

13th UIC Sustainability Conference



**Energy efficiency projects: potential
improvements for mid and long term**

**STATE OF THE ART OF NEW TECHNOLOGIES FOR ENERGY
EFFICIENCY AND CO2 REDUCTIONS IN THE RAILWAY
SYSTEM**

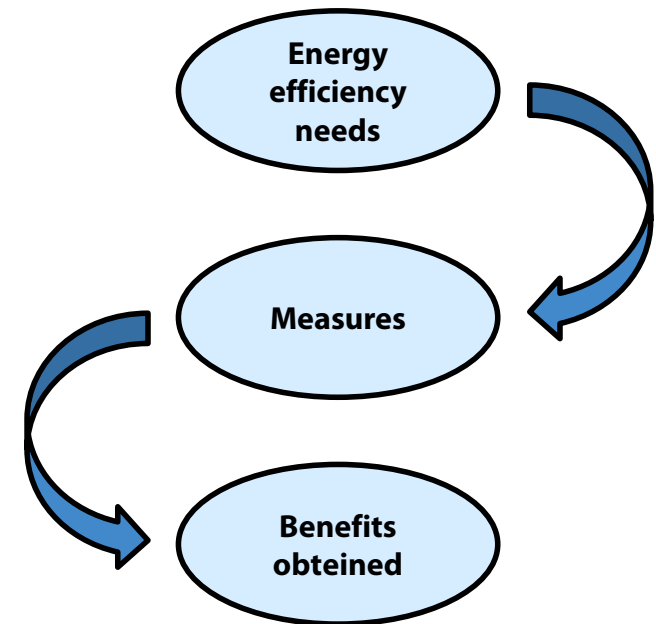
Eduardo Prieto



12, 13, 14 October 2016

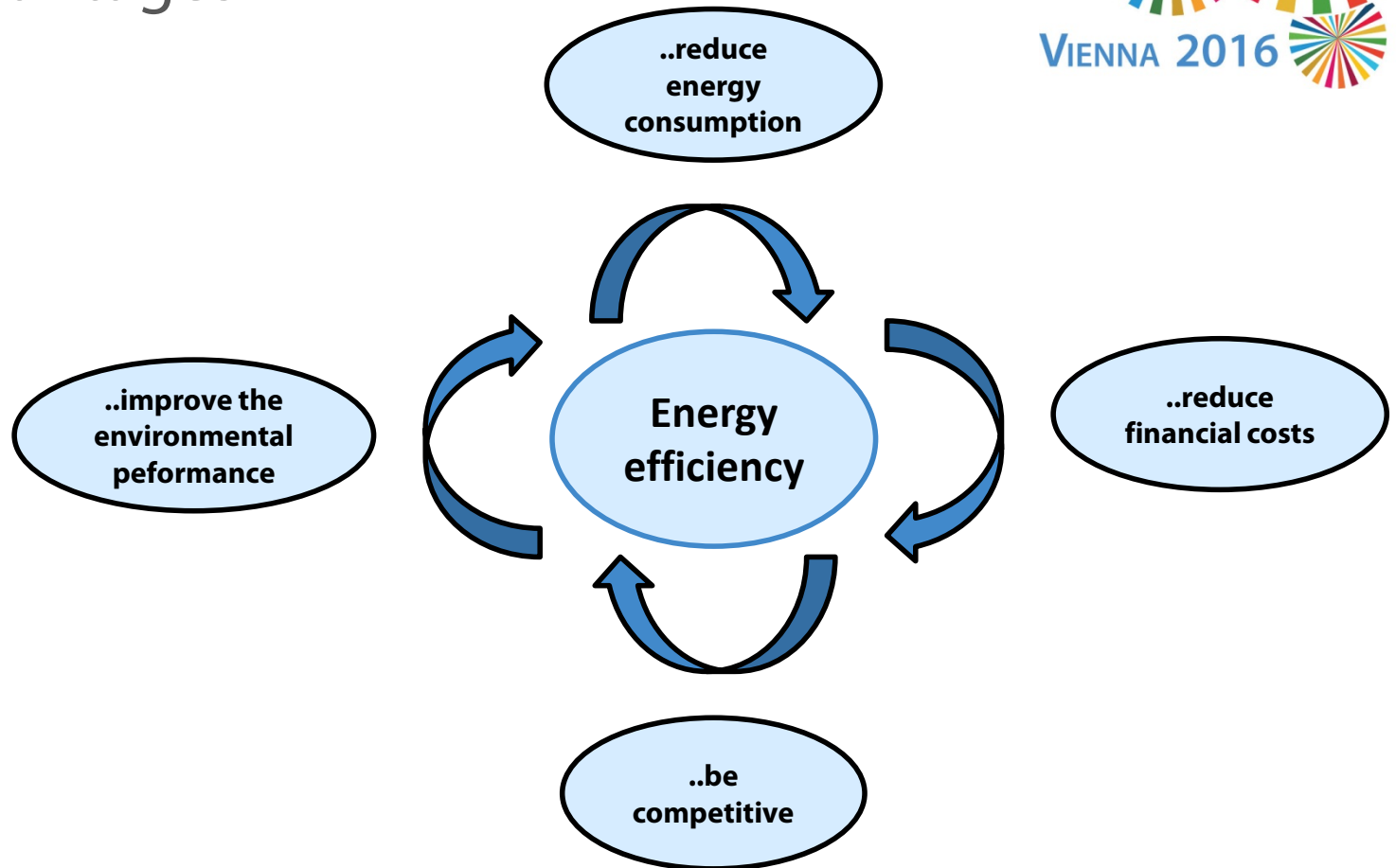
What is the objective ?

