ventilation • Powered equipment like escalators & elevators • Passenger information • Shops and concessions	●●○	●●○	●●●
2. Workshops, depots and service buildings • Lighting • Heating, cooling and ventilation • Powered equipment like machines, pumps and cranes	●●○	●●○	●●●
3. Heating of switches	●○○	●●●	●●●
4. Technical railway operation • Lighting of infrastructure • Signalling, trackside equipment and level crossings • Telecom like train radio, GSM-R etc. • Traffic control and data centres (including outsourcing)	●●○	●●●	●●●
5. Offices and administration (outside scope of this study) • Lighting • Heating, cooling and ventilation • Powered equipment like escalators & elevators	●●●	●●●	●●●

Relevance and responsibility: ●●● high ●●○ medium ●○○ low

Table 1 Main fields of activity for non-traction energy consumption

The UIC energy efficiency and CO_2 expert network has played active part in the definition of the scope and the following has been agreed: The scope for this study is all non-traction energy consumption for the UIC members with special focus on the railway specific consumption. This means that energy consumption and efficiency measures for offices and normal administration is not further elaborated since much literature and examples of good practise exist in this field already.

Also it was agreed not to include energy consumption from railway road vehicles and infrastructure construction, the ladder is treated using requirements to contractors. Finally energy consumption for parked trains is not part of this study with some exceptions due to the different approached around Europe. At SBB in Switzerland energy for parked trains is within the non-traction energy field also due to way it is being managed.

2.2 Methodology

The methodology for this study is based on a combination of actions:

- Desktop research and active collection of information
- Interviews with selected UIC members and experts
- Online survey circulated to all UIC/EES members
- Systematic evaluation and assessment of technology and operational options, and saving potentials
- Assessment of non-traction indicators (energy and CO_2)
- Assessment of barriers, incentives and implementation schemes

3. Legal framework and standardisation

With respect to railway non-traction energy efficiency two EU Directives are relevant at European level and will have impacts in the next years on main energy consuming sectors and systems. In addition, national legislation and non-legislative elements (e.g. “Long term agreements” in the Netherlands) could tackle specific parts and applications of energy consumption and efficiency of whole companies but are not covered in this study.

The two Directives in question are the Energy Efficiency Directive (Proposal for a Directive on energy efficiency COM(2011)370) as well as the Directive on Energy Performance of Buildings (Directive 2010/31/EU). Together they cover main energy consumers such as buildings and companies.

3.1 Directive on Energy Performance of Buildings (2010/31/EU)

This Directive[2] concerns the residential and the tertiary sector (offices, public buildings, etc.) and is the main legislative instrument at EU level to achieve better energy efficiency in buildings. Under the Directive, member states have to enforce minimum requirements with regards to energy performance of new and existing buildings as well as technical building systems whenever they are installed, replaced or upgraded[3]. Additionally, certification of buildings’ energy performance as well as regular inspections of boilers and air conditioning systems in buildings is required. Part of this is the setting up of energy labels for buildings, see illustration below.

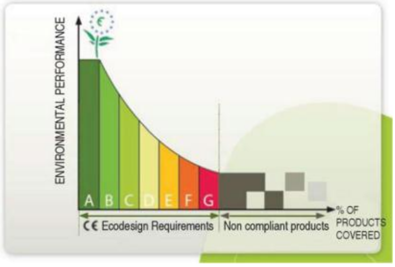


Figure 1: The relationships between eco-design, energy label and eco-label

The Directive includes *inter alia* minimum standards on the energy performance of new buildings as well as existing buildings that are subject to major renovation and methodologies for calculating the energy performance of buildings. The results of applying these methodologies may serve as input for standard performance indicators for the energy performance of railway buildings covered by the Directive.

The Directive demands that by 2020 all new buildings are nearly zero-energy buildings and by 2018 that new buildings occupied and owned by public authorities are nearly zero-energy buildings. The Directive demands additionally new buildings to be build using high-efficiency alternative systems like de-centralized energy supply systems based on energy from renewable sources, co-generation, district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources, heat pumps – after assessment of the technical, environmental and economic feasibility – technologies that have already been partly applied by some railway companies.

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[2] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast); http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

[3] Technical equipment for the heating, cooling, ventilation, hot water, lighting or for a combination thereof

The European Commission considers railway stations to be directly covered by the provisions of the Directive on energy performance of buildings as communicated to the European Parliament. According to the statement, new railway stations will have to be nearly "zero-energy" by the end of 2018 and member states will have to "take measures to stimulate the transformation of existing buildings into nearly zero-energy buildings" [4,5]. As Member States have to set minimum requirements for existing buildings that are subject to major renovation works, railway station may be targeted by such requirements too. Technical buildings such as workshops are not covered by the Directive (Art. 4, (c)).

3.2 Directive on Energy Efficiency (COM(2011)370)

This proposed Directive[6] concerns an overall energy efficiency improvement towards the EU target of 20% primary energy savings in 2020. It is in the process of negotiations and the time plan foresees a finalization of the legislative process until 2013. The following observations are therefore only reflecting the status as of end March 2012[7]:

The main proposals include provisions that public bodies would need to buy energy-efficient buildings, products and services, and refurbish 3% of their buildings each year. Mandatory energy audits and the introduction of Energy Management Systems for large companies will have to be implemented as well as a more systematic use of Energy Performance Contracting[8].

Additionally, Member States shall set up an energy efficiency obligation scheme that ensures energy distributors or retail energy sales companies achieve annual energy savings equal to 1,5 % of their energy sales. This amount of energy savings shall be achieved by the obligated parties among final customers. Member states can decide whether or not to include transport. This provision is also not yet decided.

It is to be expected that railways – with respect to current and former state owned operators and infrastructure managers – will not be treated as public bodies; however this is still not finally decided. Additionally, the demand for company-wide Energy Management Systems and Energy Performance Contracting may be applied to railway companies too. Finally, railways with a unified energy purchase and holding-internal retail system as well as own electricity generation facilities may fall under the provisions of 1,5% p.a. reduction of energy consumption of their customers.

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[4] Answer given by the Commissioner for Energy on behalf of the Commission www.europarl.europa.eu/sides/getAllAnswers.do?reference=E-2011-001650&language=en

[5] Parliamentary questions from 23 February 2011 (E-001650/2011), question for written answer to the Commission, Rule 117, Oreste Rossi (EFD), Subject: 'Green' railway stations www.europarl.europa.eu/sides/getDoc.do?type=WQ&reference=E-2011-001650&language=EN

[6] Proposal for a Directive on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC [COM(2011)370, 22/06/2011]; http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

[7] Communication with CER (Ilja Lorenzo Volpi) March 28th 2012

[8] According to EU's definition „a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, according to which the payment for the investment made by the provider is in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings." (Proposal for a Directive on energy efficiency, art. 2, (13))

3.3 Energy Management Systems (ISO 50001)

Energy management in the railway companies is often performed as part of their environmental management systems. Such system could be standardized according to e.g. ISO 14001 which is already more than 15 years old. Since June 2011, a new standard focusing on energy only has seen the daylight: ISO 50001. The rising energy prices have forced the international business community to act and enforce this useful energy management system.

In brief, ISO 50001 will provide public and private sector organizations with management strategies to increase energy efficiency, reduce costs and improve energy performance. The standard is intended to provide organizations with a recognized framework for integrating energy performance into their management practices. Multinational organizations will have access to a single, harmonized standard for implementation across the organization with a logical and consistent methodology for identifying and implementing improvements.

In particular, ISO 50001 follows the Plan-Do-Check-Act process for continual improvement of the energy management system. These characteristics enable organizations to integrate energy management now with their overall efforts to improve quality, environmental management and other challenges addressed by their management systems. ISO 50001 provides a framework of requirements enabling organizations to:

- Develop a policy for more efficient use of energy
- Fix targets and objectives to meet the policy
- Use data to better understand and make decisions concerning energy
- Use and consumption
- Measure the results
- Review the effectiveness of the policy
- Continually improve energy management

ISO 50001 is a standardised alternative to internal and informal management structures and is a step up compared to the UIC initiative “Process, Power, People” from 2008.

4. Analysis of results from survey and interviews

As part of this study an online survey and several interviews were performed analysing the current status and activities for non-traction energy efficiency at European UIC members. Figure 2 below illustrates the coverage of the online survey and the interviews performed. In total six face-to-face interviews were performed with seven different UIC members. 23 answers were received from 22 UIC members for the online questionnaire[9]. The following sections present the main findings from these answers.

