ERJU SYSTEM PILLAR

# Stakeholder Requirements Specification : Manage Energy Capability

# Stakeholder Requirements Specification : Manage Energy Capability

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|---|---|
| Author(s) | Olivier |
| Abstract | The report below presents the functional description of the SP Task 1 architecture proposal for the railway network capability: Manage Energy. On top of this, the SP Task 1 has issued a limited number of global recommendations for the Railway network architecture in order to reach the common business objectives set out and pain points for System Pillar. |
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Authors:

### SEMP Role Allocation - ARC, REQ and OD

**ARC, REQ and OD**

System Architect, Requirements Manager and Operational Design (respectively)

The REQ, OD and ARC roles have been assigned to the team by studied capabilities :

| Capability | Person |
|---|---|
| Manage Energy | Oskar Gonzalez |
| | Zbigniew Jancewicz |
| | Artur Rojek |
| | Artur Fojud |
| | Emre Teke |
| | Edyta Gladysz |

| | |
|---|---|
| ID | SPT1RS-767 |

### SEMP Role Allocation - External Experts for: ARC, REQ and OD

**External Experts for: ARC, REQ and OD**

System Architect, Requirements Manager and Operational Design (respectively).

| Capability | Person |
|---|---|
| Manage Energy | Artur Rojek |

| | |
|---|---|
| ID | SPT1RS-768 |



Facilitated by:

### SEMP Role Allocation - MOD Modeller

**MOD, TOOL Capella**

Modeller & Capella Superusers

| | |
|---|---|
| Assignee(s) | CESAMES - Olivier EBEL |
| | |
| Role in Team | SP Task 1 Railway System |

| | |
|---|---|
| ID | SPT1RS-555 |

### SEMP Role Allocation - TOOL Polarion Polarion Superuser

**TOOL Polarion**

Polarion Superuser

| | |
|---|---|
| Assignee(s) | FOJUD Artur; |
| | CHAILLEY Aude |
| Role in Team | SP Task 1 Railway System |

| | |
|---|---|
| ID | SPT1RS-551 |

### SEMP Role Allocation - QM

**QM**

Quality Manager

| | |
|---|---|
| Assignee(s) | Emre TEKE |
| | Frederic HENON |

| | |
|---|---|
| | CESAMES - Olivier EBEL |
| Role in Team | SP Task 1 Railway System |

| | |
|---|---|
| ID | SPT1RS-759 |

With the supervision of:

**SEMP Role Allocation - LEAD Railways**
**LEAD Railways**
Domain Lead

| | |
|---|---|
| Assignee(s) | Frederic HENON |
| Role in Team | SP Task 1 Railway System |

| | |
|---|---|
| ID | SPT1RS-554 |

**SEMP Role Allocation - LEAD Suppliers**
**LEAD Suppliers**
Domain Lead

| | |
|---|---|
| Assignee(s) | TEKE Emre |
| Role in Team | SP Task 1 Railway System |

| | |
|---|---|
| ID | SPT1RS-553 |

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# 1 Preamble

## 1.1 Purpose

The purpose of this document is to provide a comprehensive overview of the energy management capability in the railway sector. It aims to describe the current (AS-IS) and future (TO-BE) functional architecture of the "Manage Energy" capability, as well as the recommendations derived from this new architecture. The description includes the capabilities and related entities, activities and interfaces. This document will serve as a reference point to the sector to modelize energy management of the railway sector at the different levels and show the TO-BE architecture for achieving the desired outcomes and building the necessary capabilities.

## 1.2 Intended Audience

This document is intended for railway undertakings, operators, industry, project managers, team members, and other stakeholders of the railway sector who are directly involved in or impacted by the energy management project. The content is designed to provide detailed information and guidance to both technical and non-technical readers, ensuring that everyone has the necessary information to contribute effectively to the railway sector's success.

## 1.3 Document context

This document is one of the capabilities of System Pillar Task 1 models developed into this project. It is created in the context of the "Manage Energy" capability and aligns with the overall objectives and strategies of the sector. As departure point there was an AS-IS Version 1 model that has been updated considering the Pain Point Mapping analysis, CBOs Mapping and TSI & other regulation mapping. From these activities that carried out during this contract, results an AS-IS version 2 an and a new TO-BE model of “Manage Energy” capability.

## 1.4 Glossary

### 1.4.1 Terms

**Accident**
Accident’ means an unwanted or unintended sudden event or a specific chain of such events which have harmful consequences; accidents are divided into the following categories: collisions; derailments; level crossing accidents; accidents to persons involving rolling stock in motion; fires and others. **[**SPT1RS-1000, Definition **]**

**Serious Accident**
Serious accident means any train collision or derailment of trains resulting in the death of at least one person or serious injuries to five or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other accident with the same consequences which has an obvious impact on railway safety regulation or the management of safety; ‘extensive damage’ means damage that can be immediately assessed by the investigating body to cost at least EUR 2 million in total. **[**SPT1RS-1001, Definition **]**

**Allocation**
Allocation means the allocation of railway infrastructure capacity by an infrastructure manager **[**SPT1RS-1002, Definition **]**

**Allocation Body**
An Allocation Body is an independent organization responsible for train path allocation to Railway Undertakings and other Applicants; this includes the designation of individual paths and the assessment of their availability. In most cases, the AB is the same organization as the Infrastructure Manager. But if the rail operator is not independent from the Infrastructure Manager, then path allocation must be carried out, according to Directive 2012/34/EU, by an independent Allocation Body. **[**SPT1RS-1003, Definition **]**

**Allocation process**
The process by which capacity is granted to an Applicant by the Infrastructure Manager or relevant capacity Allocation Body; this capacity is available for the duration of the working timetable period only. **[**SPT1RS-1004, Definition **]**

**Applicant**
Applicant means a railway undertaking or an international grouping of railway undertakings or other persons or legal entities, such as competent authorities under Regulation (EC) No 1370/2007 and shippers, freight forwarders and combined transport operators, with a public-service or commercial interest in procuring infrastructure capacity; **[**SPT1RS-1005, Definition **]**

**Holder of the vehicle type authorization**
Holder of the vehicle type authorization means the natural or legal person that has applied for and received the vehicle type authorization, or its legal successor **[**SPT1RS-1006, Definition **]**

**Certification body**
Certification body means a body, responsible for the certification of entities in charge of maintenance or for certification of the entity or organization that fulfill maintenance functions referred to in points (b), (c) or (d) of Article 14(3) of Directive (EU) 2016/798, or parts of those functions **[**SPT1RS-1007, Definition **]**

**Competent Authority**
Competent authority means any public authority or group of public authorities of a Member State or Member States which has the power to intervene in public passenger transport in a given geographical area or any body vested with such authority **[**SPT1RS-1008, Definition **]**

**Competent Local Authority**
Competent local authority means any competent authority whose geographical area of competence is not national **[**SPT1RS-1009, Definition **]**

**Coordination**
Coordination means the process through which the infra structure manager and applicants will attempt to resolve situations in which there are conflicting applications for infrastructure capacity. **[**SPT1RS-1010, Definition **]**

**ECM**
Entity in charge of maintenance (‘ECM’) means an entity in charge of the maintenance of a

vehicle, and registered as such in a vehicle register referred to in Article 47 of Directive (EU) 2016/797
The maintenance of vehicles is defined in the Article 14 of Directive (EU) 2016/798.
In particular, the four functions of ECMs are described in the Article 14 (3):
(a) a management function to supervise and coordinate the maintenance functions referred to in points (b) to (d) and to ensure the safe state of the vehicle in the railway system; [editorial edition : ECM 1 in this document]
(b) a maintenance development function responsible to manage the maintenance documentation, including the configuration ation management, based on design and operational data as well as on performance and return on experience; [editorial edition : ECM 2 in this document]

(c) a fleet-maintenance management function to manage the vehicle's removal for maintenance and its return to operation after maintenance; [editorial edition : ECM 3 in this document]

(d) a maintenance delivery function to deliver the required technical maintenance of a vehicle or parts of it, including the release to service documentation. [editorial edition : ECM 4 in this document]

The entity in charge of maintenance shall carry out the management function itself, but may outsource the maintenance functions referred to in points (b) to (d), or parts thereof, to other contracting parties such as maintenance workshops.
**[**SPT1RS-1011, Definition **]**

**Existing Railway System**
Existing rail system means the infrastructure composed of lines and fixed installations of the existing rail network as well as the vehicles of all categories and origins traveling on that infrastructure **[**SPT1RS-1012, Definition **]**

**Fleet**
All the vehicles of the railway company **[**SPT1RS-1013, Definition **]**

**Incident**
Incident means any occurrence, other than an accident or serious accident, affecting the safety of railway operations **[**SPT1RS-1014, Definition **]**

**Infrastructure Capacity**
Infrastructure capacity means the potential to schedule train paths requested for an element of infrastructure for a certain period **[**SPT1RS-1015, Definition **]**

**RNE Glossary**
Narrow definition: the maximum number of trains which can be planned to move in both directions over a specified section of track in a 24hour period.
General definition: the totality of potential train paths that can be accommodated on a

railway line or a network
[SPT1RS-1016, Definition ]

**Infrastructure Manager**
Infrastructure manager means any body or firm responsible in particular for establishing, managing and maintaining railway infrastructure, including traffic management and control-command and signalling; the functions of the infrastructure manager on a network or part of a network may be allocated to different bodies or firms. [SPT1RS-1017, Definition ]

**Innovative solutions**
The article 10 of the INFRA TSI shall be taken into account regarding innovative solutions for maintenance, upgrading and renewal of infrastructure. [SPT1RS-1018, Definition ]

**Keeper**
Keeper means the natural or legal person that, being the owner of a vehicle or having the right to use it, exploits the vehicle as a means of transport and is registered as such in a vehicle register referred to in Article 47 [SPT1RS-1019, Definition ]

**Exchanged Data**
Data interchanged between at least two entities (in this case, data generated and processed by the IMs). [SPT1RS-1020, Definition ]

**Monitoring data**
The entity in charge of maintenance shall, either directly or via the keeper provide information to the railway undertakings and infrastructure managers operating the vehicles, keepers, manufacturers, holders of vehicles authorizations and holders of the type authorization of vehicles, subsystems or components, as most appropriate and shall in particular, inform them of exceptional maintenance findings beyond wear and tear.
[SPT1RS-1021, Definition ]

**National Safety Authority definition 1**
National safety authority means a safety authority as defined in point (7) of Article 3 of Directive (EU) 2016/798 [SPT1RS-1022, Definition ]

**National Safety Authority definition 2**
National safety authority means the national body entrusted with the tasks regarding railway safety in accordance with this Directive [ 2016 / 798 ]or any body entrusted by several Member States with those tasks in order to ensure a unified safety regime
[SPT1RS-1023, Definition ]

**Network**
Network means the entire railway infrastructure managed by an infrastructure manager;
[SPT1RS-1024, Definition ]

**Network Statement**
Network statement means the statement which sets out in detail the general rules, deadlines, procedures and criteria for charging and capacity-allocation schemes, including such other information as is required to enable applications for infrastructure capacity.
[SPT1RS-1025, Definition ]

**Railway Infrastructure**
Railway infrastructure means the items listed in Annex I [of DIRECTIVE 2012/34/EU OF THE

EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 November 2012 establishing a single European railway area (recast) **[**SPT1RS-1026, Definition **]**

**Railway Undertaking**

Railway undertaking means any public or private under taking licensed according to this Directive, the principal business of which is to provide services for the transport of goods and/or passengers by rail with a requirement that the undertaking ensure traction; this also includes under takings which provide traction only; **[**SPT1RS-1027, Definition **]**

**Regulatory authorities**

Under European Union legislation, each Regulatory Body (RB) has the task to oversee the application of Community rules and act as an appeal body in case of disputes.
DIRECTIVE 2012/34/EU, Article 55: 'Each Member State shall establish a single national regulatory body for the railway sector. Without prejudice to paragraph 2, this body shall be a stand-alone authority which is, in organizational, functional, hierarchical and decision-making terms, legally distinct and independent from any other public or private entity. It shall also be independent in its organization, funding decisions, legal structure and decision- making from any infrastructure manager, charging body, allocation body or applicant. It shall furthermore be functionally independent from any competent authority involved in the award of a public service contract.'
Thus it shall ensure that charges set by the Infrastructure Manager comply with Chapter II of 2001/14/EU and are non-discriminatory. The RB oversees negotiations between applicants and the IM and intervenes when the requirements of 2001/14 are likely to be contravened.
Applicants have the right to appeal to the RB if they believe that they have been unfairly treated, discriminated against or are in any other way aggrieved. In particular, they may appeal against decisions adopted by the IM (or where appropriate the Railway Undertaking) concerning: a) the network statement; b) criteria contained within it; c) the allocation process and its outcome; d) the charging scheme; e) level or structure of infrastructure fees which it is, or may be, required to pay; f) arrangements for access.
**[**SPT1RS-1028, Definition **]**