- To highlight the state of the art of new technologies for energy efficiency and CO2 reductions in the railway system. Starting from the needs of energy savings, the measures and technologies achieve the aim are explained.



Why..?

- Main advantages



Measures

- 31 measures have been analyzed. The number of measures has been the result of the analysis of the state of art.
- At first the report began by fewer and finally, after developing the state of the art with energy reduction measures that are already implemented and the ones considered in theoretical studies the number grew drastically.

NOW OPEN



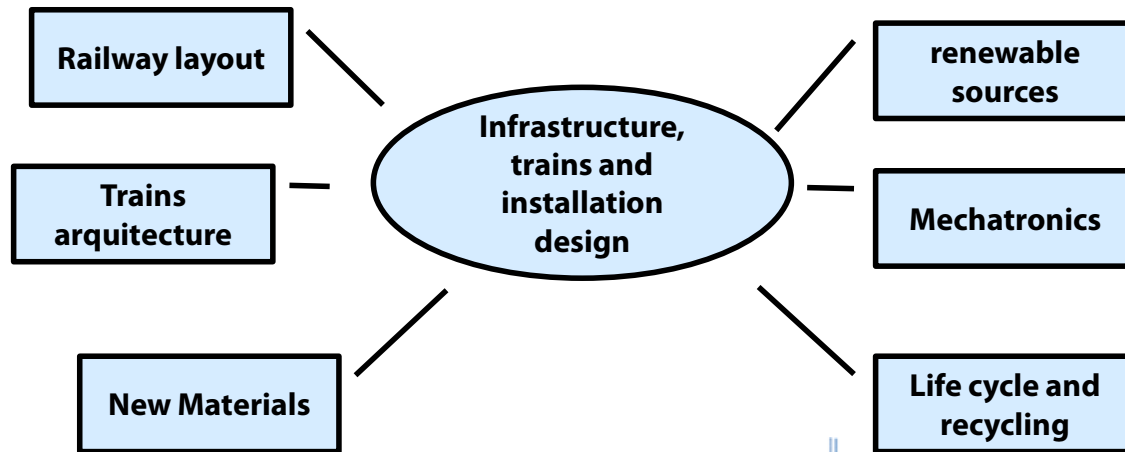
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Topics covered