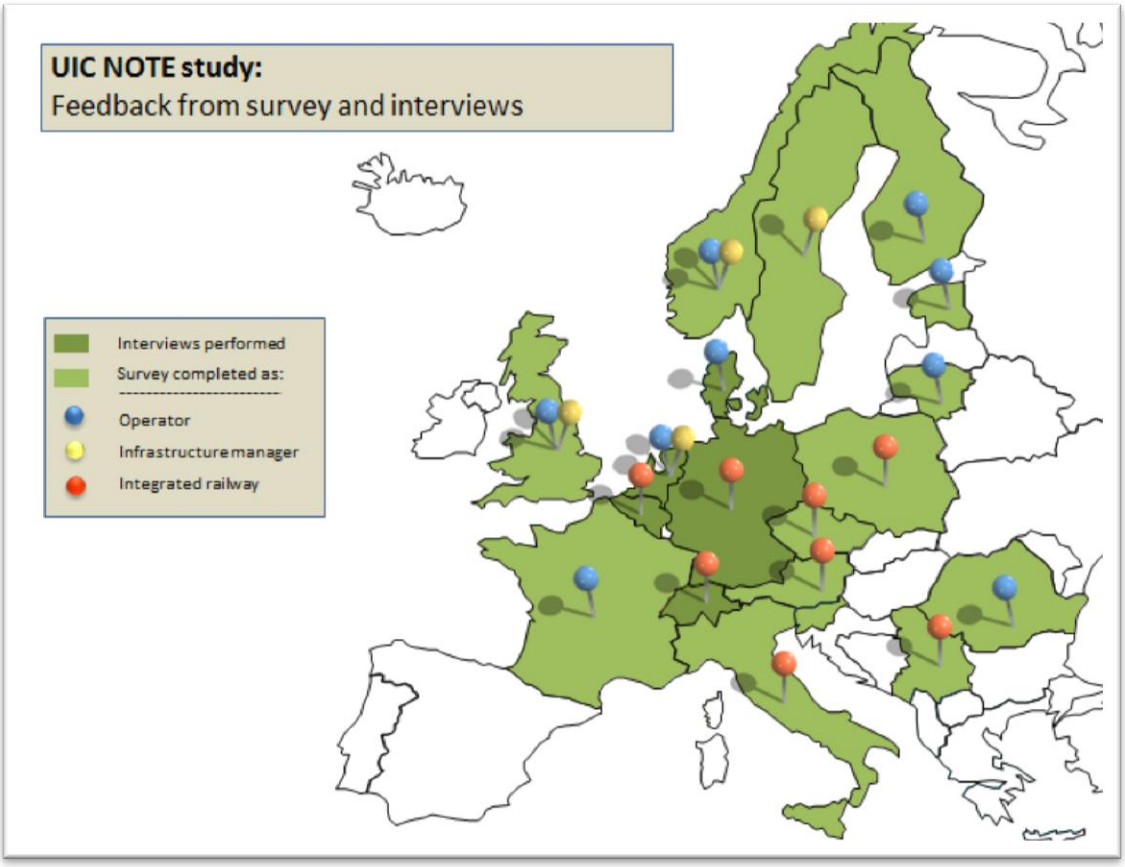

Figure 2 Overview of feedback from online survey and interviews

4.1 Typical breakdown for non-traction energy consumption

The breakdown of non-traction energy has some similarities but it is difficult to create a typical breakdown for infrastructure managers and operators. This is not due to the technical conditions and performance but rather because of organisational and country-specific differences. The implementation of EU-Directive 91/440/EC with the split of infrastructure managers and operators is done in so different ways that it is very difficult to compare and benchmark the UIC members in a consistent way. The main point here is the ownership of the stations, sometimes it is the infrastructure manager and sometimes the operator.

For infrastructure managers, two large activities are signalling/telecom and switch heating each counting for approximately 20 % of the overall energy consumption. Energy consumption in stations is around 30%

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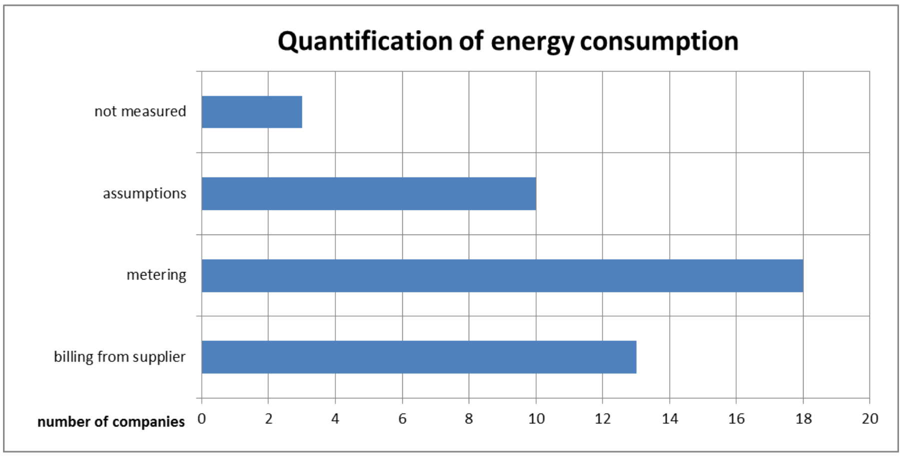
[9] See annex 7.3 and 7.4 for details of respondents

(light, equipment, passenger information) while other 20% is energy for other infrastructure elements (lights and other buildings). Finally around 10% is for offices/administration. This split is inspired from the ProRail breakdown.

For operators, the main parts are stations and concessions (if applicable), workshops, depots for trains and offices/administration. If stations are applicable the split could look like this: stations and concessions (40%), depots (20%), workshops (30%) and administration (10%). This split is inspired from the DSB breakdown.

4.2 Quantification of non-traction energy consumption

The quantification of non-traction energy consumption is usually carried out by a combination of energy metering and assumption/calculations. Based on this rough breakdown of consumption, billing is done mostly either by the energy provider or by the infrastructure manager. With a few exceptions the metering is performed on an aggregated level – e.g. for a whole railway station. In some companies there are already ongoing activities for detailed metering e.g. on a single concession level. Although the main driver for installing sub-meters is transparent billing of energy consumption, energy efficiency aspects do play a role as well.

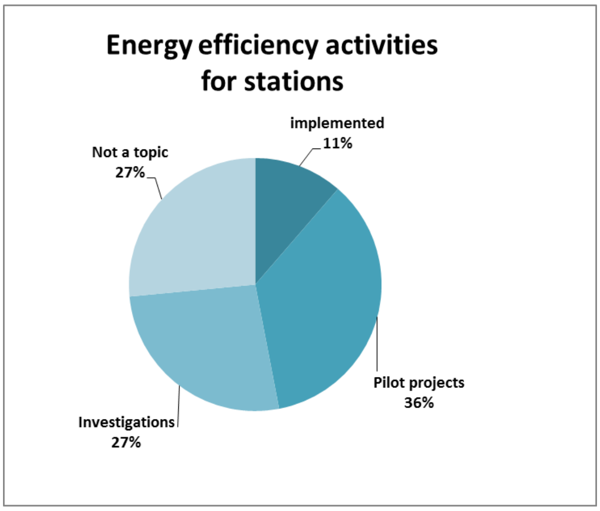


4.3 Stations and concessions

There is a broad spectrum of energy efficiency activities in European railway companies concerning stations and ranging from new lighting systems, management of heating and cooling and energy efficient equipment to energetic overhaul of buildings. The following table gives an overview over the status of the different activities within the European railways. The activity with the highest number of pilot projects is new lighting systems for station buildings and platforms. Here the railways are testing the advantages of LED lighting solutions and intelligent lighting control. The leading activities regarding the number of already implemented solutions are the energetic overhaul of buildings and energy efficient equipment. For the buildings the focus is on improved design and buildings standard as well as optimized insulation. More advanced solutions in the area of air conditioning of station buildings include the use of heat pumps to reduce the needed energy for cooling in the summer (NS Poorts).

Energy efficiency activity	**implementation level**				
	implemented	**pilot projects**	**investigations**	**not a topic**	**Total answers**
New lighting systems for station buildings		12	6	4	22
New lighting systems for platforms	1	10	5	6	22
Optimized heating systems	3	8	6	5	22
Optimized air conditioning and cooling	1	6	7	8	22
Energy efficient equipment (e.g. escalators)	5	5	6	6	22
Energetic overhaul of buildings	5	6	5	6	22

The average level of implementation can be described as follows: the current focus is on investigations and pilot projects (62,5%), practical implementation beyond pilot projects is still rather low (11%). For the remaining 26,5% energy efficiency measures stations is not yet a topic.