**Renewal**

Renewal means any major substitution work on a subsystem or part of it which does not change the overall performance of the subsystem; **[**SPT1RS-1029, Definition **]**

**Services**

Services are one of the two key components of economics, the other being goods. A service is a type of economic activity (or series of activities) that is of a more or less intangible nature, is not stored and does not result in ownership. Normally (but not necessarily) it takes place in interactions between the customer and service employees and /or systems of the service provider, provided as solutions to customer problems. Examples of services include the transfer of goods, such as the postal service delivering mail, and the use of expertise or experience, such as a person visiting a doctor. Services include the provision of what is necessary for maintenance of thing or operation, assistance and advice. RNE

dictionary
[SPT1RS-1030, Definition ]

**Service Facility**
Service facility means the installation, including ground area, building and equipment, which has been specially arranged, as a whole or in part, to allow the supply of one or more services referred to in points 2 to 4 of Annex II of DIRECTIVE 2012/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 November 2012 establishing a single European railway area (recast). [SPT1RS-1031, Definition ]

**Substitution [in the framework of maintenance]**
Substitution in the framework of maintenance' means any replacement of components by parts of identical function and performance in the framework of preventive or corrective maintenance [SPT1RS-1032, Definition ]

**Timetable**
Document or system that gives details of a train(s) schedule over a particular route (OPE TSI appendix J)
This definition can be completed by the RNE definition:
' A schedule listing the times at which certain events, such as arrivals and departures at a transport station, are expected to take place. The timetable defines all planned train and rolling-stock movements which will take place on the relevant infrastructure during the period for which it is in force. Example: "annual timetable" ("yearly timetable" is incorrect)'
[SPT1RS-1033, Definition ]

**Working Timetable**
Working timetable means the data defining all planned train and rolling-stock movements which will take place on the relevant infrastructure during the period for which it is in force
[SPT1RS-1034, Definition ]

**Traffic Management**
Traffic management shall ensure the safe, efficient and punctual operation of the railway, including effective recovery from service disruption.
The infrastructure manager shall determine procedures and means for:
— the real time management of trains,
— operational measures to maintain the highest possible performance of the infrastructure in case of delays or incidents, whether actual or anticipated, and
— the provision of information to the railway undertaking(s) in such cases.
Any additional processes required by the railway undertaking and which affect the interface with the infrastructure manager(s) may be introduced after being agreed with the infrastructure manager.
[SPT1RS-1035, Definition ]

**Operation and Traffic Management**
The procedures and related equipment permitting coherent operation of the various structural subsystems, during both normal and degraded operation, including in particular train composition and train driving, traffic planning and management. [SPT1RS-1036, Definition ]

**Traffic Monitoring**

The monitoring of railway traffic involves systematically keeping track of (or supervising) and collecting information concerning parameters such as: train location, train speed, train direction. It uses uses graphical systems. The main graphic screens of these systems show two kinds of diagrams: train tracks and train schedules. Train track diagrams indicate the actual layout of railway tracks, signals, stations, and so on. They indicate the current position of trains, the condition of signals, the direction of switches, and so on, using simplified drawings of actual railway tracks and signals. To notify operators of this information, the color of tracks and signals are displayed, and a train's number is displayed in text that dynamically changes according to supervisory data. Train schedule diagrams consist of lines which correspond to the movements of trains, train numbers for each train line, and horizontal lines which show the positions of stations. They are presented as charts that illustrate train movements in actual time depicted along a horizontal axis.
[SPT1RS-1037, Definition ]

**Train**

Eurostat/ITF/UNECE definition: one or more railway vehicles hauled by one or more locomotives or rail-cars, or one rail-car traveling alone, running under a given number or specific designation from an initial fixed point to a terminal fixed point. (A light engine, i.e. a locomotive traveling on its own, is not considered to be a train.)
UNISIG definition for ERTMS: a traction unit (vehicle from where a train is operated) with or without coupled railway vehicles or a train set of vehicles with train data available.
General definition: one or more railway vehicles capable of being moved. It may consist of a locomotive (sometimes more than one) to provide power with various unpowered vehicles attached to it. It may consist of a multiple unit, i.e. several vehicles formed into a fixed formation or set, which carry their own power and do not require a locomotive. A train may be only a locomotive running light (deadheading) to a point elsewhere on the railway. A train may carry passengers, freight or, rarely nowadays, both.
[SPT1RS-1038, Definition ]



**Train crew**

Members of the on-board staff of a train, who are certified as competent and appointed by a railway undertaking to carry out specific, designated safety related tasks on the train, for example the driver or the guard. [SPT1RS-1039, Definition ]

**Train dispatch**

The indication to the person driving the train that all station or depot activities are completed and that, as far as the staff responsible are concerned, movement authority has been granted for the train. [SPT1RS-1040, Definition ]

**Train Driver**

Train driver means a person capable and authorized to drive trains, including locomotives, shunting locomotives, work trains, maintenance railway vehicles or trains for the carriage of passengers or goods by rail in an autonomous, responsible and safe manner. [SPT1RS-1041, Definition ]

**Train Path**

Train path means the infrastructure capacity needed to run a train between two places over a given period. **[**SPT1RS-1042, Definition **]**

**Train preparation**

Ensuring that a train is in a fit condition to enter service, that the train equipment is correctly deployed and the train composition matches the train's designated route(s). Train preparation also includes technical inspections carried out prior to the train entering service. **[**SPT1RS-1043, Definition **]**

**Upgrading**

Upgrading means any major modification work on a subsystem or part of it which results in a change in the technical file accompanying the 'EC' declaration of verification, if that technical file exists, and which improves the overall performance of the subsystem. **[**SPT1RS-1044, Definition **]**

**Vehicle**

Vehicle means a railway vehicle suitable for circulation on wheels on railway lines, with or without traction; a vehicle is composed of one or more structural and functional subsystems. **[**SPT1RS-1045, Definition **]**

### 1.4.2 Abbreviations

This paragraph contains the definition, abbreviations and symbols used by the Arcadia method with Capella throughout the all document.

**Operational Capability**

Capability of an organization to provide a high level service leading to an operational objective being reached (for example Provide weather forecasts, etc.);

**Operational Entity**

Entity belonging to the real world (organization, existing system, etc.) whose role is to interact with the system being studied or with its users (for example Crew, Ship, etc.);

**Operational Actor**

Particular case of a (human) non-decomposable operational entity (for example Pilot, etc.);

**Operational Activity**

Process step carried out in order to reach a precise objective by an operational entity, which might need to use the future system in order to do so (for example Detect a threat, Collect meteorological data, etc.);

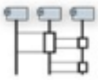
**Operational Interaction**

Exchange of information or of unidirectional matter between operational activities (for example meteorological data, etc.);

**Operational Process**

Series of activities and of interactions that contribute toward an operational capability.

**Operational Scenario**



Scenario that describes the behavior of entities and and/or operational activities in the context of an operational capability. It is commonly represented as a sequence diagram, with the vertical axis representing time.



## 2 Introduction

Energy management is one of the most important parts of the railway sector (current electricity management in the railway sector and future challenges for electricity and other sources). This is the part that generates significant costs (purchase and distribution of energy; construction and maintenance of technical infrastructure) and has a direct impact on the consumer (ticket buyer).

In the case of electrical energy, the supply and distribution of electricity are subject to general energy regulations, and the railway sector has no separate solutions, which take into account its specificity.

Distributing electricity to trains also requires reliable infrastructure on the part of both energy entities and railway entities. This requires a coherent policy of developing distribution networks and railway networks.

Ultimately, the rail sector must meet the current challenges of implementing green energy. It is also an opportunity to seek new and innovative solutions for the rail sector in the area of green energy.

In the document, the organization of the chapter "2 Manage Energy Functional Architecture Description" will be as follows:

2.1 AS-IS : This section describes the workflow followed to describe the existing functional architecture of the "Manage Energy" capability.

2.2 TO-BE : This section describes the workflow followed to describe the TO-BE functional architecture of the "Manage Energy" capability as well as the recommendations raised by this new architecture.

2.3 Discussion of the architecture : This section describes the conclusion of the development of the architecture at a high level and the synthesis of contribution to the identified CBOs.

# 3 Manage Energy Functional Architecture Description

## 3.1 AS-IS

The description of the AS-IS is a static picture of the Railway sector as it exists today. The view is an idealized view of the system, it is therefore assumed that in the AS-IS all currently applicable TSIs are fully implemented.

### 3.1.1 Process followed

The activities pursued on the AS-IS architecture were the following:

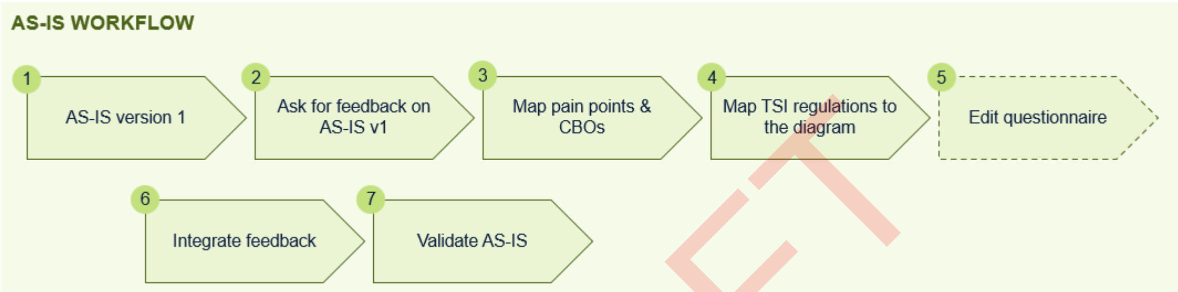



*Figure 1 : AS-IS workflow*

where:

- AS-IS Version 1: refers to the deliverable from last year, SC2.1: 240307 SP-LOT2-TASK1-Deliverables-SC2_1-v1-1
- Ask for feedback on AS-IS v1: Last year's deliverable was sent out to all contributors of System Pillar in order to collect feedback.
- Map Pain Points & CBOs: From previous years and programs, a list of pain points and Common Business Objectives (CBOs) have been compiled, this activity consisted in locating them on the Manage Energy capability view.
    - Pain points: are described in the document: *SPT1RailwaySystem/Pain Points/Pain points list : 724260* . The aim of the mapping was to identify current difficulties observed with the 'Manage Energy' capability and identify the associated activities. A visual representation of the mapping is included in the annexes of this report.
    - Common Business Objectives: are described in the document: Common Business Objectives . The aim of the mapping is to identify areas of potential improvement of the architecture. A visual representation of the mapping in included in the annexes of this report.
- Map TSI regulations to the diagram: consisted in identifying the field of application of the various TSIs, described in this document: TSIs & other regulations . The objective for this activity is to identify areas of the diagram that are already constrained or optimised. A visual representation of this mapping is included in the annexes of this report.
- Edit questionnaire: consisted in listing questions relative to the Manage Energy capability that were either difficult to address or need to be assessed by a broader audience. Therefore, the questionnaire could be sent out to a wider audience and was a different means of collecting feedback. This activity was not performed for Manage Energy due to lack of time.