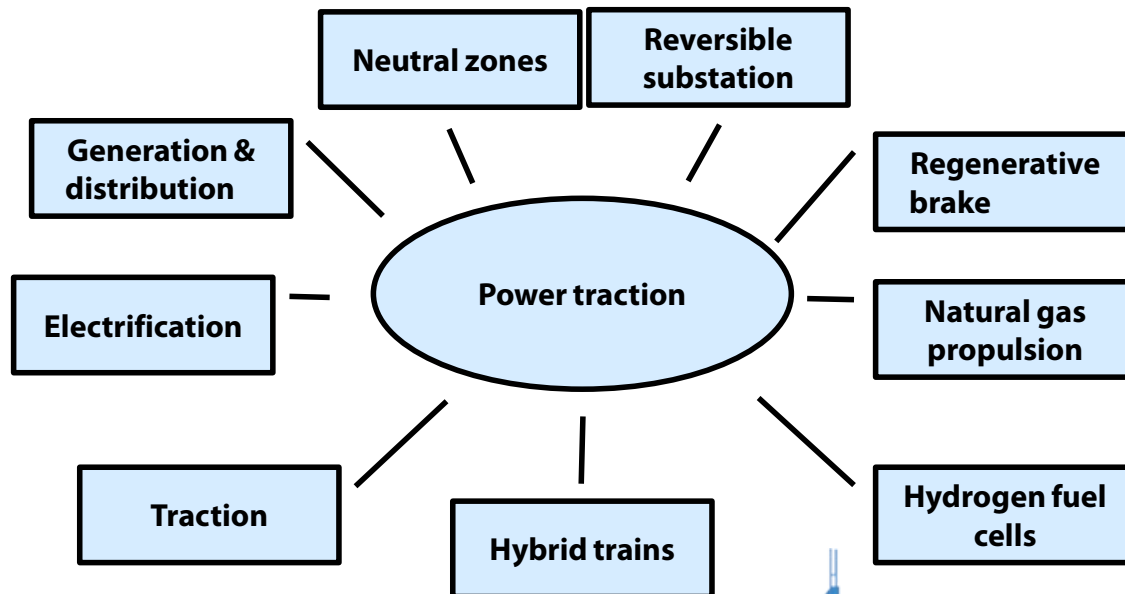
- 4 different sections according to their relation with ...



Topics covered



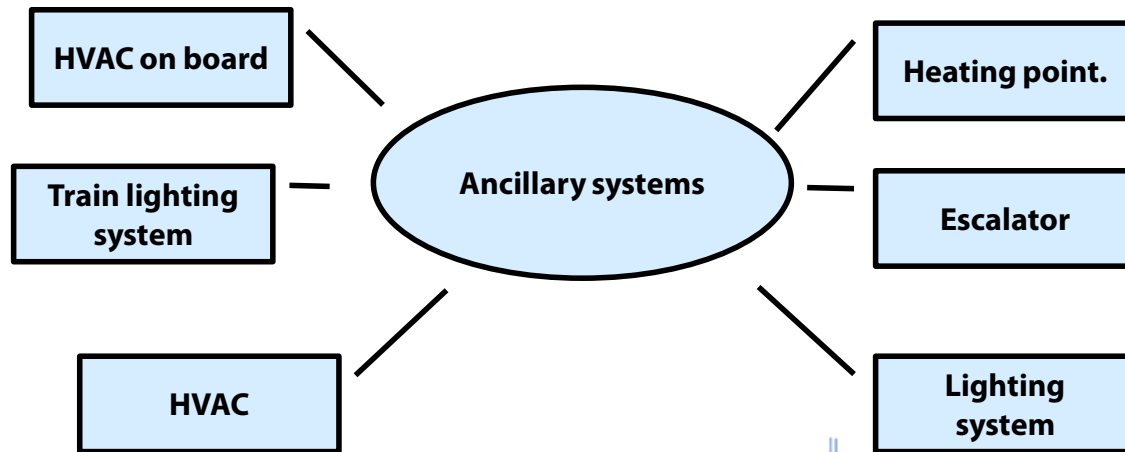
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Topics covered