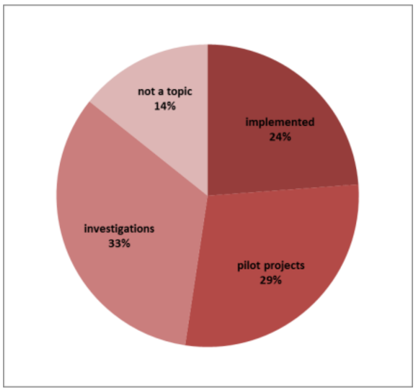


One of the most problematic areas regarding the energy efficiency of stations is the implementation of energy saving solutions for concessions. Most railways exert only little or no influence on the energy consumption of the concessions in their railway stations. An exception is NS Poorts (NL) who still owns and manages 50% of its concessions and systematically introduces energy efficiency solutions in the shops. Furthermore, the successful pilot projects and implementations are used to spread the efficiency solutions to concessions which are not operated by NS Poorts.

4.4 Workshops, depots and service buildings

Workshops and depots	**implementation level**				
	implemented	**pilot projects**	**investigations**	**not a topic**	**Total answers**
Energy management in workshops	5	6	7	3	21

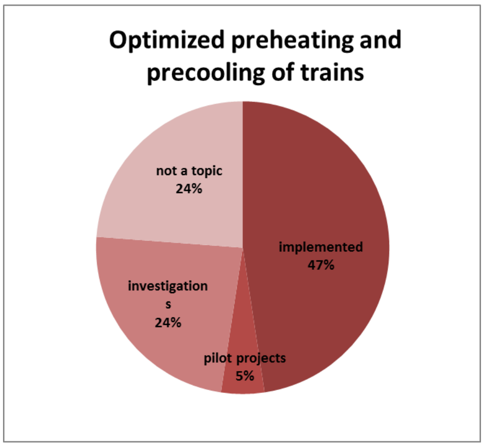
Energy efficiency activities for workshops, depots and service buildings comprise mainly new lighting systems and energy management solutions for heating and cooling. There are also a few examples for energy efficient equipment. Like for the stations, the main focus of the railways is currently on investigations and pilot projects which indicate the importance of this area. Some isolated implementations can be found for energy management in workshops. Some railways have already started to investigate the energy consumption of workshops in a systematic way e.g. by performing energy audits to provide a solid basis for the prioritization of measures and later implementation.



4.4.1 Pre-heating and pre-cooling of parked trains

Parked trains	implementation level				
	implemented	pilot projects	investigations	not a topic	Total answers
Optimized management of preheating and precooling	10	1	5	5	21

The energy for pre-heating and pre-cooling of parked trains is not always seen as non-traction energy. It can either be taken from the catenary or from shore supply. Rather independent of the energy source railways classify this energy consumption differently. For some it belongs to traction energy, for others to non-traction energy consumption. Energy efficiency measures in this field mainly focus on approaches which take the actual train schedules into account in order to start the pre-heating of pre-cooling process at a well-defined time interval before departure. More sophisticated solutions take weather conditions into account in order to minimize pre-heating and pre-cooling times and the respective energy consumptions. The implementation of energy efficiency measures is with 47% rather high, only one quarter of the railways do not consider it a topic at the moment.



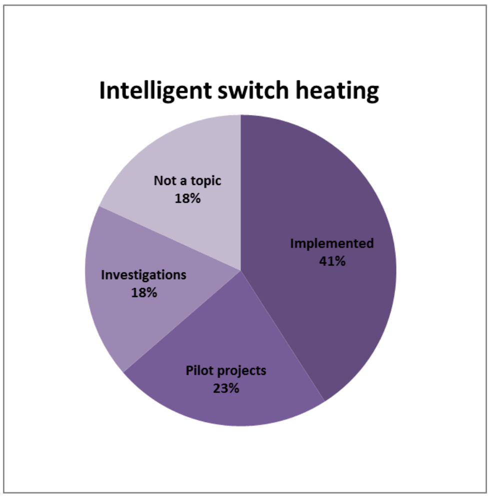
4.5 Switch heating

Switch heating	implementation level				
	Implemented	Pilot projects	Investigations	Not a topic	Total answers
Optimized management	9	5	4	4	22

Switch heating is one of significant areas of non-traction energy consumption. For an infrastructure manager, the typical share of non-traction energy needed for switch heating is between 10% and 20%. Activities range from simple single switch and rail-temperature based controlling solutions to sophisticated systemic approaches which take also into account actual weather data and weather projections, especially for snowfall.

As can be seen from the table above, many railways have either already implemented energy efficiency solutions for switch heating or are performing pilot projects in the area. The average implementation rate is among the highest of non-traction energy efficiency measures:

More than 40% have already implemented energy saving measures and for only 18% the energy management of switch heating is currently not a topic. Despite the rather good implementation rate there is still a large saving potential to be exploited since many solutions are still rather low tech and based on single switch approaches. Even the railways most advanced in this field as e.g. SBB state that more than 30% of the overall saving potential are not yet exploited.



A dedicated systemic approach in this field should also assess the number of switches needed for current and future traffic demand. Interesting saving potentials can be activated by redesigning parts of the network and reducing the number of switches needed. This approach is especially relevant for projects concerning the overhaul and modernization of railway stations. One of the few railways which systematically follow this approach is ProRail.

4.6 Lighting of infrastructure, operation of signalling, telecom, traffic control and data centres

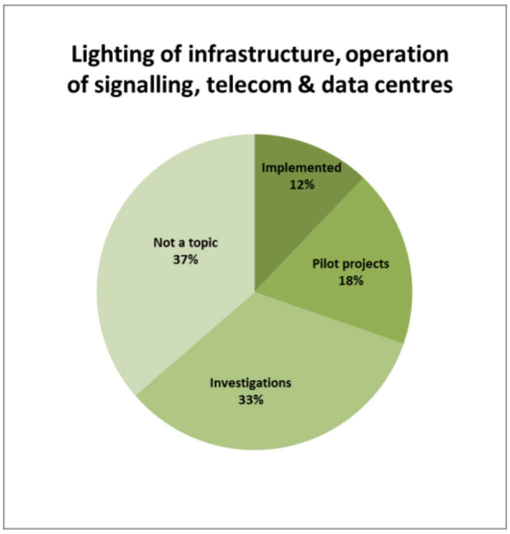
Energy efficiency activities for lighting of infrastructure focus mainly on new lighting technologies and optimised controlling according to ambient conditions and occupational health issues for marshalling yards and sidings. For signalling and telecommunications energy efficiency activities focuses mainly on efficient cooling of track side equipment such as switch boxes, classical communication boxes and GSM radio boxes. Measures range from management of fan speed and exchange of cooling liquid to more advanced and efficient solutions with ambient air cooling. There are also a few activities in the area of LED signalling but because of the high safety relevance barriers for implementation are high.

Lighting of infrastructure, operation of signalling, telecom and data centres	**implementation level**				
	Implemented	**Pilot projects**	**Investigations**	**Not a topic**	**Total answers**
New lighting systems for marshalling yards	0	8	8	7	23
Energy efficient control of track side equipment	4	3	5	10	22
Energy efficient data centres	4	1	9	7	21

Energy efficient data centres is an upcoming topic since the energy demand in this application area is constantly increasing. For practical implementations energy demand is currently only rarely an assessment criterion despite the fact that a wide range of technical solutions exists. Against this background the saving potentials which can be still exploited are high.

The average level of implementation in this field is rather low: only 19% of the railways have already implemented energy efficiency measures and only 9% are carrying out pilot projects. Since about 40% of the railways consider it not a topic at the moment it is also the field which gets currently the smallest attention. This should not lead to the conclusion that energy efficient signalling and telecom cannot substantially contribute to energy savings in non-traction energy.

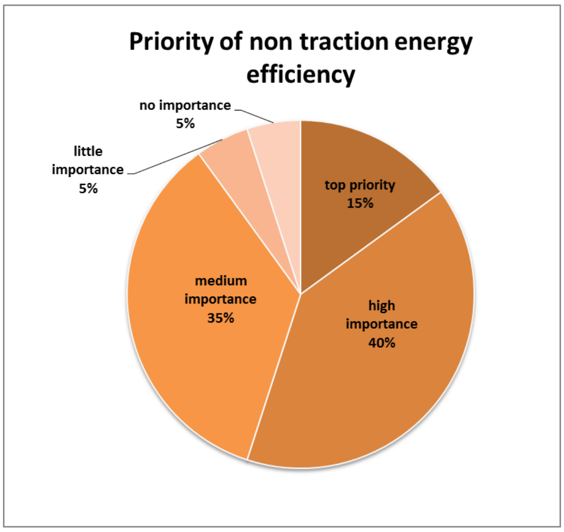
On the contrary – since its share at overall non traction energy consumption is typically around 10% the potentials are high and successful examples e.g. at SBB show that a considerable part can already be exploited with relatively simple measures.