### 3.1.2 Functional Description

#### 3.1.2.1 AS-IS version 2

On the following page is a view of the validated AS-IS capability view for Manage Energy:

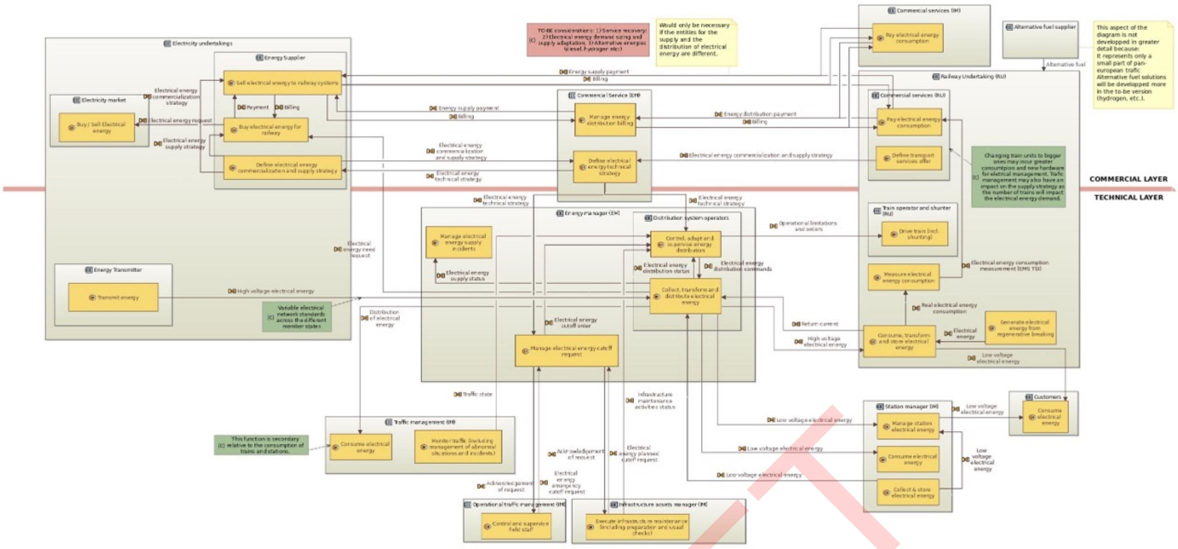



*Figure 2 : Manage Energy AS-IS Version 2*

The view of the AS-IS Manage Energy capability has been improved in 2024. The view above is the second iteration on this view, the first having been published in the end of year report 2023. The main modifications between these two version are:

- Adding new entities from energy market
- Different models of electricity distribution (energy managers, distribution system operators)
- Detailed analysis for cutoff requests
- Adding relevant payment & billing information
- Disclaimer added for non-electric fuel sources
- Separation of the diagram in two distinct layers: Commercial & Technical
- Adding activities for the station manager.

A short description of these changes is presented below:

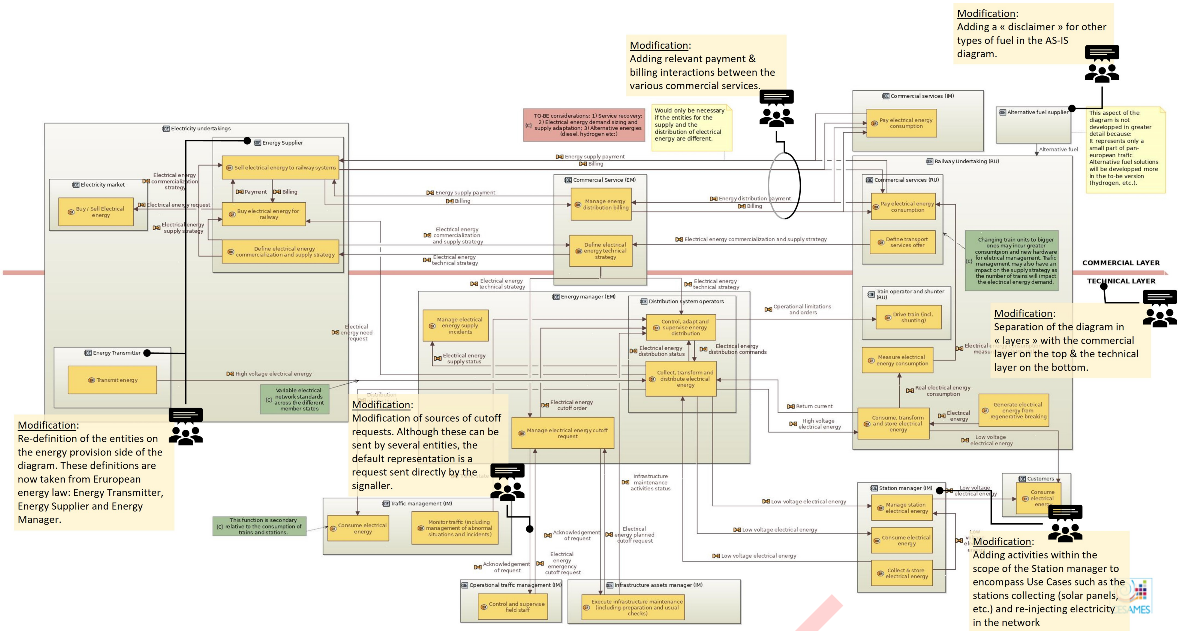



*Figure 3 : Modifications of Manage Energy version 2*

The main modifications between these two version are:

- **Adding new entities from energy market**

Electricity undertakings, that remain outside the railway sector, due to their relevant role in energy management as primary suppliers, have been included in the diagram. They are the entities from which the energy supply for the railway system is requested and paid. Three operational entities are differentiated on it.

- Energy supplier: In charge of buying and selling energy for the railway system in the energy market.

- Energy transmitter: Transmission of high voltage energy to the energy manager's transformer stations.

- Access to the electricity market: Buy and sell electrical energy in the the electricity (wholesale) market, this is an activity outside the railway sector.

- **Different models of electricity distribution (energy managers, distribution system operators)**

The models of electricity distribution for railways in the EU countries are different. In some cases, all functions are concentrated by the energy manager (distribution, technical management of the energy infrastructure, maintenance). In other cases, the distribution part is performed by the distribution system operator (DSO) where the functions of the energy manager and the distribution system operator are separated.

- **Detailed analysis for cutoff requests**

The operation is carried out by the energy manager and its distribution system operator. But the request for a stop or power cutoff, whether emergency or scheduled, can come from various actors or operational entities (such as drivers, maintenance staff, signaller) which must be informed if a cutoff has been made or is scheduled. This request can come from the "Infrastructure assets manager" or the "Operational traffic management" which are both operational entities of the infrastructure manager. Sometimes the request may also come from decisions related to the activity of “Define electric energy technical strategy”, for example due to night periods or periods of non-activity.

- **Adding relevant payment & billing information**

In the new commercial layer of the diagram has been represented the payment & billing interactions that were not represented in the previous version. These interactions are relevant to manage energy activities. The representation has been defined to support the different schemas presented all around Europe. Including commercial services of energy manger entity and of infra manager entity associated to the network usage.

- **Disclaimer added for non-electric fuel sources**

Added a “disclaimer” for other energy sources as diesel and hydrogen, although it has not been represented in detail as the case of electrical power supply, which is the most representative source of energy in the railway sector. Separation of the diagram in two distinct layers: Commercial & technical.

Two well-differentiated layers have been identified and differentiated, one technical and the other commercial. Several of the operational entities have a commercial service area or sub-entity. This commercial layer collects the operational interactions, described above, related to payment & billing and electrical energy technical and commercial strategy.

- **Adding activities for the station manager**

Multi-modal stations as large energy consumers, have more operational activities apart from the manage station electrical energy itself. In this diagram version have complemented with consumption but also with collect and store electrical energy coming from renewable sources for instance, even electric vehicle charging.

#### 3.1.2.2 AS-IS version 3

For contract SC2.4, the development of an AS-IS V3 version simply consisted of updating the names of certain operational entities and certain operational activities. The integration of these changes was carried out directly in the TO-BE reference model.



## 3.2 TO-BE

### 3.2.1 Process followed

The activities pursued for the TO-BE architecture:

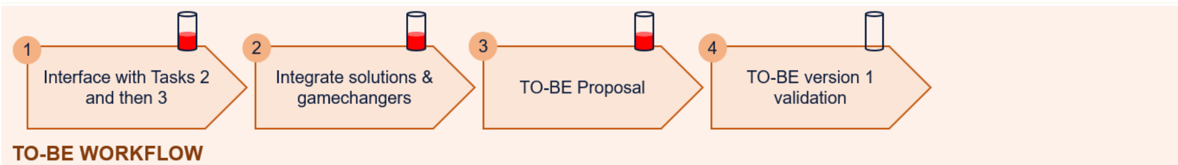



*Figure 4 : TO-BE Workflow*

Moreover, the activities for the AS-IS were used as inputs for the work on the TO-BE following the process below:

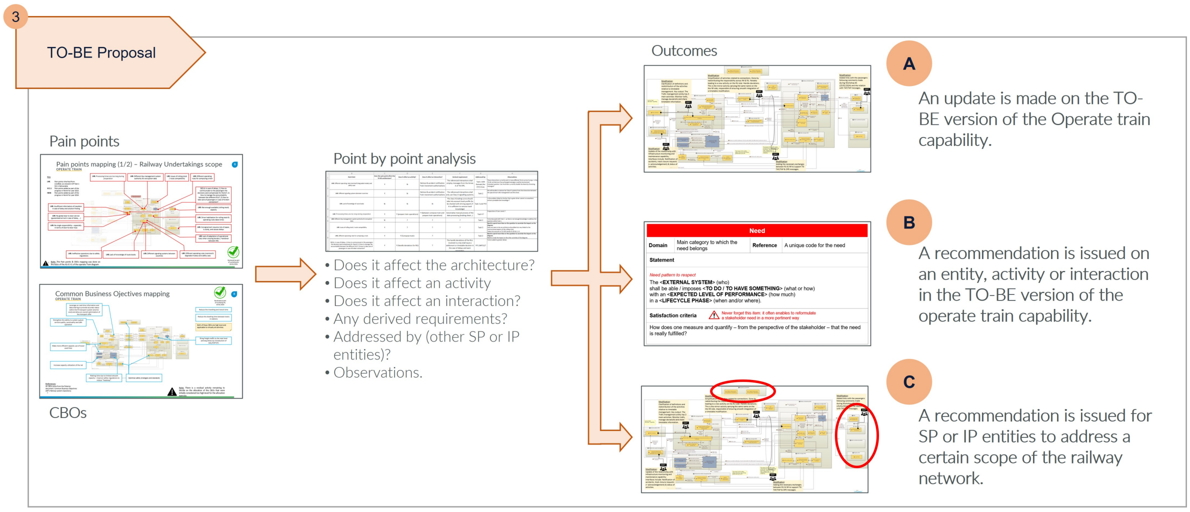



*Figure 5 : TO-BE outcomes*

The important information from the schema above is the fact that the outcomes of the TO-BE architecture analysis can be of three different formats:

1. **An update in the diagram**: Some proposed modifications can be seen directly on the capability view and therefore appears as an update from the AS-IS architecture to the TO-BE.
2. **A recommendation issued on a modelling artefact:** Many modifications may be significant but do not involve a tangible modification of the view since the impact is in the measure of performance associated to the Entity, Activity or interaction. In this case, the modification (or suggestion) is described in the form of a recommendation following a structured template.
3. An **Open point**: A possible outcome is also to identify areas of the diagram that are highlighted in the analysis as being a space for improvement but which isn't addressed in the current System Pillar organization.



### 3.2.2 Functional Description

This section aims at describing the TO-BE architecture. The description shall start by introducing the entities and actors involved in the capability and then their responsibilities in terms of activities and interactions.