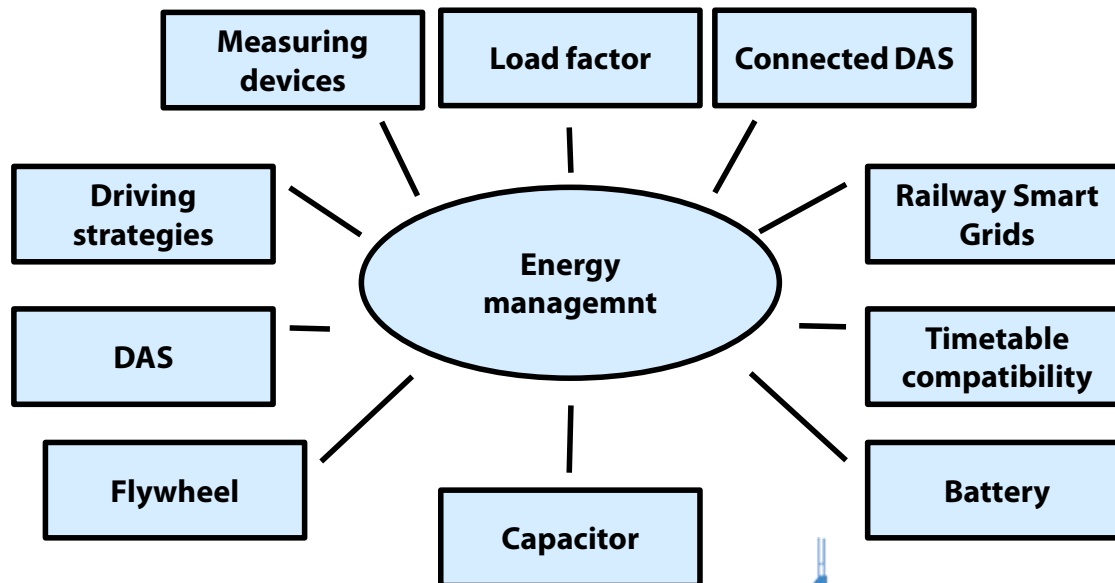
- 4 different sections according to their relation with...



Topics covered



- 4 different sections according to their relation with...





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UIC - Sustainable Development Unit - Fundamental Values Department -
State of the art of new technologies for energy efficiency and CO₂ reductions
in the railway system



3.3.1. Heating points

Introduction

Efficiency

Heating points is a necessity to ensure proper operation of rail switches in cold climates. By introducing newer heaters with improved insulation and regulation (thermostats, monitoring and control), their energy expenditure may be reduced significantly. Another alternative is to power such systems with geothermal energy harvested near the track, hence cutting down the need for external power supply.

Investment

The investment cost of newer heaters with better insulation and thermostats is relatively low, and such systems are designed to be durable and require low maintenance. Installing a system to harvest geothermal energy requires higher investment costs, but this can be compensated in a few years with the cost of the energy saved.

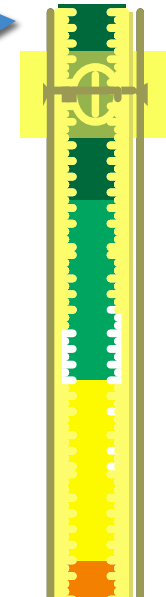
Scope of the measure

- ➔ More efficient point heaters, powered partially with geothermal energy, may achieve a significant reduction of energy consumption.
- ➔ More efficient point heaters do not generate energy to be exported.
- ➔ Heaters may be powered totally or partially with geothermal energy, which is a source of renewable energy.
- ➔ As part of the energy may be provided from geothermal sources, the ratio of CO₂ per kWh consumed is reduced.
- ➔ More efficient point heaters do not affect the location of emissions at local level.

Efficiency

Investment

Scope of the measure



Field of Application	Field 0	Field 1	Field 2	Field 3	Field 4	Field 5
	Common measures to other sectors	Measures of train and track design	Efficient use of power traction	Optimization of operations	Use of the regenerated energy	Interaction between electricity networks
Heating points						
	Design Measures		Redesign Measures		Operation Measures	



Technology analysis

of a railway network. These mechanical installations regulate track junctions and diversions and their reliability is critical to ensure safe railway transportation. Railway tracks are mostly outdoors, and thus are exposed to adverse weather. In colder climates such as the ones found in Northern Europe, low temperatures and snowfall are quite common during part of the year. Snow tends to accumulate over the track and may block the switch mechanism, hence hampering its normal operation. Even without snow, below-zero temperatures may cause frost to the point that moving point blades freeze to fixed stock rail or support slide plates, thus blocking the switch.

Figure 1: Railway switch with gas heater. Source: Fabian Grunder, Wikipedia Commons.



In order to avoid this problem, railway switches in cold climates are equipped with heaters that keep the temperature of the rails and other elements over a fixed threshold so as to melt any snow and frost accumulated and to ensure a smooth operation.