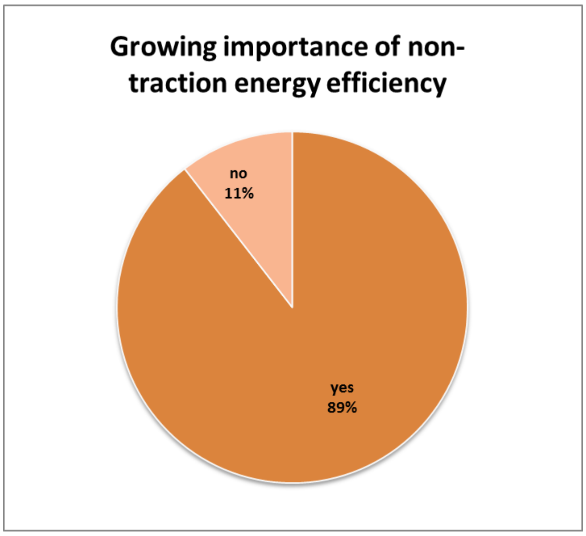


4.7 Company policy and strategy for non-traction energy efficiency

The overall importance of non-traction energy efficiency for European railways is already rather high. For 17% the topic has already top priority and for 38% the topic is of high importance. Only for one company non traction energy efficiency is of little importance and for one not important at all.

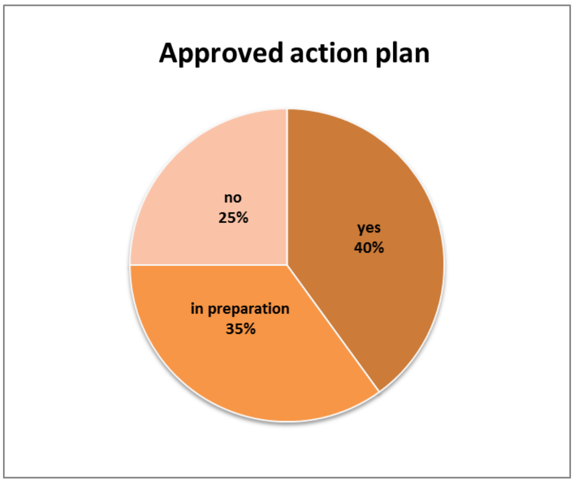
Priority of non traction energy efficiency	**Priority**					
	Top priority	High importance	Medium importance	Little importance	No importance	Total answers
	3	8	7	1	1	20





The perception of a growing importance of non traction energy efficiency in the future is almost unanimous – whereas for 17 companies this trends is already clearly established, only 2 company do not perceive a growing importance.

Approved action plan	**Yes**	**In preparation**	**No**	**Total answers**
	8	7	5	20



Within the last few years the implementation of energy efficiency measures for non-traction has significantly increased within the railways. This development is mirrored in the fact that the majority of companies either has already approved action plans for this area or is currently developing such action plans:

Most of the companies with approved action plans have also committed themselves to mid- and long-term saving targets for non-traction energy. In addition, some companies without action plans have defined operative saving targets. In total, 50% of the companies who have answered this question in the survey have official saving targets.

An interesting framework for mid- and long-term saving has been developed in the Netherlands with the Long Term Agreement (LTA) between the government and NS/ProRail/NS Poorts/Nedtrain. These long-term saving target is defined for a 10 year period and is broken down into yearly saving targets of 2% for non-traction providing the basis of updated actions plans and programs. Some companies do not define energy saving targets but work with CO2 reduction targets instead. An example is Network Rail with a 20% CO2 reduction target for non-traction energy for the 8 year period 2006-2014.

	Yes	In preparation	No	Total answers
Official saving targets	11	2	7	20

4.8 Stakeholder involvement

The planning and implementation of energy efficiency measures for non-traction energy involves different internal stakeholders in the railway companies. Typically, at least the energy, infrastructure and environmental departments are co-operating and technical expertise is integrated from the relevant application area. External stakeholders are only rarely integrated, in some cases there is already a co-operation with concessions and in very few cases with the energy provider.

A positive example for internal and external stakeholder integration are the Netherlands where an integrated energy efficiency effort of NS, NS Poorts, ProRail and Nedtrain is also involving NL Agency. The most visible outcome of this common activity is a dedicated long term agreement (LTA). Successful implementations and projects show that a multi-stakeholder effort is needed which should in more advanced stages also include contractors and other relevant external stakeholders.

4.9 Drivers and barriers for implementation of energy efficiency measures

The main drivers for the implementation of energy efficiency measures are energy costs and legislation. Already rather high energy costs and especially the expectation of rising energy costs in the future lead to growing demand for energy efficiency solutions. The most important legislative driver in the area of non-traction energy is the EU Directive on energy efficiency (2011/370). But compliance with national legislation plays also an important role. For some railways the overall reduction of the carbon footprint and related explicit long-term targets has become significant driving forces as well.

One of the main barriers for the implementation of energy efficiency solutions is the fact that energy billing is often not reflecting real energy consumption. Energy metering is mostly only available on a highly aggregated level and the applied breakdown models and assumptions are too rough and too static. Due to the fragmented structure of many railways the investment costs and energy efficiency benefits are often not very well aligned, i.e. the one who does the investment does not necessarily profits from the savings.

Another barrier is a rather strong focus on initial investment and very short payback times. Further restrictions include the lack of internal manpower for the coordination of energy efficiency projects and high costs of some advanced saving technologies. Railways also report that planning and approving procedures are too time consuming and bureaucratic. In addition, the current economic crisis also prevents railway companies to invest more heavily into energy efficiency technologies.

5. Indicators for non-traction energy consumption

UIC has a strong tradition for defining clear key performance indicators within the field of environment. The UIC leaflet 330 defines the main environment indicators by relating e.g. energy consumption to the relevant business activity (train production). For non-traction energy a similar approach is planned on the basis of a draft set of indicator areas elaborated by SNCB Holding[10]. The following revision of indicators follows the principles outlined in leaflet 330 as regards transparency, systematic and functional approach.

5.1 Overview of possible non-traction indicators

The following table is based on the SNCB Holding proposal and lists the non-traction indicators revised according to the structure and analysis outlined in chapter 2 of this report with revised denominators proposed for local (single site) and company benchmarking:

ID	Field of coverage	Main energy consuming activities	Proposed denominator for local benchmarking	Proposed denominator for company benchmarking
1	**Commercial activities:** Stations and concessions	Lighting, heating, cooling, ventilation and air-conditioning in stations, platforms and shops/concessions, station elevators and escalators, maintenance and depots	Number of daily/annual passengers using a specific station or station class (e.g. divided into four categories: rail cities, bigger stations, smaller stations, simple stops)	Number of annual passengers per country or region for a given collection of stations
2	**Maintenance activities:** Workshops, depots and service buildings	Lighting, heating, cooling, ventilation and air-conditioning, equipment, machinery, maintenance and cleaning of workshop and depots.	Building surface or daily/annual production of locos/train sets per site or site class (e.g. divided into three levels: daily cleaning and maintenance, light and heavy maintenance/overhaul)	Annual production of trains (locos and train sets) for all relevant sites
3	**Heating of switches**	Heating of switches (gas, electric, heat pumps)	Number of switches	Relevant (national) production (train-km)
4	**Technical railway operation:** • Lighting of infrastructure • Signalling and telecom • Traffic control and data centres	• Lighting of infrastructure, sidings and marshalling yards • Daily operation and cooling/ventilation of signalling equipment (switch boxes and dispatching centres) and telecom (GSM-R, train radio, etc.) • Heating, cooling and ventilation of traffic control and data centres	• Length of tracks for marshalling • Local train production or trains passing the defined infrastructure.	Relevant (national) production (train-km)
5	**Administration:** Offices	Lighting, heating, cooling, ventilation and air-conditioning of office buildings	Local building surface, annual hours or employees per site	Total building surface, annual hours or total employees in organisation

Table 2: Five non-traction energy indicator areas

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[10] Quoted in the Terms of Reference for this study

5.2 Electric versus heating energy indicators

The five indicators could be used for electric and heating final energy consumption and they can be summed up using primary energy as outlined in UIC leaflet 330. By splitting up into electric and heat consumption on local sites, transparent comparison and benchmarking is made possible for stations and workshops both inside and between companies.