**[OAB] Manage electrical energy [Operational activity allocation]**

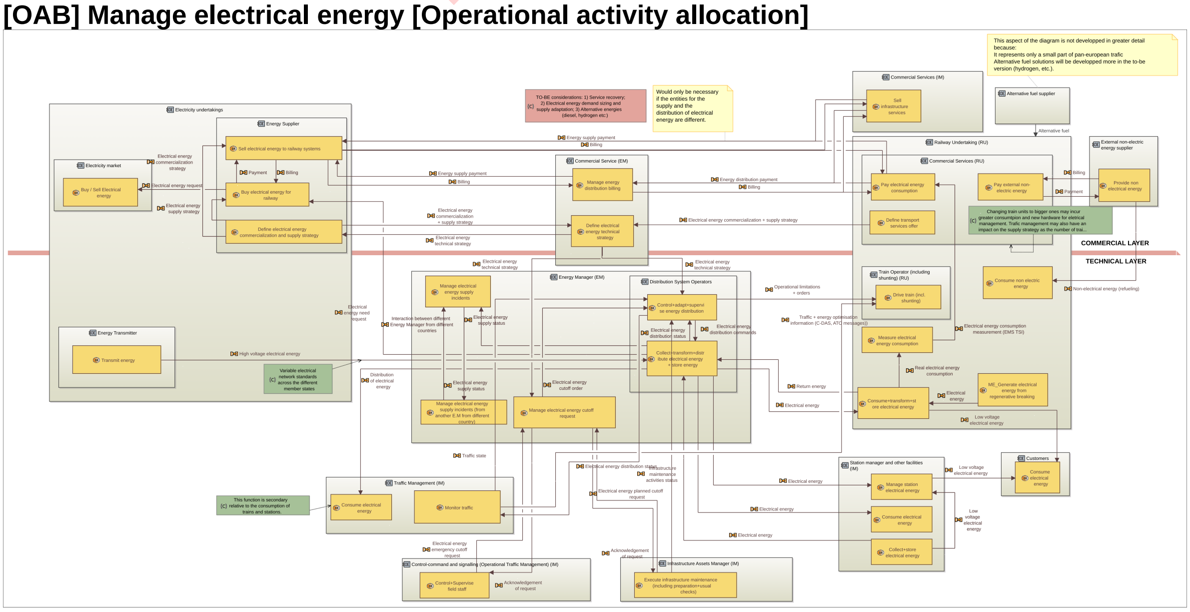


*Figure 6 Diagram [OAB] Manage electrical energy [Operational activity allocation]*

**[**SPMS-3886 **]**

### 3.2.2.1 Operational Artefacts (Capability, Entities & Activities)

**Manage electrical energy**
The manage Energy for the railway infrastructure capability is a continuous process that starts once conditions for energy distribution are met on a network and ends with energy being distributed to the infrastructure in a stable manner and specific requests have been addressed (cutoff, maintenance operations etc.). The porcess is continuous since any disruptions to the stable state of energy distribution will trigger new operations of the Manage Energy capability.
Alternative energies (hydrogen, diesel) are not described here
**[**C2P-Capability **]**

The Operational Capability "Manage electrical energy" is composed of 8 operational entities which are:

- Electricity undertakings
- Railway Undertaking (RU)
- Energy Manager (EM)
- Commercial Service (EM)
- Infrastructure Manager (IM)
- Customer
- Alternative fuel supplier
- External non-electric supplier

**[COC] Manage electrical energy [Single operational capability context]**

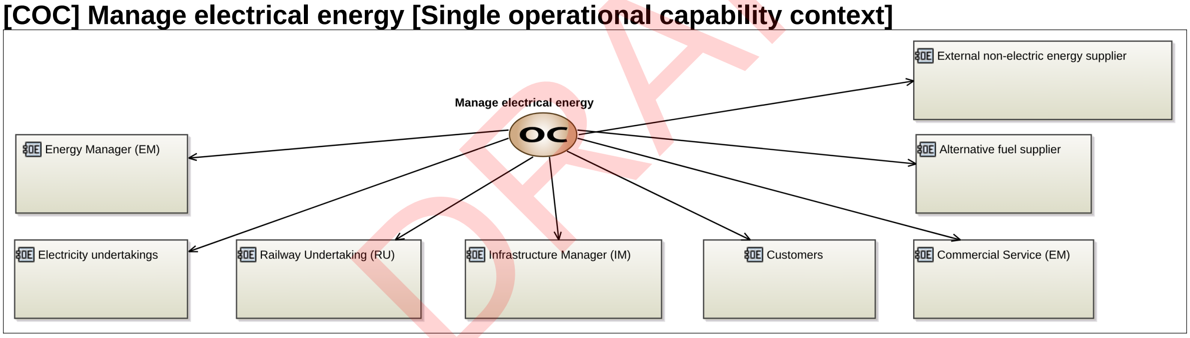



*Figure 7 Diagram [COC] Manage electrical energy [Single operational capability context]*

**[**SPMS-3893 **]**

#### 3.2.2.1.1 Electricity undertakings

**C2P-Operational Entity - Electricity undertakings**
A natural or legal person who carries out at least one of the following functions: generation, transmission, distribution, aggregation, demand response, energy storage, supply or purchase of electricity, and who is responsible for the commercial, technical or maintenance tasks related to those functions, but does not include final customers
DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019

on common rules for the internal market for electricity and amending Directive 2012/27/EU

| | |
|---|---|
| ID | SPMS-4054 |

The Operational Entity "Electricity undertakings" is composed of 3 operational entities which are:

- Electricity market
- Energy Supplier
- Energy Transmitter

### C2P-Operational Entity - Electricity market

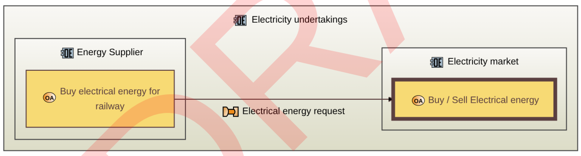
Markets for electricity, including over-the-counter markets and electricity exchanges, markets for the trading of energy, capacity, balancing and ancillary services in all timeframes, including forward, day-ahead and intraday markets.
DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

| | |
|---|---|
| ID | SPMS-4059 |
| Allocated | • SPMS-3966 - Buy / Sell Electrical energy |

The Operational Entity "Electricity market" is composed of 1 operational activity which is:

- Buy / Sell Electrical energy

### C2P-Operational Activity - Buy / Sell Electrical energy

| | |
|---|---|
| Context Diagram |   *Figure 8 Context Diagram of Buy / Sell Electrical energy* |
| Allocated to | • SPMS-4059 - Electricity market |
| ID | SPMS-3966 |



### C2P-Operational Entity - Energy Supplier

Entity who sell, including the resale of electricity to a wholesale or final customer of electricity (e.g. RU, station manager)
DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

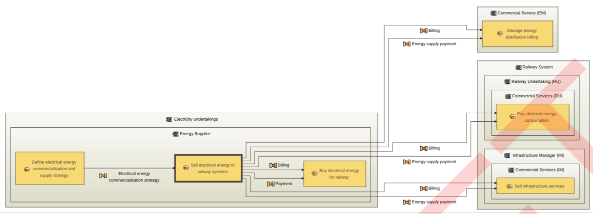
| | |
|---|---|
| ID | SPMS-4065 |

| | |
|---|---|
| Allocated | • SPMS-3955 - Sell electrical energy to railway systems<br>• SPMS-3980 - Buy electrical energy for railway<br>• SPMS-3991 - Define electrical energy commercialization and supply strategy |

The Operational Entity "Energy Supplier" is composed of 3 operational activities which are:

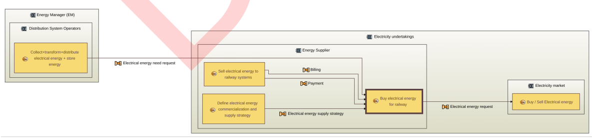
- Sell electrical energy to railway systems
- Buy electrical energy for railway
- Define electrical energy commercialization and supply strategy

**C2P-Operational Activity - Sell electrical energy to railway systems**
Sell electrical energy by supplier to railway entities. Receives payments and issues payments billing information.

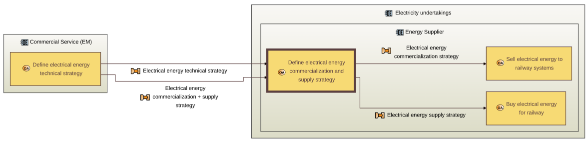
| | |
|---|---|
| Context Diagram | <br>*Figure 9 Context Diagram of Sell electrical energy to railway systems* |
| Allocated to | • SPMS-4065 - Energy Supplier |
| ID | SPMS-3955 |



**C2P-Operational Activity - Buy electrical energy for railway**
Purchase of electricity by railway entities from the supplier according to energy supply strategy.

| | |
|---|---|
| Context Diagram | <br>*Figure 10 Context Diagram of Buy electrical energy for railway* |
| Allocated to | • SPMS-4065 - Energy Supplier |
| ID | SPMS-3980 |

**C2P-Operational Activity - Define electrical energy commercialization and supply strategy**
Supply strategy defines how the required quantity of energy to supply and will be procured in order to reduce the overall cost per energy unit (or other commercial criteria)

| | |
|---|---|
| Context Diagram |   *Figure 11 Context Diagram of Define electrical energy commercialization and supply strategy* |
| Allocated to | • SPMS-4065 - Energy Supplier |
| ID | SPMS-3991 |

### C2P-Operational Entity - Energy Transmitter

A natural or legal person who is responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity.
DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

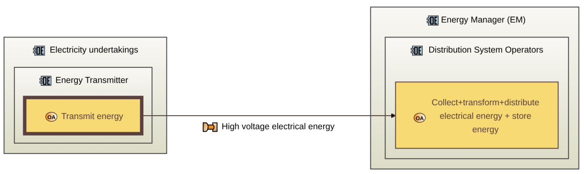
| | |
|---|---|
| ID | SPMS-4062 |
| Allocated | • SPMS-4044 - Transmit energy |

The Operational Entity "Energy Transmitter" is composed of 1 operational activity which is:

- Transmit energy

### C2P-Operational Activity - Transmit energy

The transport of electricity on the extra high-voltage and high-voltage interconnected system with a view to its delivery to final customers or to distributors, but does not include supply

| | |
|---|---|
| Context Diagram |   *Figure 12 Context Diagram of Transmit energy* |
| Allocated to | • SPMS-4062 - Energy Transmitter |
| ID | SPMS-4044 |

#### 3.2.2.1.2 Railway Undertaking (RU)

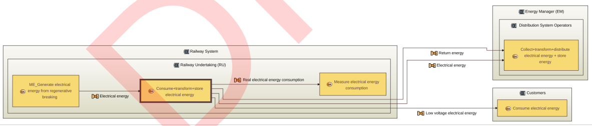
**C2P-Operational Entity - Railway Undertaking (RU)**
'Railway Undertaking' means any public or private undertaking licensed according to this Directive, the principal business of which is to provide services for the transport of goods and/or passengers by rail with a requirement that the undertaking ensure traction; this also includes undertakings which provide traction only;
DIRECTIVE 2012/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 November 2012 establishing a single European railway area (recast) – Article 3 definition 1

| | |
|---|---|
| ID | SPMS-4063 |
| Allocated | • SPMS-3978 - ME_Generate electrical energy from regenerative breaking<br>• SPMS-3983 - Measure electrical energy consumption<br>• SPMS-4037 - Consume+transform+store electrical energy<br>• SPMS-7896 - Consume non electric energy |

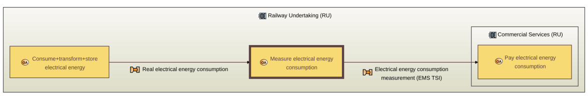
The Operational Entity "Railway Undertaking" is composed of 3 operational activities which are:

- Consume+transform+store electrical energy
- Measure electrical energy consumption
- Generate electrical energy from regenerative breaking

**C2P-Operational Activity - Consume+transform+store electrical energy**
Refers to all activities performed by the train relative to electrical energy management.
ESS (Enegy Storage Systems) could be batteries, ultracaps, ...