A point heating system should be able to perform in light winds and maintain the rail temperature above a predefined temperature against a minimum ambient temperature (e.g. 3°C against -25°C according to UK regulations). The system should perform three functions (Heat Trace):

- Prevent the moving switch rail from freezing to the fixed stock rail.
- Prevent the switch rail from freezing to the support slide plates.
- Prevent any build of snow, sleet or hail between the switch rail and the stock rail that could compact and prevent the point system from operating correctly.

The importance of such systems in cold climates is highlighted by the following table, where the some average data regarding snow and low temperatures is shown (UK annual average for the 1981-2010 period).

Event	Average number of days per year
Ground frost	>100
Sleet/ snow falling	South: 20-30 / North 50-60
Sleet/ snow lying	South: 20-30 / North 50-60

Table 1: Average number of days per year with cold events in the UK. Source: Met Office.

The impact of such systems in the overall energy expenditure of a railway infrastructure may be noticeable. For instance, a heating system for a single switch which operates continuously during cold months (i.e. from October to April) may require up to 34,000 kWh per year, or about 28,000 kWh if it is equipped with a thermostat (Eltherm).

Considering a whole railway network, the amount of energy needed to power these systems is significant. In Germany, Deutsche Bahn (DB) alone has 64,000 points heated with electrical resistance and gas heaters, a combined power of 900 MW which consume up to 230 GWh/year (BINE).



Objectives and benefits

Most conventional points heaters are either electrical resistances or gas heaters. Over the past years some improvements and variations have been researched and tested so as to increase their energy efficiency. The main issue with conventional heaters is that only a fraction of the energy is actually consumed to heat up the rail or other track elements, while the rest is lost as waste heat. In order to solve this, the main focus of most modern heater designs is to improve their insulation and ensure that most of the heat generated goes into the rails.

Figure 2: Railway switch equipped with electrical heater. Source: railway-technology.com



On the other hand, traditional heaters operated on an on/off basis i.e. they turned on as soon as the temperature fell below a defined threshold and worked at full power until the room temperature rose again. Newer heaters are equipped with thermostats or even controlled through a centralized network so that they adapt their workload depending on the actual temperature.

The combination of better insulation and regulation increases significantly the energy efficiency of heaters. Many new commercial designs guarantee improvements ranging from 10% to even 80% with regards to traditional heaters, depending on different factors. The next table shows a summary of average energy savings for different scenarios compared to the energy consumption of a traditional heater with ON/OFF operation.

Scenarios	Average energy saving vs case 1
1. Conventional heater, ON/OFF operation	0
2. Better insulated heater ON/OFF operation	8%
3. Better insulated heater, thermostat	30%
4. Better insulated, thermostat, monitoring and control	70%

In addition to the aforementioned measures, another alternative has been evaluated over the past few years. Under certain conditions, it is possible to harvest geothermal energy from the underground and use to power heaters, either partially or even completely, thus reducing the need for external power supply.

This alternative has been already tested with different prototypes in several locations with promising results. The investment costs are higher than for conventional heaters due to the additional equipment required (heat pipes, boreholes, condensers) but this can be compensated in a few years as the heaters require very low (or even any) external energy supply.

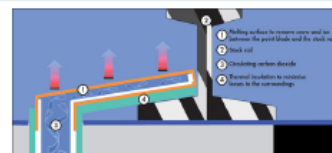



Figure 3: Scheme of a rail heated with geothermal energy. Source: BINE


Applications

Bibliography



FUNDACIÓN
de los
FERROCARRILES
ESPAÑOLES

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the railway system



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Applications

Real applications. Demonstrator

Author	Explanation	Benefits
Eltherm GmbH	This company has developed new points heaters with improved insulation and regulation.	Theoretical calculations under several operational scenarios have yield an average energy saving of 30% compared to conventional heaters. This accounts for an average reduction of 17.3 tonnes of CO ₂ per switch and year.

Author	Explanation	Benefits
German Federal Ministry of Economics and Technology PINTSCH ABEN geotherm GmbH Bavarian Center for Applied Energy Research	A research project developed to make further progress in point heaters powered completely with geothermal energy. Experimental prototypes have been tested under real conditions.	Geothermal powered heaters do not require external energy sources, hence cutting energy costs to zero. Higher investment cost compared to conventional heaters, but compensated after 8-10 years of use.