Indicators 1, 2 and 5 all consist of a nominator that could either be representing the use of electric energy (total electric consumption including heat pumps), heating energy (total consumption of gas, oil and coal) or both depending on the focus of the investigation. Indicator 3 is mainly relevant for electric energy while energy for heating is only relevant for switches running on gas. Indicator 4 is relevant for both electric and heating energy due to contributions from all kind of electric equipment and heating of traffic control centres. Table 3 below outlines the relevant contributions from the five indicators to electric and heating energy consumption:

ID	Field of coverage	Electric energy consumption	Heating energy consumption
1	Commercial activities: Stations and concessions	Lighting, cooling, ventilation and air-conditioning in stations, platforms and shops/concessions, station elevators and escalators, maintenance and cleaning	Heating in stations and shops/concessions using gas, oil or coal
2	Maintenance activities: Workshops, depots and service buildings	Lighting, cooling, ventilation and air-conditioning, equipment, machinery, maintenance and cleaning of workshops, depots and service buildings	Heating of workshops, depots and service buildings using gas, oil or coal
3	Heating of switches	Lighting of marshalling yards and heating of switches (electric and heat pumps)	Heating of switches (gas only)
4	Technical railway operations: Lighting of infrastructure, Signalling, telecom, traffic control and data centres	Lighting of marshalling yards and sidings, daily operation and cooling/ventilation of signalling equipment (switch boxes and dispatching centres), telecom (GSM-R, train radio, etc.) and data centres	Heating of signalling boxes and other service buildings for the railway operation management (traffic control)
5	Administration: Offices	Lighting, cooling, ventilation and air-conditioning of office buildings	Heating of office buildings using gas, oil or coal

Table 3: coverage of electric and heating energy for the five indicators

5.3 Energy efficiency versus CO_2/GHG emission indicators

The energy efficiency performance is reflected in the specific energy consumption itself (measured, calculated or estimated) but also indirectly in the associated specific CO_2 emissions. The CO_2 emission performance is influenced not only by the energy consumption but also the CO_2 intensity of the energy carrier or electric energy mix. Table 4 below outlines the units for various nominators for non-traction energy/CO_2 indicators.

Nominators for non-traction indicators	Energy consumption	CO_2/GHG emissions
Heating (gas, oil, coal)	[TJ] or [TOE]	[Tons CO_2 equivalents] outside EU ETS[11]
Electric energy (including heat pumps)	[GWh] Final energy	[Tons CO_2 equivalents] inside EU ETS
Total energy consumption	[TJ] Primary energy	[Tons CO_2 equivalents]

Table 4: Units of various nominators for non-traction energy indicators

For all purposes of benchmarking energy efficiency performance – be it on detailed or aggregated level – it is recommended to stick to energy nominators only. For purposes of benchmarking CO_2 or GHG emissions performance it is recommended to stick to total numbers on company level (summing up CO_2 and GHG values for indicators 1, 2, 3 and 5) and to be aware of the purpose of such benchmarking/survey. For some purposes it will be correct to include CO_2 emissions from electric energy consumption (currently reported inside the EU ETS, Emission Trading Scheme) whereas for others only emissions outside EU ETS should be taken into account.

5.4 Recommendations for non-traction indicators

Following the revision of the SNCB proposal it is deemed likely that consistent, reliable and usable non-traction energy indicators for railway operation could be defined and applied successfully among the UIC members covering operators, infrastructure managers as well as integrated companies.

It is therefore recommended to launch a targeted UIC project to discuss and agree upon the description and definition of the non-traction energy indicators relevant for railway operation. This includes description of data collection, comparison and quality control comparable to existing leaflet 330. The new set of indicators for non-traction energy could either become an extension of the leaflet (when doing an update) or be included in a separate document.

It is furthermore recommended to launch a targeted UIC project to collect, benchmark and communicate among UIC members their non-traction energy efficiency and CO_2 performance according to agreed indicator definitions. It could include e.g. total non-traction energy consumption divided by total train production (gross ton-km) for a given network (not adjusted for climate and topography) or electric energy consumption in stations divided by total person-km for a given network.

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[11] Production facilities with more than 20 MW installed power are included in the EU ETS

6. Recommendations – Lanes of action for non-traction energy efficiency

The most promising technical and operational measures are listed within each of the following four fields of activity: station and concessions, workshops and depots, marshalling yards and switches and signalling, telecom and data centres.

6.1 Commercial activities: Stations and concessions

The trend is that energy consumption generally is going up due to higher activity and comfort levels in this field. Legislation does exist for new buildings and major upgrades and future legislation will be even stricter but currently this effect is superseded by the increasing activity level e.g. the building of "rail cities" in the bigger cities where the stations become a vital part of urban development.

- <u>Insulation of existing buildings</u> is often rather poor which makes the improvement of insulation a top priority. It is a well-established measure with short payback time.

- <u>Lighting in stations and platforms:</u> LED lighting is favourable, not always from component efficiency point of view but due to the potential intelligent management of lighting level as such and the life cycle costs associated. Exchanging spotlights (halogen) to LED is normally a simple measure as the lighting concept remains untouched and only components have to be exchanged. However, heat dissipation from LED lighting can be critical and tests should validate any given lighting concept before exchange.

- <u>Heating and cooling:</u> The comfort level is the main driver and temperature settings should be carefully reviewed. Optimisation of actual station designs based on system view is needed followed by optimising the technical settings of cooling and heating systems. Measures could include heat pumps and shift of cooling agents, reduction of the losses e.g. improved insulation.

- <u>Powered equipment e.g. escalators, elevators, ventilation:</u> These should be fitted or upgraded with energy efficient drives and should be intelligently controlled. Standardised solutions are available in the market but substantial potential is still to be exploited in the railways.

- <u>Passenger information systems:</u> Energy efficiency aspects should be taken into account for acquisition of new and upgrade of existing systems. For standard components like certain displays energy labelling could be used in the decision making process. New technologies like LED backlight displays and bi-stable displays (e.g. E-ink) exists as commercially available solutions and should be considered.

- <u>Concessions/shops:</u> Targets and energy audits should be built into the contracts. Energy billing should be done based on real consumption using sub-metering. Efficiency benchmarking is possible with indicators for average energy consumption per m2 for different types of concessions (e.g. food shops, cafés/restaurants, non-food). Railway owned shops could act as show cases for successful implementation of energy efficiency measures.

- <u>Major upgrades and new stations concepts:</u> Radical new designs and concepts like zero-energy, sustainable stations and "cradle to cradle" stations could serve as guidelines for station developments where the energy is being produced and stored locally or transferred back to the grid.

Commercial activities: Stations and concessions

Top 4 Energy efficiency measures

Field of activity	Present typical technology or situation	Recommended efficiency measure	Subsystem saving potential
Lighting	Tubes and halogen spots	• Intelligent control • Replacement of less efficient lighting	• 10-30% • 10-40%
Heating and cooling	Existing buildings with often poor insulation standard. Traditional heating systems based on oil and gas plus smaller inefficient HVAC units.	• Intelligent control including temperature setting • Insulation of roof and wall • Renewal of installation • Modern heat pumps (A+)	• 10-20% • 10-30% • 20% • Up to 30%
Powered equipment	Old inefficient drives and no control	New efficient drives (A+) and intelligent control	10-40%
Concessions/shops	Billing by m^2, no focus on energy	• Energy consumption separately invoiced • Targets and energy audits built into contracts	• 10-20% • Up to 20% *

*) Up to 40% including the technical measures listed above

6.2 Maintenance: Workshops, depots and service buildings

The trend is that energy consumption in this area is going down due to the overall improvements of energy efficiency in buildings and the reduction in numbers of workshops and depots due to improved operations. This is mainly driven by building legislation and the need to reduce operational costs. For equipment, the technological improvements in other sectors e.g. manufacturing is driving efficiency gains. The recommendations for this field follow to a large extent the recommendations given for stations:

- Energy audits for single workshops and depots are highly recommended since customised solutions often have to be developed taking into account significant differences in age of buildings, equipment standard and their use etc.

- Insulation of existing buildings is often rather poor which makes the improvement of insulation a top priority. It is a well-established measure with short payback time.

- Lighting in workshops and depots: The recommended solutions depend on the actual used lighting technology and the quality of light required for specific purposes. The component solutions could cover energy saving bulbs, tubes, LED and low pressure sodium lights. The intelligent management of lighting systems is crucial using time, ambient conditions, quality, and comfort levels as control parameters.