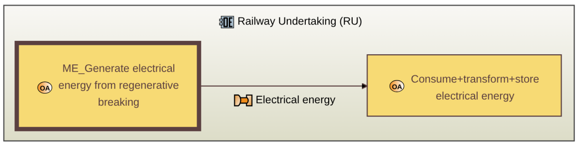
| | |
|---|---|
| Context Diagram |  <br>*Figure 13 Context Diagram of Consume+transform+store electrical energy* |
| Allocated to | • SPMS-4063 - Railway Undertaking (RU) |
| ID | SPMS-4037 |

**C2P-Operational Activity - Measure electrical energy consumption**
Energy Measurement System (EMS) of traction energy compliant with EN50463, GM/RT2132, IEC62888 and TSI. There are undoubtedly other activities for measurement of energy in other areas of the railway network but they are not represented in the diagram because the focus is on the operational constraints (driven by pain points analysis).

| | |
|---|---|
| Context Diagram |  <br>*Figure 14 Context Diagram of Measure electrical energy consumption* |

| | |
|---|---|
| Allocated to | • SPMS-4063 - Railway Undertaking (RU) |
| ID | SPMS-3983 |

### C2P-Operational Activity - ME_Generate electrical energy from regenerative breaking

| | |
|---|---|
| Context Diagram | <br>*Figure 15 Context Diagram of ME_Generate electrical energy from regenerative breaking* |
| Allocated to | • SPMS-4063 - Railway Undertaking (RU) |
| ID | SPMS-3978 |

And, the Operational Entity "Railway Undertaking" is composed of 2 operational entities which are:

- Train Operator (including shunting)
- Commercial Services

### C2P-Operational Entity - Train Operator (including shunting) (RU)

An entity operating a train through its life-cycle.
IM handles traffic management during crisis situations in coordination with the concerned RUs. This can result in train deviation, rerouting, adding stops , or re-sequencing in case of a reduced 'real-time' capacity, train cancellations can be also decided.

| | |
|---|---|
| ID | SPMS-4084 |
| Allocated | • SPMS-3948 - Plan train traffic (incl. allocating rolling stock to journey)<br>• SPMS-3957 - Prepare train operations<br>• SPMS-4007 - Compose train<br>• SPMS-4010 - Allocate crew to timetable<br>• SPMS-4018 - Compose train<br>• SPMS-4029 - Dispatch train (incl. shunting)<br>• SPMS-4030 - Manage deviations (including Staff & fleet management)<br>• SPMS-4039 - Drive train (incl. shunting) |

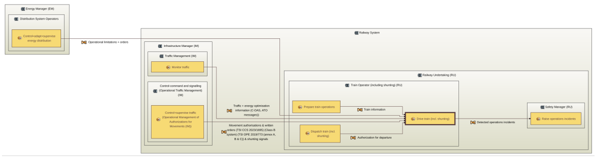
The Operational Entity "Train Operator (including shunting)" is composed of 1 operational activity which is:

- Drive train (incl. shunting)

### C2P-Operational Activity - Drive train (incl. shunting)

Refers to all actions the driver performs during the operation of a train.
"'Train driver" means a person capable and authorized to drive trains, including locomotives, shunting locomotives, work trains, maintenance railway vehicles or trains for the carriage of passengers or goods by rail in an autonomous, responsible and safe manner.'
DIRECTIVE 2007/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2007 on the certification of train drivers operating locomotives and trains on the railway system in the Community – Article 3 (b)

Could be implemented through DAS, ATO for GoA 0, 1 & 2 (TSI CCS)

| | |
|---|---|
| Context Diagram |  *Figure 16 Context Diagram of Drive train (incl. shunting)* |
| Allocated to | • SPMS-4084 - Train Operator (including shunting) (RU) |
| ID | SPMS-4039 |

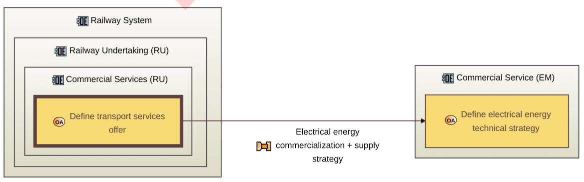
### C2P-Operational Entity - Commercial Services (RU)

| | |
|---|---|
| ID | SPMS-4050 |
| Allocated | • SPMS-3982 - Pay electrical energy consumption<br>• SPMS-4021 - Define transport services offer<br>• SPMS-7895 - Pay external non-electric energy |

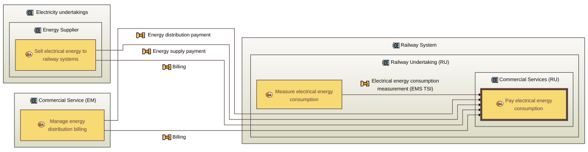
The Operational Entity "Commercial Services" is composed of 3operational activities which are:

- Define transport services offer
- Pay electrical energy consumption
- Pay external non-electric energy

**C2P-Operational Activity - Define transport services offer**
Defines the the RU foreseen trafic and equipment. May notably influence the Energy Manager's technical strategy if the RU fleet has an impact on energy consumption.

| | |
|---|---|
| Context Diagram |  *Figure 17 Context Diagram of Define transport services offer* |
| Allocated to | • SPMS-4050 - Commercial Services (RU) |
| ID | SPMS-4021 |

**C2P-Operational Activity - Pay electrical energy consumption**
Payment for elecrtical energy (e.g. RU/ station manager)

| | |
|---|---|
| Context Diagram | <br>*Figure 18 Context Diagram of Pay electrical energy consumption* |
| Allocated to | • SPMS-4050 - Commercial Services (RU) |
| ID | SPMS-3982 |

### 3.2.2.1.3 Energy Manager (EM)

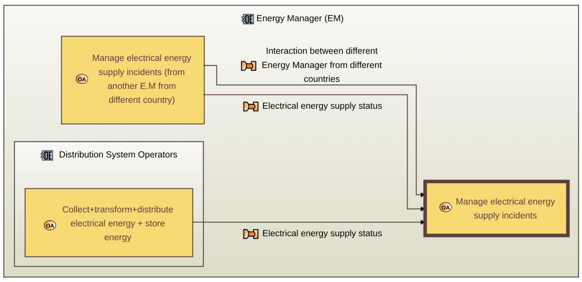
**C2P-Operational Entity - Energy Manager (EM)**
The role of the entity « energy management" here in the TO-BE architecture is only to adapt the energy consumption in real time depending on the activity in the network, to save energy whenever it is possible. The failures and traffic restrictions are taken into account in real time by another entity of the IM and the traffic is updated at first by the traffic management, that can transfer the information to the energy manager.
So in that case, there is no direct interaction between operational traffic management and energy manager.
Sometimes energy manager is part of Infrastructure Manager, sometimes it's same entity. It depends on country organization. In this case we want to show that role of energy manager can be independent.

| | |
|---|---|
| ID | SPMS-4077 |
| Allocated | • SPMS-3995 - Manage electrical energy supply incidents<br>• SPMS-4032 - Manage electrical energy cutoff request<br>• SPMS-7963 - Manage electrical energy supply incidents (from another E.M from different country) |

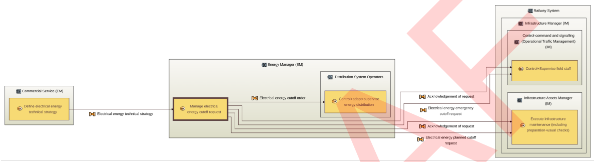
The Operational Entity "Energy Manager" is composed of 2 operational activities which are:

- Manage electrical energy supply incidents
- Manage electrical energy cutoff request

**C2P-Operational Activity - Manage electrical energy supply incidents**
Management of the technical and operational aspects of incidents in energy system: Identifies incidents and applies the appropriate protocols in accordance to Operational or Safety policy if necessary.

| | |
|---|---|
| Context Diagram |  <br>*Figure 19 Context Diagram of Manage electrical energy supply incidents* |
| Allocated to | • SPMS-4077 - Energy Manager (EM) |
| ID | SPMS-3995 |

**C2P-Operational Activity - Manage electrical energy cutoff request**
Management of the technical and operational aspects of energy cut-off: Converts the cutoff requests into cutoff orders - this may sometimes require an interpretation of the request by the Energy manager or is directly transmitted.

| | |
|---|---|
| Context Diagram | <br>*Figure 20 Context Diagram of Manage electrical energy cutoff request* |
| Allocated to | • SPMS-4077 - Energy Manager (EM) |
| ID | SPMS-4032 |



And, the Operational Entity "Energy Manager" is composed of 1 operational entity which is:

- Distribution System Operators

**C2P-Operational Entity - Distribution System Operators**
DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

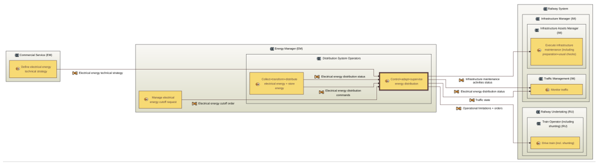
| | |
|---|---|
| ID | SPMS-4083 |
| Allocated | • SPMS-4022 - Collect+transform+distribute electrical energy + store energy<br>• SPMS-4038 - Control+adapt+supervise energy distribution |

The Operational Entity "Distribution System Operators" is composed of 2 operational activities which are:

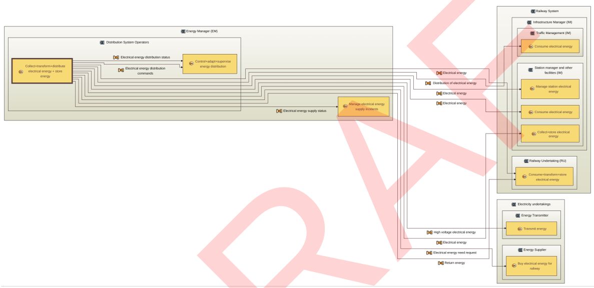
- Control+adapt+supervise energy distribution

◦ Collect+transform+distribute electrical energy

**C2P-Operational Activity - Control+adapt+supervise energy distribution**

| | |
|---|---|
| Context Diagram |  *Figure 21 Context Diagram of Control+adapt+supervise energy distribution* |
| Allocated to | • SPMS-4083 - Distribution System Operators |
| ID | SPMS-4038 |

**C2P-Operational Activity - Collect+transform+distribute electrical energy + store energy**
Collect, transform and distribute electrical energy from distribution system to substations and contact line according to the distribution commands. This activity also receives return current due to regenerative braking and local energy collection from entities within the railway network. This activity is also responsible for providing a status of electrical distribution network.

| | |
|---|---|
| Context Diagram |  *Figure 22 Context Diagram of Collect+transform+distribute electrical energy + store energy* |
| Allocated to | • SPMS-4083 - Distribution System Operators |
| ID | SPMS-4022 |

### 3.2.2.1.4 Commercial Service (EM)

**C2P-Operational Entity - Commercial Service (EM)**
Supply of electrical energy.

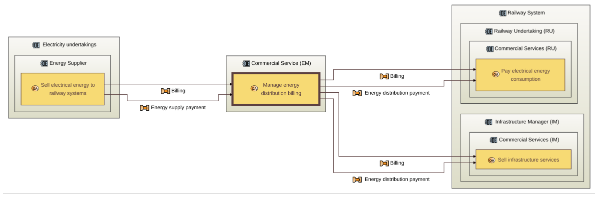
| | |
|---|---|
| ID | SPMS-4072 |
| Allocated | • SPMS-3981 - Manage energy distribution billing<br>• SPMS-3992 - Define electrical energy technical strategy |

The Operational Entity "Commercial Service" is composed of 2 operational activities which are:

◦ Manage energy distribution billing

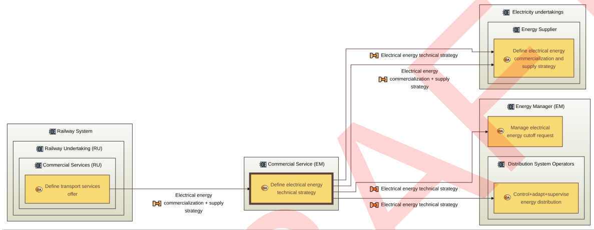
- ◦ Define electrical energy technical strategy

### C2P-Operational Activity - Manage energy distribution billing

| | |
|---|---|
| Context Diagram | <br>*Figure 23 Context Diagram of Manage energy distribution billing* |
| Allocated to | • SPMS-4072 - Commercial Service (EM) |
| ID | SPMS-3981 |

### C2P-Operational Activity - Define electrical energy technical strategy

Technical strategy defines the quantity of energy required and how it shall be distributed across the railway energy infrastructure according to the transport offer.

| | |
|---|---|
| Context Diagram | <br>*Figure 24 Context Diagram of Define electrical energy technical strategy* |
| Allocated to | • SPMS-4072 - Commercial Service (EM) |
| ID | SPMS-3992 |

### C2P-Operational Entity - External non-electric energy supplier

| | |
|---|---|
| ID | SPMS-7897 |
| Allocated | • SPMS-7894 - Provide non electrical energy |

## 3.2.2.1.5 Infrastructure Manager (IM)

### C2P-Operational Entity - Infrastructure Manager (IM)

| | |
|---|---|
| ID | SPMS-4049 |

The Operational Entity "Infrastructure Manager" is composed of 5 operational entities which are:

- ◦ Traffic Management

- Control-command and signalling (Operational Traffic Manangement)
- Infrastructure Assets Manager
- Station Manager
- Commercial Services

### C2P-Operational Entity - Traffic Management (IM)

**OPERATE TRAIN:** Traffic management shall ensure the safe, efficient and punctual operation of the railway, including effective recovery from service disruption.
The infrastructure manager shall determine procedures and means for:

- The real time management of trains,
- Operational measures to maintain the highest possible performance of the infrastructure in case of delays or incidents, whether actual or anticipated, and
- The provision of information to the railway undertaking(s).