- Heating and cooling: The agreed temperature level for occupational health is the main driver but temperature settings should be still reviewed or updated. Optimisation of actual workshop designs based on system view (e.g. actual and planned work flows) is needed followed by optimising the technical settings of cooling and heating systems. Measures could include heat pumps, solar heating, and cooling agents, reduction of the losses e.g. improved insulation.
- Powered equipment e.g. cranes, pneumatics, pumps: These should be fitted or upgraded with energy efficient drives and solutions and should be intelligently controlled. Standardised solutions are available in the market to some extent and substantial potential is still to be exploited in the railways.
- Major upgrades and new workshop concepts: Radical new concepts like zero-energy and "cradle to cradle" could serve as guidelines for workshop designs and developments where the energy is being produced and stored locally or transferred back to the grid or in some kind of symbiosis with neighbouring areas (e.g. district heating).

Maintenance: Workshops, depots and service buildings

Top 3 Energy efficiency measures

Field of activity	Present typical technology or situation	Recommended efficiency measure	Subsystem saving potential
Lighting	Tubes and halogen spots	• Intelligent control • Replacement of less efficient lighting	• 10-30% • 10-40%
Heating and cooling	Existing buildings with often poor insulation standard. Traditional heating systems based on oil and gas plus smaller inefficient HVAC units.	• Improved insulation of buildings • Intelligent control including temperature setting • Modern heat pumps (A+)	• 10-30% • 10-20% • Up to 30%
Powered equipment	Old inefficient drives and pumps, no control	New efficient drives and pumps (A+) plus intelligent control	10-40%

6.3 Heating of switches

The trend is that the energy consumption in this area is going down as the energy cost itself is a strong driver and efficiency measures have been implemented to a certain extent within the last decade. Furthermore the rail networks are getting more productive which means that the total amount of switches is going down despite of growing traffic. In this area no legislation exists neither is it foreseen.

<u>Heating of switches:</u> The following is a prioritised list of actions to reduce the energy consumption:

1. Reduce the number of switches needed for current and future traffic demand.
2. Optimise the switch designs to reduce energy losses e.g. heat pumps and improved insulation.
3. Optimise the switch control taking into account rail and ambient temperature, humidity and snow/ice forecasts.
4. Upgrading of the switches should take place according to normal overhaul schedules to reduce costs.

Heating of switches

Top 2 Energy efficiency measures

Field of activity	**Present typical technology or situation**	**Recommended efficiency measure**	**Subsystem saving potential**
Number of switches	Present unchanged infrastructure	Planned and optimised network design with reduced number of switches	Up to 30%
Heating of switches	Traditional heating systems based on electricity and gas, basic control	• Intelligent control including optimised temperature settings & accurate weather forecasting • Improved switch heating design	In total 20-50%

6.4 Lighting of infrastructure and operation of signalling, telecom, traffic control and data centres

The trend is that energy consumption is going up due to higher activity and information levels in this field partly due to the technology shift in signalling and communication i.e. the shift from relay-based to electronic technologies. The fast growing activity of mobile communication also contributes to rising energy consumption. No energy legislation exists but since most of the activities in this field are safety relevant, special care is needed for implementing energy efficient solutions.

- <u>Lighting in marshalling yards:</u> The recommended solutions depend on the actual used lighting technology and the quality of light required for specific purposes. The component solutions covers LED and low pressure sodium lights. The intelligent management of lighting systems is crucial using time, ambient light and safety levels as control parameters.

- For trackside equipment the most promising energy saving measure is intelligent cooling. This concerns switch boxes and other IT trackside equipment, classical communication boxes, tunnel radio boxes as well as GSM-R boxes. This could be realised as ambient air cooling with or without fans, improved air flow design, shift of cooling agents as well as replacement of filters for the cooling units.
- The main energy saving measure for signalling is use of LED technology which is available in the market with an additional resistor to maintain the standard safety features (track circuit detection).
- Energy consumption for data centres is growing rapidly due to technology shift and should be managed using the developed innovative solutions for “green data centres” developed outside the railway sector. Similar requirements should be applied when out-sourcing this service.
- Energy efficiency aspects and requirements should be taken into account for acquisition of new and upgrade of existing equipment for signalling and telecom.

Technical railway operation:

Lighting of infrastructure and operation of signalling, telecom, traffic control and data centres

Top 5 Energy efficiency measures

Field of activity	**Present typical technology or situation**	**Recommended efficiency measure**	**Subsystem saving potential**
Lighting of marshalling yards	High pressure sodium lamps	• Intelligent control • Replacement with low-pressure sodium or LED lamps	• 10-30% • 10-40%
Cooling of trackside equipment	Traditional HVAC units	• Intelligent control • Improved design including ambient air • Replacement of cooling agents and filters	• 10-30% • Up to 30% • Up to 15%
Management of signals	Present unchanged infrastructure	Planned and optimised network design with optimised use of signals e.g. switch off during night	10-20%
Signal lighting	Traditional light bulb systems	LED based light systems (with built-in resistors due to safety)	20-30%
Data centres	Older data centres with traditional HVAC cooling units	“Green data centres” with intelligent control, efficient equipment and ambient air/soil cooling	25-50%

6.5 User behaviour and service quality

User behaviour and service quality are two “soft factors” which significantly influence non-traction energy consumption. So far the trend has been that because of more advanced and powerful technology “more has become better” with regards to standards for heating, ventilation, air-conditioning and lighting.

New innovative concepts are more focussed on assessment of real user needs and meeting adequate service quality for the railway customers. Rethinking e.g. levels for lighting, heating and ventilation and making use of ambient conditions and renewable energy sources all lead to significant energy savings on system level. Likewise user behaviour and working procedures have not been systematically addressed concerning efficient use of non-traction energy.

- Comfort levels and quality criteria should be optimised with regards to energy efficiency while improving the user experience e.g. adequate lighting levels on platforms, temperature settings for heating and cooling in stations and workshops, adaptation to use patterns and changing ambient conditions.

- Working procedures should be revised and optimised so that energy efficiency aspects are integrated. This could include improved procedures for cleaning and maintenance in stations, workshops and depots where it would affect the need for lighting, heating, cooling or ventilation.

- Awareness raising campaigns could influence and improve employee behaviour within all fields of activities. Such campaigns typically use a broad variety of communication channels and events to get attention within the organisation. Since the effect usually wears off after some time, repeated action is necessary in order to exploit the potential.

User behaviour and service quality

Top 3 Energy efficiency measures

Field of activity	Present typical situation	Recommended efficiency measure	Subsystem saving potential
Comfort levels and quality criteria	Old comfort levels/criteria with static parameter setting	Revision of comfort levels and quality criteria with respect to energy efficiency and based on assessment of shifting needs	Up to 15%
Working procedures	Existing procedures for operation, cleaning and maintenance	Improved procedures with integration of energy efficiency aspects	Up to 10%
Awareness	Energy efficiency not considered among staff	Awareness campaigns focussing on energy efficient behaviour	5-10%

6.6 Strategic level

The non-traction energy efficiency should be tackled using both approaches found in the interviews: Bottom up (concrete projects and activities starting small) and top down (company strategy with target setting).

A clear strategy will enhance the implementation of the measures described in the lanes of action above. The key elements in such a strategy are:

- Mapping and assessment
- Targets and action plan
- Implementation
- Monitoring scheme

Figure 3 Energy management system (source: ISO 50001)

1. Mapping and assessment provides detailed information about the current non-traction energy consumption, the actual energy service needs and should be used to identify key potentials and prioritise the effort.

2. Targets and action plan are developed based on the mapping and assessment results and gives a clear direction and structures the activities. Targets and plans are often long term but should be broken down into annual units.

3. Implementation of the planned actions is the next crucial step. It concerns both new technical solutions and revised procedures to minimize energy consumption.

4. Monitoring and measurements based on metering and improved breakdown models should be implemented to monitor progress and target compliance. It is also the background for reporting and continuous revision of action plans and targets. The monitoring schemes also contribute to transparent billing.

6.7 Next steps

For UIC and its members the most important next steps would be the following:

- Networking and exchange of experience and good practices between railway experts within the specific fields identified in this report.
- Facilitation of knowledge exchange within the sector as well as with rail manufacturers, research institutions and academia.
- Development of a targeted EU or UIC project. The aim of such project could be:
    - Knowledge transfer within the sector
    - Migration and adaptation of non-railway specific technologies
    - Development of a professional web-based dissemination platform like for the UIC project EVENT or as an E-learning system like for the UIC/SkillRail project for Railenergy outputs
    - Development of the framework for benchmarking non-traction energy efficiency activities

7. Annexes

The annexes will be completed in the final version of the report.

7.1 List of legal references (EU)

- Communication "Energy Efficiency Plan 2011" [COM(2011)0109] http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast); http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm
- Proposal for a Directive on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC [COM(2011)370, 22/06/2011]; http://ec.europa.eu/energy/efficiency/eed/eed_en.htm
- Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings http://europa.eu/legislation_summaries/other/l27042_en.htm

7.2 List of good practise

No	Title of the project	Company
1	Heat pumps (geothermal, soil reservoir, air-based)	NS Poort/ProRail
2	Solar panels (PV) mounted on platform roofs, stations and/or workshops	DB AG, NetworkRail, NS Poort/ProRail,
3	Upgrade of heating systems in stations, office buildings and workshops	NS Poort/ProRail, SNCB/Infrabel
4	SUS Station - Supporting Sustainable Stations	DB Station & Service AG, ProRail, Translink, Lancashire County Counsil, Boulogne
5	Check lists for good practise examples for shops/concessions in stations	NS/ProRail
6	Optimising electric equipment in stations	Railways: DB AG, Crossrail, SNCB, SNCF, ÖBB, JSC Manufacturers: Kone, Schindler, Otis, Thyssen/Krupp
7	Control of lighting	SBB, NS, DB AG, Go-Ahead and other
8	Energy upgrade of buildings (offices, stations and workshops)	DB AG, NS, Infrabel, NetworkRail
9	Awareness campaigns for Energy Efficiency	SNCB, NS
10	Reuse of waste heat from workshops for district heating	NS Poort/Nedtrain
11	Intelligent lighting management for railway depots	Go-Ahead, UK
12	Energy management for railway workshops	Infrabel, DB AG, NS, ÖBB, Trenitalia and others
13	Weather data based heating and cooling control of railway workshop	DB AG
14	LED lighting systems for marshalling yards	SBB
15	LED lighting systems for signalling	ProRail
16	Green data centres	BITKOM Germany, US Department of Energy Ferderal Energy Management Program), Carbon Trust UK, CISCO, ORACLE
17	Energy efficient cooling of switch boxes	SBB
18	Control of switch heating	SBB, ÖBB Infrastructure, ProRail, Tafikverket, Trenitalia
19	Using heat pumps for heating of switches	ProRail
20	The Carbon ladder - contractor involvement	NS/ProRail/NedTrain

Examples of good practice	Heat pumps (geothermal, soil reservoir, air-based)
Project aims	Use of heat pumps for railway stations to reduce the energy needed for cooling in the summer and to a smaller extent for heating in winter.
Short project description	NS Poorts has equiped 3 stations up to now with heat pumps (Amersfort, Hengelo, Arnheim). 10 more stations to follow (Utrecht and other). Heat pumps are used for the whole station, not only for single buildings. Heat pumps extract low-grade heat from the soil (constant 12°C for NS Poort applications).

Examples of good practice	Solar panels (PV) mounted on platform roofs, stations and/or workshops
Project aims	DB: PV modules on roof of Berlin main train station - supplying green energy. NS Poort/ProRail: Solar panels as part of solutions for upgrade of stations
Short project description	DB: PV modules on roof of Berlin main train station. Biggest PV installation in Berlin, delivers almost 2% of the station's electricity consumption. Part of Green Terminal / DB Eco Program. NS: has mounted PV equipment on three stations: Utrecht, Amsterdam and Amersfort (the latter with flexible (amorf) panels integrated into the roof).

Examples of good practice	Upgrade of heating systems in stations, office buildings and workshops
Project aims	Most heating systems are not very efficient. In recent years these systems have improved a lot. This project aims at further improving the energy efficiency of the heating systems using a variety of technological and control measures.
Short project description	Elements include advanced heating control, thermostats, change of temperature settings, and exchange of ineffecient heating units.

Examples of good practice	SUS Station - Supporting Sustainable Stations (EU project)
Project aims	The project aims at developing and implementing new genre of sustainable, low carbon stations.
Short project description	The main aim of the project is to achieve low carbon Sustainable Stations This will be achieved through - Delivering 4 demonstration SusStations schemes and 1 design scheme - Delivering a Sustainable Stations Assessment Tool - Achieving a high level of trans-national co-operation within the rail sector· - Develop dialogues with local communities & with government - Disseminating findings effectively. Within the framework of SUS Station appropriate innovations and eco technologies for stations will be explored and assessed. The implemented technologies comprise better building materials, PV on roofs, solarthermal installations, naturally insulated green roofs, use of ambient light, intelligent ligthing control etc. The project is co-funded by the partners and the EU Interreg IVB NWE programme.

Examples of good practice	Check lists for good practise examples for shops/concessions in stations
Project aims	The aim of the project is to considerably reduce energy consumption in shops and concessions by installing submeters and implementation of energy saving measures using the NS owned shops as role models.
Short project description	In average 50% of the shops in the stations are owned by NS Poort. For the other shops: transparent billing in needed – therefore the sub-metering program (2000 sub meters) is being implemented. For own shops: implementation of energy saving measures. The focus is on closing doors of fridges in stores. This is a very visible way of reducing energy waste. Moreover, in the Netherlands it is becoming a requirement.

Examples of good practice	Optimising electric equipment in stations
Project aims	Reduction of the energy consumption of stations by utilization of energy efficient equipment such as escalators, elevators and ventilation fans.
Short project description	The use of energy efficient equipment in stations focuses on two aspects. The first one is the procurement of energy efficient equipment and components and especially such ones which already provide advanced energy management options. The second aspect is the efficient operation of such equipment, e.g. the operations of escalators with motion sensors which are only switched on when people actually start to use them. Energy efficient elevators with permanent magnet synchronous motor and energy recuperation can save up to 70% of the energy.

Examples of good practice	Control of lighting (for stations, platforms, workshops, offices etc.)
Project aims	Intelligent control of lighting systems for stations, platforms, workshops, office buildings etc. adjusted to ambient (day)light, occupancy and scheduling.
Short project description	Daylighting. 35% savings from daylighting controls in daylit spaces is typical of documented energy savings from available, monitored case studies. For example, the testing at the San Francisco Federal Building indicates that the savings potential from daylighting is between 16-41% (estimated annual savings). Since only a fraction of building space is daylit (estimate 35%), the 35% savings is diluted by 35% to obtain average energy savings of 12% across all floor space. Tuning. Measurements at the National Center for Atmospheric Research [Mannicia 2000] suggest that the energy potential of light level tuning is about 15%. Measurements of the effectiveness of energy of bi-level switching [Rubinstein 1998] indicate that the savings from tuning could be as high as 25% if the switches are well utilized by the occupants. Studies on the energy saving impact on tuning light levels according to spectral content [scotopic work] suggest a 25% savings from that technique alone. We have used 25% savings for the energy saving potential for tuning. Scheduling. Although occupancy sensors will capture much of the savings in occupancy-based lighting controls, the use of intelligent dimming strategies will further increase the energy savings in many applications. We assume that integrated lighting controls would result in an additional 10% energy savings compared to that from occupant sensors alone.

Examples of good practice	Energy upgrade of buildings (offices, stations and workshops)
Project aims	Energy audit and major overhaul of 31 selected stations across Germany as part of the measures within the framework of the “Konjunkturprogramm” as one example for major energy upgrades of buildings
Short project description	

Examples of good practice	Awareness campaigns for Energy Efficiency
Project aims	Raise the awareness of employees regarding the efficient use of energy.
Short project description	The awareness campaigns have been carried out in the railway companies using different channels for communications such as events, intra-net, flyers and posters. They were focussing on topics like heating, cooling, lighting and energy efficient use of personal computers.

Examples of good practice	Reuse of waste heat from workshops for district heating
Project aims	The main idea is to exchange waste heat between railway sites and nearby industrial or residential areas, thereby saving energy.
Short project description	A pilot is being developed and tested at the moment near to Rotterdam. The idea is to stablish a pipe connection to the local vicinity in order to reuse waste heat from NedTrain workshops in local district heating systems for the benefit of domenstic and industrial users.

Examples of good practice	Intelligent lighting management for railway depots
Project aims	Energy Savings, Reduction of carbon footprint, Reduction of LCC.
Short project description	Within the framwork of a cooperation between Go-Ahead and the Carbon Trust of UK an overall energy and CO2 saving strategy was developed. As one of the high potential measures with good cost-benefit ratio intelligent lighting systems were implemeted at 45 of the companies biggest sites (train maintencance and bus depots). Technically, the old lighting has been replaced by intelligent high bay lighting systems equipped with integral lux and movement sensors ensuring that light comes only on when required and at a level that takes into account ambient light.