Any additional processes required by the railway undertaking and which affect the interface with the infrastructure manager(s) may be introduced after being agreed with the infrastructure manager.'
COMMISSION IMPLEMENTING REGULATION (EU) 2019/773 of 16 May 2019 on the technical specification for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union and repealing Decision 2012/757/EU Annex – Article 4.2.3.4.1.
This definition could be completed by the following: Operation and Traffic Management: The procedures and related equipment permitting coherent operation of the various structural subsystems, during both normal and degraded operation, including in particular train composition and train driving, traffic planning and management.
DIRECTIVE (EU) 2016/797 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 May 2016 on the interoperability of the rail system within the European Union (recast) – Annex II - Article 2

**MANAGE ENERGY:** 'Infrastructure Manager' means any body or firm responsible in particular for establishing, managing and maintaining railway infrastructure, including traffic management and control-command and signalling; the functions of the infrastructure manager on a network or part of a network may be allocated to different bodies or firms (DIRECTIVE 2012/34/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 November 2012 establishing a single European railway area (recast) - Article 3)

| ID | SPMS-4068 |
|---|---|
| Allocated | • SPMS-3947 - Monitor traffic (for another IM)<br>• SPMS-3990 - Consume electrical energy<br>• SPMS-4031 - Manage timetable deviation (including connections management)<br>• SPMS-4033 - Issue traffic information<br>• SPMS-4043 - Monitor traffic |

The Operational Entity "Traffic Management" is detailled in the "Operate Train Architecture Report".

### C2P-Operational Entity - Control-command and signalling (Operational Traffic Management) (IM)

Issues the movement permission for a given train, provided conditions controlled by the IM are fulfilled (e.g., interlocking, flank protection, train spacing...). This can be done by several ways depending on implemented technology (line side signalling, cab signals, written orders, ETCS movement authority...).
It is composed of the fixed installations (as per CCS definition : All the equipment necessary to ensure safety and to command and control movements of trains authorized to travel on the network), and the signaler who operates them.

| ID | SPMS-4060 |
| --- | --- |
| Allocated | • SPMS-3949 - Update CS infrastructure data<br>• SPMS-4019 - Control+Supervise field staff<br>• SPMS-4023 - Control+Supervise trackside assets<br>• SPMS-4040 - Control+supervise traffic (Operational Management of Authorizations for Movements (IM)) |

The Operational Entity "Control-command and signalling (Operational Traffic Management)" is detailled in the "Operate Train Architecture Report".

### C2P-Operational Entity - Infrastructure Assets Manager (IM)

| ID | SPMS-4081 |
| --- | --- |
| Allocated | • SPMS-3956 - Manage infrastructure maintenance certification<br>• SPMS-3958 - Manage infrastucture data<br>• SPMS-3973 - Plan works<br>• SPMS-3984 - Request capacity for infrastructure maintenance<br>• SPMS-3986 - Organize (planned & unplanned) infrastructure maintenance (including asset management & obsolescence management)<br>• SPMS-3987 - Develop infrastructure maintenance capabilities (including tools)<br>• SPMS-3988 - Execute infrastructure maintenance (including preparation+usual checks)<br>• SPMS-3993 - Manage parts supply (including obsolescence management)<br>• SPMS-4005 - Request an infrastructure certification<br>• SPMS-4035 - Supervise+coordinate infrastructure maintenance |



The Operational Entity "Infrastructure Assets Manager" is detailled in the "Infrastructure Architecture Report".

### C2P-Operational Entity - Station manager and other facilities (IM)

Does not include the commercial services (shops etc.) hosted inside the station. The Station manager is the entity that manages energy consumption and track occupancy in the station.

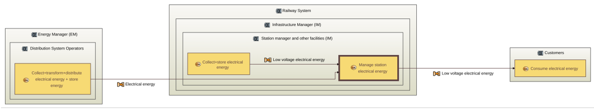
| ID | SPMS-4091 |
| --- | --- |
| Allocated | • SPMS-4016 - Manage station electrical energy<br>• SPMS-4045 - Consume electrical energy<br>• SPMS-4046 - Collect+store electrical energy |

The Operational Entity "Station manager" is composed of 3 operational activities which are:

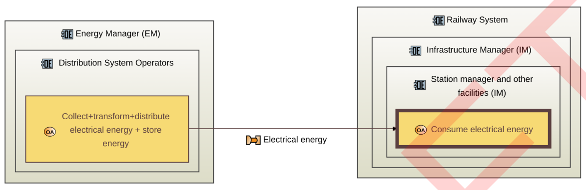
- Manage station electrical energy
- Consume electrical energy

- ◦ Collect+store electrical energy

### C2P-Operational Activity - Manage station electrical energy
This activity aims to propose and lead methodologies and processes to reduce energy consumption in a Station.

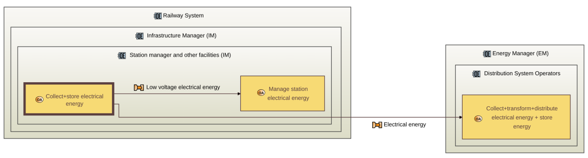
| | |
|---|---|
| Context Diagram |  *Figure 25 Context Diagram of Manage station electrical energy* |
| Allocated to | • SPMS-4091 - Station manager and other facilities (IM) |
| ID | SPMS-4016 |

### C2P-Operational Activity - Consume electrical energy

| | |
|---|---|
| Context Diagram |   *Figure 26 Context Diagram of Consume electrical energy* |
| Allocated to | • SPMS-4091 - Station manager and other facilities (IM) |
| ID | SPMS-4045 |



### C2P-Operational Activity - Collect+store electrical energy
Refers to collecting and storing energy obtained through photovoltaic means (or other energy collection methods) to reduce overall station consumtion.

| | |
|---|---|
| Context Diagram |  *Figure 27 Context Diagram of Collect+store electrical energy* |
| Allocated to | • SPMS-4091 - Station manager and other facilities (IM) |
| ID | SPMS-4046 |

### C2P-Operational Entity - Commercial Services (IM)
Entity that supplies access to the tracks.
Entity that supplies infrastructures services for energy distribution in case of "Manage Energy".

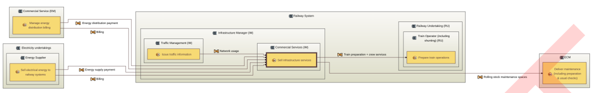
| | |
|---|---|
| ID | SPMS-4055 |
| Allocated | • SPMS-3967 - Pay electrical energy consumption<br>• SPMS-3974 - Sell infrastructure services |

The Operational Entity "Commercial Services" is composed of 1 operational activity which is:

◦ Sell infrastructure services

**C2P-Operational Activity - Sell infrastructure services**

Interface between RU and IM, two missions are taken into account here : selling the services described in the network statement and charging the services based on real usage of infrastructure after the train has run, taking into account the operational deviations.
Selling the service involves considering the capacity and performance of the network, gathering the RUs needs, and defining with the RUs the timetable and services, and conditions of sales

| | |
|---|---|
| Context Diagram | <br>*Figure 28 Context Diagram of Sell infrastructure services* |
| Allocated to | • SPMS-4055 - Commercial Services (IM) |
| ID | SPMS-3974 |

### 3.2.2.1.6 Customers

**C2P-Operational Entity - Customers**

**OPERATE TRAIN:** Any external entity using a transport service, eg passengers, freight carrier, entities responsible for the ticket selling and after sales services
**MANAGE ENERGY:** a wholesale or final customer of electricity (e.g. RU, station manager). DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

| | |
|---|---|
| ID | SPMS-4056 |
| Allocated | • SPMS-4017 - Consume electrical energy |

The Operational Entity "Customers" is not detailled in this document.

### 3.2.2.1.7 Alternative fuel supplier

**C2P-Operational Entity - Alternative fuel supplier**

Other energy sources and their supplies (e.g. fuels, heat, renewable energy or any other form of energy; not electrical energy).

DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU

| | |
|---|---|
| ID | SPMS-4079 |

### 3.2.3 Recommendations

Recommendations are issued on certain aspects of the TO-BE architecture, the recommendations are organized according to the aspect they contribute to. These recommendations are written using the following template:

- Task 1 recommends that <Operational Entity/ Activity or interaction> should <Level of performance> to contribute to <associated CBO/Pain Point>.

**Eco-driving**

**Problem statement**: One of the basic tasks of the railway sector should be to strive to optimize electricity costs. This aspect is strictly connected with exchange data between railway and energy entities.

**Hypothesis**: If the Traffic Manager receives real-time information from the Vehicles, restrictions from the Traffic Manager infrastructure, then the Traffic Manager is able to issue instructions to find the right balance between the energy consumption and timetable compliance.

**Task 1 recommends that railway and energy entities should exchange data to provi...**
**Task 1 recommends that railway and energy entities should exchange data to provide drivers with tips on how to drive efficiently to reduce electricity costs. Exchange data should include:**

- the Railway Undertakings should issue train composition information (Rolling stock & loading mass, available braking capacity, adhesion, position of front & rear) to the Traffic Manager in real time in operation;
- the Energy manager should share energy infrastructure restrictions in real time in operation;
- the Traffic manager should locate all rolling stocks on the network in real-time with specific accuracy (in meters)
- based on the above data, the driver can receive eco-driving instructions that will enable him to drive eco-driving

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-211 - efficient energy use(1)<br>is derived from : SPT1RS-221 - standardized architecture(1)<br>is derived from : SPT1RS-210 - efficient energy use(2)<br>is derived from : SPT1RS-209 - sustainable materials, renewable energy sources<br>is derived from : SPT1RS-204 - light materials<br>is derived from : SPT1RS-206 - new solution for non-electrified lines<br>is derived from : SPT1RS-223 - SERA, single European railway area<br>is derived from : SPT1RS-222 - efficient train com positioning<br>is derived from : SPT1RS-219 - robust, comprehensible, sustainable framework<br>is derived from : SPT1RS-218 - modularity<br>is derived from : SPT1RS-220 - overall CAPEX/OPEX optimisation(2)<br>has parent : SPT1RS-799 - Recommendations |

| | |
|---|---|
| ID | SPT1RS-852 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO:

- Manage more efficient energy consumption
- Standardize architecture (reduce overall CAPEX/OPEX costs)

**Renewable energy sources**

**Problem statement**: The railway sector should strive for efficient and economically viable use and produce of green energy.

**Hypothesis**: Stations, stops and other railway buildings (if possible) should be used to produce green energy.

**Task 1 recommends that the Station Manager (IM) should equip stations and stops...**
**Task 1 recommends that the Station Manager (IM) should equip stations and stops with renewable energies (e.g. solar panels) where relevant based on cost benefit analyze to provide basic power to station equipment and systems. Also other railway entities (if possible) should try equip its infrastructure (buildings, substations) with renewable energies based on a CBO analysis.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-211 - efficient energy use(1)<br>is derived from : SPT1RS-210 - efficient energy use(2)<br>is derived from : SPT1RS-209 - sustainable materials, renewable energy sources<br>is derived from : SPT1RS-204 - light materials<br>is derived from : SPT1RS-206 - new solution for non-electrified lines<br>is derived from : SPT1RS-196 - increase market size by standardisation<br>is derived from : SPT1RS-197 - overall CAPEX/OPEX optimisation(1)<br>is derived from : SPT1RS-198 - automate lifecycle processes, independent lifecycle<br>is derived from : SPT1RS-202 - energy storage and charging<br>is derived from : SPT1RS-752 - Dealing with a variety of fuel sources<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-849 |
| Type | Railway Requirement |

Station Manager (IM) equips stations and stops with renewable energies (e.g. solar panels, ...) to provide basic power to station equipment and systems. The power system with renewable energies should be equipped with energy storage. This will allow energy to be stored during the day and used, for example, to illuminate platforms at night and ensure the stability of the power supply. The connection from the power grid should be considered as an auxiliary one, used in case of insufficient energy or energy storage capacity.