Examples of good practice	Energy management for railway workshops
Project aims	Energy audit and energy efficiency measures within the framework of the implementation of an environmental management system and ISO 140021 certification
Short project description	An environmental management system according to ISO 140021 was implemented and certified for the Bascoup workshop of Infrabel. Within the framework of certification process a complete energy audit has been performed and high potential energy efficiency measures have been identified and implemented. Main improvements included the reinfored insulation of the workshop buildings, the introduction of high output lighting and the improvement of the energy management of the buildings. The approach also put a strong emphasis on involving personnel and raising their awareness through training and competence management.

Examples of good practice	Weather data based heating and cooling control of railway workshop
Project aims	The aim of this pilot project was to reduce energy consumption for heating and cooling of a railway workshop.
Short project description	The ICE Workshop Krefeld of DB AG has been equipped with a weather based intelligent heating and cooling control in order to systematically reduce energy operational costs. Since the pilot was very succesful, the same approach is now being used for some railway stations in Germany.

Examples of good practice	LED lighting systems for marshalling yards
Project aims	Reduction of LCC, energy efficiency. Reduction of energy costs and maintenance effort, increased service life time, improved safety by increasing the color temperature of the lights.
Short project description	Within the framework of a pilot project, the conventional high presssure sodium vapour lamps with orange light (3700K) of a marshalling yard have been replaced by bright LEDs with a higher color temperature (4700 K). This new LED lamps are not yet commercial, prototypes have been deliverd by the Technical University of Berlin. Advantages are energy savings, reduced LCC and increased safety. Energy savings consist of two parts: One part is due to higher efficiency of the LEDs, the other due to the better options of light management and control. Important is the thermo-management of the LED: junction temperature has to be <80°C for an expected lifetime of 100'000hrs.

Examples of good practice	LED lighting systems for signalling
Project aims	Reduction of LCC, reduction of energy consumptions and maintenance effort, increased service life
Short project description	Conventional signalling lights have been replaced by LEED signalling lights. In order to gurantee the current level and procedures of safety (failure detection circuitry), additional resistors have been installed which allow the detection of not functioning lights. The replacement is carried our during the normal maintenance cycles. The new LED singalling lights consume less energy and have a higher lifetime.

Examples of good practice	Green data centres
Project aims	Increase the overall energy efficiency of data centres and increase the usage rates of servers and storage
Short project description	Energy efficient or green data centres use a wide range of measures in order to improve efficiency. One of the key factors is the virtualisation concept which implements many virtual servers for different purposes on a single physical drive and thus can increase the currently low server efficiency rate of about 15% to around 70%. A second important area is the optimization of cooling systems for data centres ranging from optimized dimensioning and positioning of cooling systems and optimized air flow through the data centre to the usage of ambient air cooling and liquid cooling for hot spots as well as the readjustment of process parameters. A third area is the use of energy efficient equipment and components as e.g. high efficiency power supply and systems with low stand-by consumption. In addition to the above mentioned areas, an energy efficient building design with a high insulation standard and resulting low heating an cooling demands adds significantly to the overall energy efficiency of data centres.

Examples of good practice	Energy efficient cooling of switch boxes
Project aims	Reduction of LCC, energy efficiency. Reduction of energy costs and maintenance effort, increased service life time. Reduction of energy consumption for switch boxes using several methods: improved design of air flow, cooling agents and filters.
Short project description	The project is divided into three parts to make switch boxes more energy efficient: 1. Cooling of switch boxes with ambient air, carefully designed air flow (free air cooling), passive and active (with fan) solutions, up to 35% efficiency improvement compared to conventional cooling, strongly dependent on insulation of the switch box itself. 2. Replacement of cooling agent, 10% efficiency improvement. 3. Replacing the filters in the cooling units, up to 5% efficiency improvement by preventive maintenance. Saving potential was measured in a pilot application (e.g. replacement of filters, changing of cooling agent), potential was confirmed. Roll-out started for part 1 and 2. Replacement of filters has been outsourced. Part 3 free air cooling still in pilot phase.

Examples of good practice	Control of switch heating
Project aims	Main drivers: LCC and renewal of old switch heating systems (gas, electric - on/off mode only). Energy efficiency gains as a surplus
Short project description	SBB: 1st phase (before 2005): Control unit, switches are on/off depending on measured rail temperatures. 2nd phase (2005-): New stage: control unit with input data from local weather station, optimized operation (on/off) depending on rail temperature and ambient temperature, local solution: every switch has it's own controller unit, weather station are feeding many switch controllers. ProRail: Automatic control of switch heating depending on track & air temperature, humidity etc. Currently, the automatic control of switch heating is too complex and is not trusted by the staff which then turns this automatic control off. A new and more robust design to be tested in 2013.

Examples of good practice	Using heat pumps for heating of switches
Project aims	Saving energy by using heat pumps for heating of switches.
Short project description	Switches using geo-thermal/heat pumps heating where economically and technically feasible. This switch design is fundamentally different compared to electric switch heating. The inherent soil heat is pumped from beneath using heat exchange in the soil which is 12-15 degrees. Isolated iron tube under the rails.

Examples of good practice	The Carbon ladder - contractor involvement
Project aims	The aim of the carbon ladder is to incentivize contractors to reduce their CO2 emissions by awarding good performance. Since there is a strong link between CO2 emissions and energy efficiency, this incentive scheme is also supporting the energy efficiency improvements.
Short project description	The carbon ladder has been developed by ProRail to keep track of contractors. The CO2-Performanceladder is a procurement tool to encourage companies to be aware of their CO2 emissions (and those of their suppliers), and to be permanently on the lookout for new ways to save energy, use materials efficiently, and to use renewable energy. It encourages companies to actually carry out such measures and to share the knowledge they have acquired in the process, and to look for yet more ways of cutting emissions, with colleagues, research institutes, NGO's and government bodies. The CO2-Performance ladder is owned by the Independent Foundation for Climate Friendly Procurement and Business (Stichting Klimaatvriendelijk Aanbesteden en Ondernemen, SKAO). The foundation stimulates the introduction of the scheme by relevant organisations in other countries. However for reasons of consistency only the full scheme without restrictions and without additions may be used. An English version of the full certification scheme is available at www.skao.nl

7.3 List of face-to-face interviews and respondents

- SNCB Holding (07/09-11 and 25/01-12): Willy Bontinck, Alain Dupont and Heylen Pascale
- Deutsche Bahn (17/10-11): Arno Seifert and Thomas Klein
- DSB (02/11-11): Anna Levin Jensen and Pia Lav
- SBB (10/11-11): Markus Halder, Andreas Haug and Peter Müller
- Rhätischer Bahn (10/11-11): Reto Sidler
- NS, NedTrain and ProRail (25/01-12):
    - Frans Slats (NS Reizigers), Chris Kuipers (NS poort), Johan Hofstede (NedTrain), Gerald Olde Monnikhof (ProRail) and Hub Cox (NL Agency)

7.4 List of answers to the online survey

- SNCB Holding; Belgium (Willy Bontinck)
- JSC Serbian Railways, Serbia (Dijana Babovic)
- Ferrovie dello Stato, Italy (Luca Carusi)
- PKP Energetyka S.A., Poland (Pawel Osuch)
- Estonian Railways, Estonia Ltd (Kai Peet)
- Network Rail, UK (Kent Farrell)
- CFR Calatori, Romania (Mihalcea Magda)
- ATOC, UK (Bryan Donnelly)
- Trafikverket, Sweden (Ann Wikström)
- ÖBB, Austria (Leopold Cecil)
- VR-Group Ltd, Finland (Vesa Stenvall)
- JSC Lithuanian Railways, Lithuania (Arnas Mankevičius)
- NSB AS, Norway (Hilde Støten Winther)
- Jernbaneverket, Norway (Gry Dahl)
- SBB, Switzerland (Markus Halder)
- Rhätische Bahn, Switzerland (Reto Sidler)
- SNCF, France (Joëlle Tournebize)
- Rom Eiendom AS (NSB), Norway (Espen Andersen)
- CD, Czech Republic (Petr Knapek)
- Deutsche Bahn AG, Germany (Thomas Klein)
- NS, Netherlands (Frans Slats)
- DSB, Denmark (Anna Levin Jensen)
- ProRail, Netherlands (Gerald Olde Monnikhof)

7.5 Background literature

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