The above recommendation contribute to the following CBO & Pain Points:

- CBO:
    - Manage more efficient energy consumption
    - Produce solutions that are economically attractive
    - Energy storage (new technical solutions, economically viable)
- Pain point:
    - Dealing with a variety of fuel sources

**Problem statement**: The railway sector and energy sector should strive for efficient and economically viable use and produce of green energy.

**Hypothesis**: New opportunities for the use of renewable energy by the Energy Manager

**Task 1 recommends that the Energy Manager (IM) should use renewable energy from...**
**Task 1 recommends that the Energy Manager (IM) should use renewable energy from wind or solar farms where relevant based on cost benefit analyze to power traction substations or traction vehicles based on a CBO analysis.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-752 - Dealing with a variety of fuel sources<br>is derived from : SPT1RS-196 - increase market size by standardisation<br>is derived from : SPT1RS-197 - overall CAPEX/OPEX optimisation(1)<br>is derived from : SPT1RS-198 - automate lifecycle processes, independent lifecycle<br>is derived from : SPT1RS-202 - energy storage and charging<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-848 |
| Type | Railway Requirement |



The above recommendation contribute to the following CBO & Pain Point:

- CBO:
    - Produce solutions that are economically attractive
    - Energy storage (new technical solutions, economically viable)
- Pain point:
    - Dealing with a variety of fuel sources

**Regeneration energy management**

The Energy Manager (EM) should equip the catenary power system with devices that allow regeneration of energy from braking trains, in case when this energy cannot be transferred in the train-to-train circuit. In AC systems, regenerative energy can be returned to the power system or stored. In DC systems, storage or bidirectional AC/DC converters in substations shall consider as alternatives. The selection of parameters and location of energy storage in AC and DC systems should be preceded by analyses, the results of which will indicate the optimal solution in terms of the potential of regenerated energy.

**Task 1 & Task 2 recommend that Energy Manager (EM) should equip the catenary pow...**
**Task 1 & Task 2 recommend that Energy Manager (EM) should equip the catenary power system with devices that allow regeneration of energy from braking trains, in case when this energy cannot be transferred in the train-to-train circuit based on a CBO analysis.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-202 - energy storage and charging<br>is derived from : SPT1RS-204 - light materials<br>is derived from : SPT1RS-206 - new solution for non-electrified lines<br>is derived from : SPT1RS-209 - sustainable materials, renewable energy sources<br>is derived from : SPT1RS-210 - efficient energy use(2)<br>is derived from : SPT1RS-211 - efficient energy use(1)<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-859 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO:

- Manage more efficient energy consumption
- Energy storage (new technical solutions, economically viable)



**The railway operator as an energy provider**

**Problem statement**: Legal solutions for the railway sector in the area of renewable energy management.

**Hypothesis**: Current legal solutions only partially see the role of the railway sector in the production of renewable energy, especially in the area of energy from regenerative braking.

**Task 1 recommends promoting/supporting legal solutions that will be strictly ded...**
**Task 1 recommends promoting/supporting legal solutions that will be strictly dedicated to regenerative energy during braking of traction vehicles**.

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-755 - Difficulty in change of energy supplier<br>is derived from : SPT1RS-754 - Difficulty in managing serveral power suppliers (in coordination)<br>is derived from : SPT1RS-753 - Different countries have different distributions of the activities on actors of the industry<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-858 |
| Type | Railway Requirement |

A braking traction vehicle, under the right technical conditions, can return electrical energy to the overhead traction line. This energy can be directly or indirectly consumed by other vehicles or transferred to the electric power system. The recovered energy is measured, but braking vehicle is not a generator of energy. It is necessary to establish uniform rules throughout the EU for accounting for regenerative energy.

The above recommendation contribute to the following Pain Points:

- Change of energy supplier (organizational and financial aspects)
- Managing several power suppliers (coordination).
- Different countries have different distributions of the activities on actors of the industry

## Cross-country energy accounting (DCS)

**Problem statement**: Lack of a single standard for meter communication with DCS applicable in all EU

**Hypothesis**: The current requirements for on-board energy meters for communication with DCS (Standard EN 50463-4) allow different solutions and data structures. EM in different countries use different standards in this regard.

**Task 1 recommends develop a single standard for meter communication with DCS app...**
**Task 1 recommends develop a single standard for meter communication with DCS applicable in all EU countries. This will avoid the need for bilateral and multilateral agreements between DCS operators. It is worth considering whether this standard should become part of the TSILoc&Pas and TSI ENE.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-746 - Exchange data between countries; common standard for settlements<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-883 |
| Type | Railway Requirement |

The above recommendation contribute to the following Pain Point:

- Pain point:
    - Exchange data between countries; common standard for settlements

## On-board energy meters - measurements at the interface of different IM

**Problem statement:** Trustable energy meters and trustable location of trains.

**Hypothesis**: According to the current requirements for on-board energy meters in terms of location data, the meter should receive data from external sources. Most solutions are based on GPS. In some areas the GPS signal is not good enough, for this reason, it is necessary to equip such sections of railway lines with GPS data correction devices.

**Task 1 recommend that Infrastructure and trains should equip when needed with GP...**
**Task 1 recommend that Infrastructure and trains should equip when needed with GPS data correction devices.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-747 - Trustable energy meters and their interoperability<br>is derived from : SPT1RS-748 - Trustable location of trains<br>has parent : SPT1RS-799 - Recommendations |

| | |
|---|---|
| ID | SPT1RS-857 |
| Type | Railway Requirement |

The above recommendation contribute to the following Pain Point:

- Trustable energy meters and their interoperability
- Trustable location of trains

**Fleet Energy Management System**

**Problem statement:** Train scheduling has a significant impact on the energy intensity of rail transportation. The accumulation of many trains in a small time interval increases energy losses in the electric traction power system.

**Hypothesis**: It is necessary to build timetable taking into account the energy intensity and loads of the traction power system. Whenever a timetable is developed or modified, it is advisable to simulate the performance and load of the traction power supply system.

While operating the railway traffic, frequent changes in the speed of trains should be avoided - if possible, traffic should be operated at a constant speed. Local speed restrictions due to infrastructure parameters should also be limited where it is possible.

**Task 1 recommends that the Traffic Manager should be in charge of managing the o...**
**Task 1 recommends that the Traffic Manager should be in charge of managing the overall circulating trains energy efficiency. Prioritizing the operational restrictions and timetables, but paying attention also in energy efficiency of the overall circulating trains. This could be carried out through one C-DASEM (Connecter Driver Advisory System including Energy Management) connecting each rolling stock an the TMS.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-204 - light materials<br>is derived from : SPT1RS-206 - new solution for non-electrified lines<br>is derived from : SPT1RS-209 - sustainable materials, renewable energy sources<br>is derived from : SPT1RS-210 - efficient energy use(2)<br>is derived from : SPT1RS-211 - efficient energy use(1)<br>is derived from : SPT1RS-744 - Energy consumption calculation for legacy, rolling stock and fixed installation<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-856 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO and Pain Point:

- CBO:
    - Manage more efficient energy consumption
- Pain point:
    - Calculation for legacy rollingstock and infrastructure

**Charging process of trains with on-board ESS**

**Problem statement**: Definition of common interfaces, especially communication protocol, between infrastructure and rolling stock, to create exchange data to optimise the charging process of trains with on-board ESS.

**Hypothesis**: In some cases the charging process of trains with on-board ESS is made directly through the collector to a permanently energized bar or cathenary. In those cases a comunication between infrastructure and rolling stock is not needed. In other cases a definition of common interfaces will be need, especially communication protocol, , to create exchange data to optimise the charging process of trains with on-board ESS.

**Task 1 recommends that IM and RU should collaborate in the definition of common communication protocol to create exchange data to optimise the charging process of train with on-board ESS.**

The above recommendation contribute to the STIP:

- STIP:
    - Communication between rolling stock and infrastructure for battery trains charging



**Non fossil fuel bi-modal rolling stock**

**Problem statement**: Replacing diesel locomotives with other types of rolling stock

**Hypothesis**: There are a number of non-electrified lines in operation, on which rail traffic is primarily carried by diesel traction. Many of these lines are local connections with low traffic volumes, mainly passenger traffic. It is recommended that EM work together with IM, RU and train keepers to replace diesel traction on these lines with electric traction in the form of dual-system vehicles, powered from the overhead contact line on electrified sections and from batteries or H2 on non-electrified sections. Battery charging takes place while driving on electrified sections or during standstill at stations from the catenary or charging stations.

**Task 1 recommend that EM, IM & RU should collaborate to replace where relevant b...**
**Task 1 recommend that EM, IM & RU should collaborate to replace where relevant based on cost benefit analysis diesel traction on these lines with electric traction in the form of dual-system vehicles, powered from the overhead contact line on electrified sections and from batteries or H2 on non-electrified sections based on a CBO analysis.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-165 - multi-modal mobility(1)<br>is derived from : SPT1RS-201 - multi-modal energy synergies<br>is derived from : SPT1RS-752 - Dealing with a variety of fuel sources<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-855 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO and Pain Point:

- CBO:
  - Multi-mode vehicles for partially electrified lines. Batteries/ H2/ Catenary…
  - Rationalise energy management infrastructure in multi-modal stations (or nodes)
- Pain point:
  - Dealing with a variety of fuel sources

**Reducing the life costs of electrified equipment**

**Problem statement**: Reduction of maintenance costs of traction power system.

**Hypothesis**: The Energy Manager will introduce, where necessary, inspection procedures for equipment installed in the traction power system based on its operation, instead of resulting from specific time intervals including CBM (Condition Based Mantenaince) systems. This will reduce the cost of equipment inspections on low-load lines gradually.

**Task 1 & Task 2 recommend that the Energy Manager (EM) should introduce where re...**

**Task 1 & Task 2 recommend that the Energy Manager (EM) should introduce where relevant based on cost benefit analysis inspection procedures for equipment installed in the traction power system based on its operation, instead of resulting from specific time intervals and including CBM (Condition Based Mantenaince) systems.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-191 - changeability<br>is derived from : SPT1RS-192 - reusable right first time work<br>is derived from : SPT1RS-193 - automate lifecycle processes<br>is derived from : SPT1RS-194 - independent lifecycle, simple exchange<br>is derived from : SPT1RS-195 - less trackside assets<br>is derived from : SPT1RS-756 - Technical reliability of EE infrastructure<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-854 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO and Pain Point:

- CBO:
  - Reduce life-cycle cost
- Pain point:
  - Technical reliability of e.e. infrastructure: predictive maintenance of e.e. infrastructure

**Reducing energy losses**

**Problem statement**: Reduction of costs of power supply facilities.

**Hypothesis**: New and modernized power supply facilities should be equipped by EM with equipment with the lowest possible idle and load losses. Examples include reducing the percentage of transformer short-circuit voltage, high efficiency of converters, etc.

**Task 1 & Task 2 recommend that the Energy Manager (EM) should equip where releva...**
**Task 1 & Task 2 recommend that the Energy Manager (EM) should equip where relevant based on cost benefit analysis new and modernized power supply facilities, with equipment with the lowest possible idle and load losses based on a CBO analysis.**

| | |
|---|---|
| Status | Open |
| Linked Work Items | is derived from : SPT1RS-204 - light materials<br>is derived from : SPT1RS-206 - new solution for non-electrified lines<br>is derived from : SPT1RS-209 - sustainable materials, renewable energy sources<br>is derived from : SPT1RS-210 - efficient energy use(2)<br>is derived from : SPT1RS-211 - efficient energy use(1)<br>is derived from : SPT1RS-191 - changeability<br>is derived from : SPT1RS-192 - reusable right first time work<br>is derived from : SPT1RS-193 - automate lifecycle processes<br>is derived from : SPT1RS-194 - independent lifecycle, simple exchange<br>is derived from : SPT1RS-195 - less trackside assets<br>has parent : SPT1RS-799 - Recommendations |
| ID | SPT1RS-853 |
| Type | Railway Requirement |

The above recommendation contribute to the following CBO:

- Manage more efficient energy consumption
- Reduce life-cycle cost

# 4 Conclusion

## 4.1 Conclusion SC2.3

As in other Task, the deep-dive into the AS-IS architecture, the study of the feedback from the sector about the version 1, the mapping of the link for rail pain points and the CBO from EU-Rail led to a consolidated description of the overall architecture.

The first conclusion of this description of the architecture at a high level has mainly been that the overall organization of entities and activities from the AS-IS to the TO-BE architecture will be very similar. Secondly, the Manage Energy area can be split to commercial and technical parts (this applies to both the AS-IS and the TO-BE architecture). This means that entities from the energy and rail markets are present in both parts (this is a unique situation, where the rail sector is strongly linked to the energy sector and dependent on energy market conditions related to the purchase and distribution of electricity). Commercial and technical parts are connected, but also have own CBOs and pain points. The above aspects are related to the overall goal of the railway sector and railway entities (RU, IM) related to manage more efficient energy consumption.

The changes resulting from the achievement of CBO will mainly concern the levels of efficiency related to the different activities and interactions with other tasks (especially in terms of optimizing electricity costs on the RU side). In addition, the search for solutions to manage more efficient energy consumption requires taking into account aspects related to the rail and energy markets. Solutions should include both technical and commercial issues, legislative support and the pursuit of cost optimization in the purchase of electricity by rail entities.

Task 1 has worked to add descriptions and definitions to the various entities and activities referenced in the model. These include the legislative references where relevant. Eventually, the definitions of entities and activities should be harmonized within System Pillar and this is an ongoing activity for the Glossary working team in EET. Through the definitions given, Task 1 has contributed to this work and will need to ensure in the next developments that this work is taken into account.

A key achievement in this year has been the integration of the Task 1 model in the Reference Model developed by EET. The Reference Model aims at merging the different Task models in development. Now that Task 1 is involved in this process, it should facilitate collaboration and integration with the different tasks and possibly Flagship projects.”

## 4.2 Conclusion SC2.4

In line with the defined milestones, during S.C 2.4 the Manage Energy Capability also focused on consolidating and further maturing last year’s To-Be architecture. The Manage Energy Capability principally interfaced and interacted with Task 3, through the outcomes of the interactions between Operate Train Capability, Task 3, and Flagship Project 4.

As a result of these activities, the Manage Energy To-Be architecture was further matured, again incorporating the Mirror Group’s comments on last year’s deliverables. The To-Be architecture has been integrated into Capella to support interactions with other tasks in line with the SEMP.

# 5 Annex

## 5.1 AS-IS Version 1

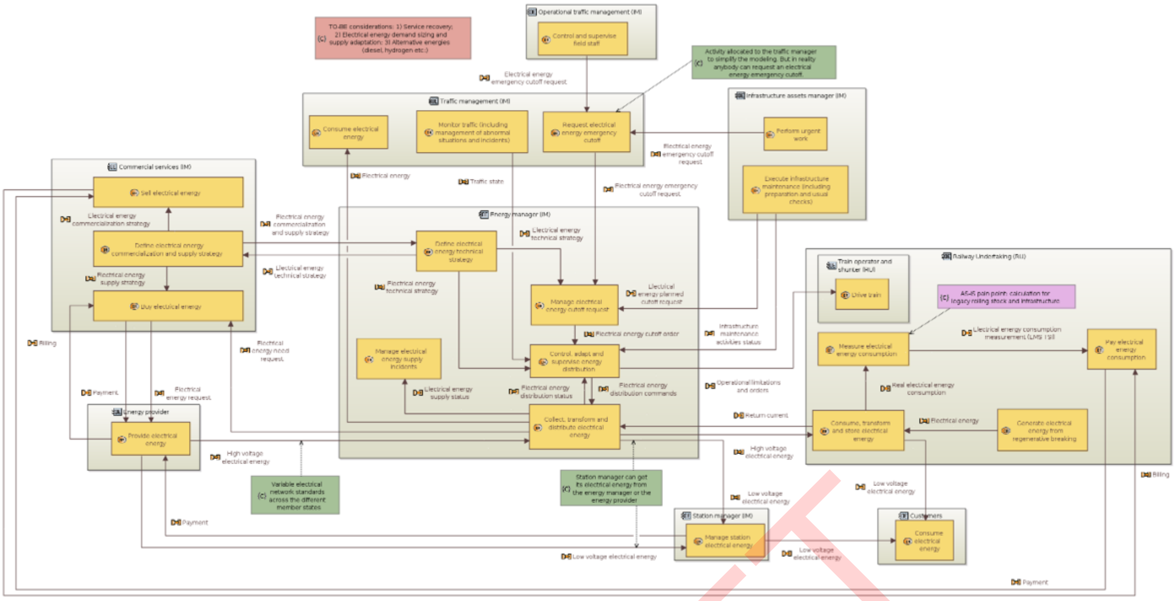
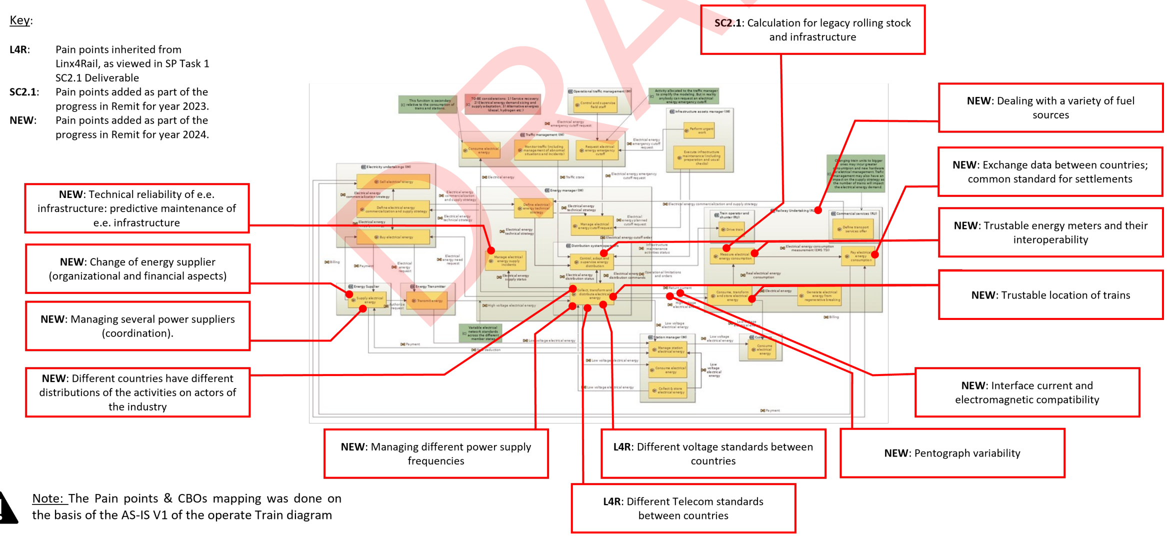


*Figure 29 : Manage Energy AS-IS Version 1*

## 5.2 Pain Point Mapping




Note: The Pain points & CBOs mapping was done on the basis of the AS-IS V1 of the operate Train diagram

*Figure 30 : Pain point mapping*

## 5.3 CBOs Mapping

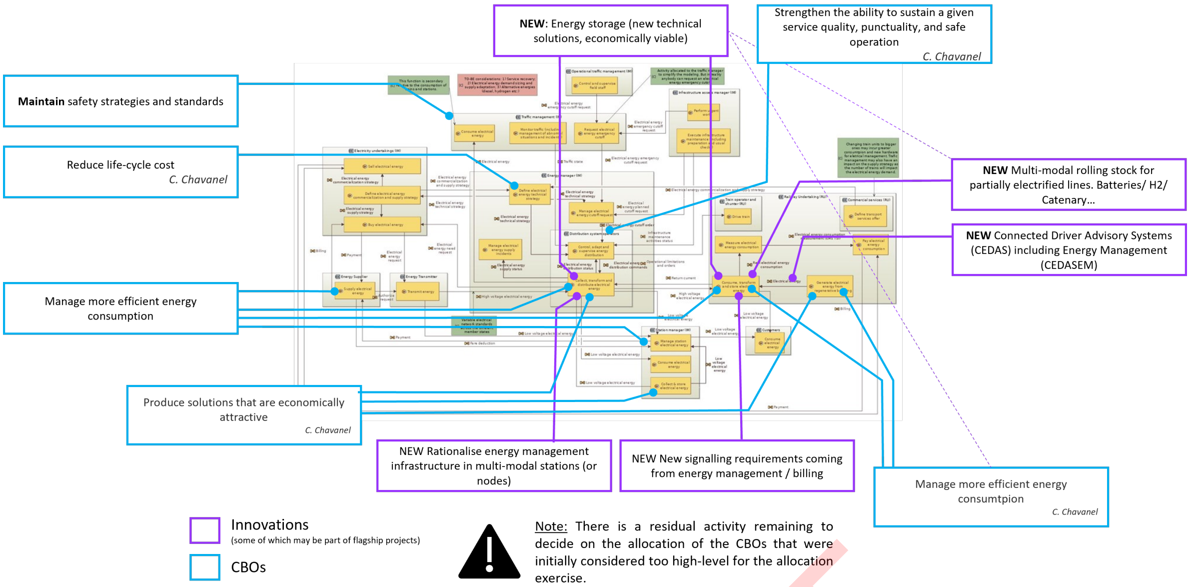



*Figure 31 CBOs Mapping*

## 5.4 TSI & other regulations mapping

References:

**ENE:** TSI - 02014R1301 - EN - 28.09.2023 - 003.001
**LOC&PASS** : TSI - 02014R1302 - EN - 28.09.2023 - 005.001

ENE TSI §5, §6 & §7 are not mappent to the detail of the Manage Electrical Energy capability because they do not relate directly to the architecture.

ENE TSI Contents:

4.2: Functional and technical specification of the subsystem
4.3: Functional and technical specificaiton of the interfaces
4.3.2: Interface with rolling stock subsystem
4.3.3: Interface with infrastructure subsystem
4.3.4: Interface with Control & Command and signalling subsystems
4.3.5: Interface with operation and traffic management subsystem
4.4: Operating rules
4.5: Maintenance rules

LOC&PASS TSI Contents:

4.2.3: Track interaction and gauging
4.2.3.1: Gauging
4.2.8: Traction & electrical equipement
4.2.8.2: Power supply
4.2.8.4: Protection against electrical hazards
5.3.10: Pantograph
5.3.11: Contact strips
5.3.12: Main circuit breaker

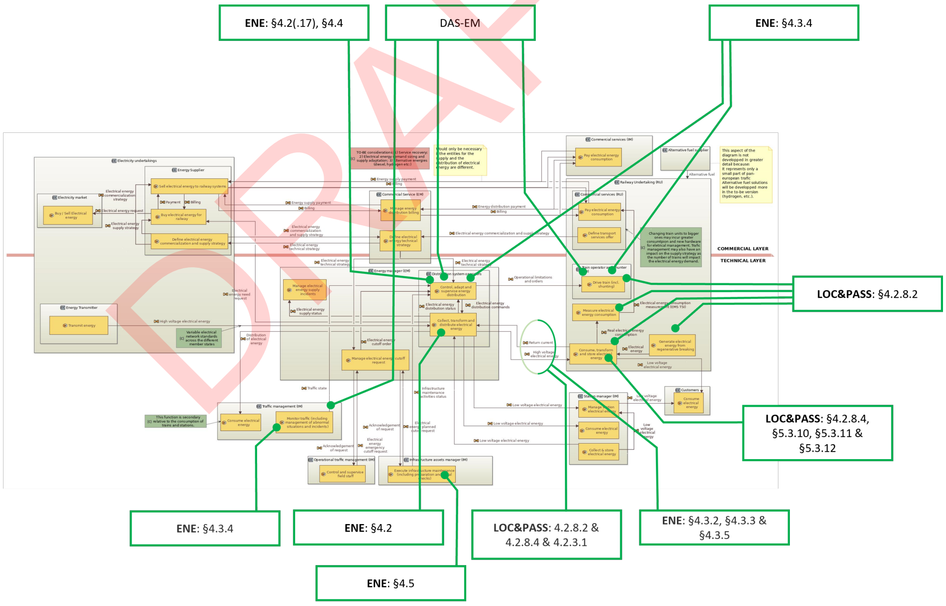



*Figure 32 TSI & other regulations mapping*