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MEASURES ANALYSIS: SECTIONS

- I. Measures related to Infrastructures, trains and installations design.
- II. Measures related to power traction
- III. Measures related to ancillary systems
- IV. Measured related to Energy management



Infrastructures, trains and installations design.



- This section is related to the infrastructure: How the track is designed and built, the homogeneous speed profile, the optimization of the station construction and location, etc....
- In this section the architecture of trains and their relationship with reductions of aerodynamic resistance is also concerned; the application of new materials to reduce the mass of the trains, to increase their efficiency; life cycle and recyclability, etc...
- Besides the implementation of renewable energy sources is studied for different uses in railway systems.



Efficiency

Infrastructures, trains and installations design.



Railway
layout

Life cycle
and recycling

New
Materials

Architecture
of trains

Mechatronics

Investment



Measures related to power traction



- This section is related to the well to tank losses and how to reduce them, like generation, transport and distribution.
- It is also related to the well to wheel losses and how to reduce them, using new fuels fuel cell, LNG..., or more efficient devices in the traction (IGBT, asynchronous motors).
- Besides, the implementation of other technologies such as regenerative brakes and reversible substations to increase the exported energy or technologies to reduce the losses and the power peak in substations are also included.



Efficiency

Measures related to power traction



Hydrogen
fuel cell

Natural gas
propulsion

Regenerative
brake

Traction

G&D

Reversible
substation

Hybrid trains

Electrification

Neutral zones

Investment



Measures related to ancillary systems

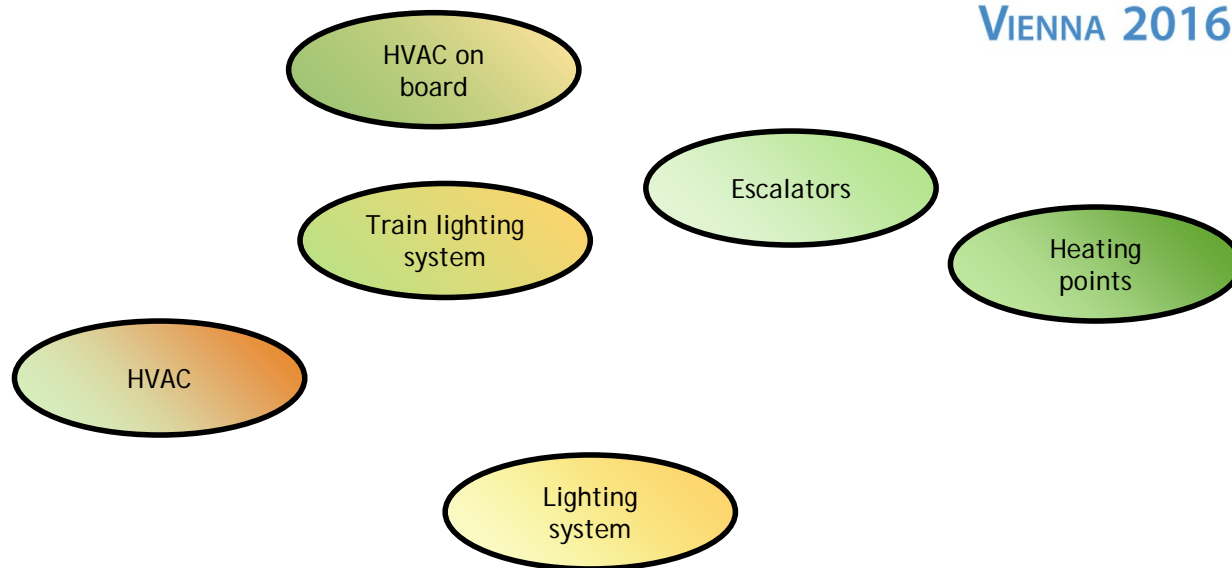


- This section is related to the ancillary system efficiency and how to improve it through the use of controlled HVAC and light on board system.
- Also, the HVAC and light system and the escalators at stations and depots and how to improve them are explained.
- Moreover, the implementation of new technologies at heating points to reduce energy consumption in the infrastructure are included in this section.



Efficiency

Measures related to ancillary systems



Investment



Measured related to Energy management

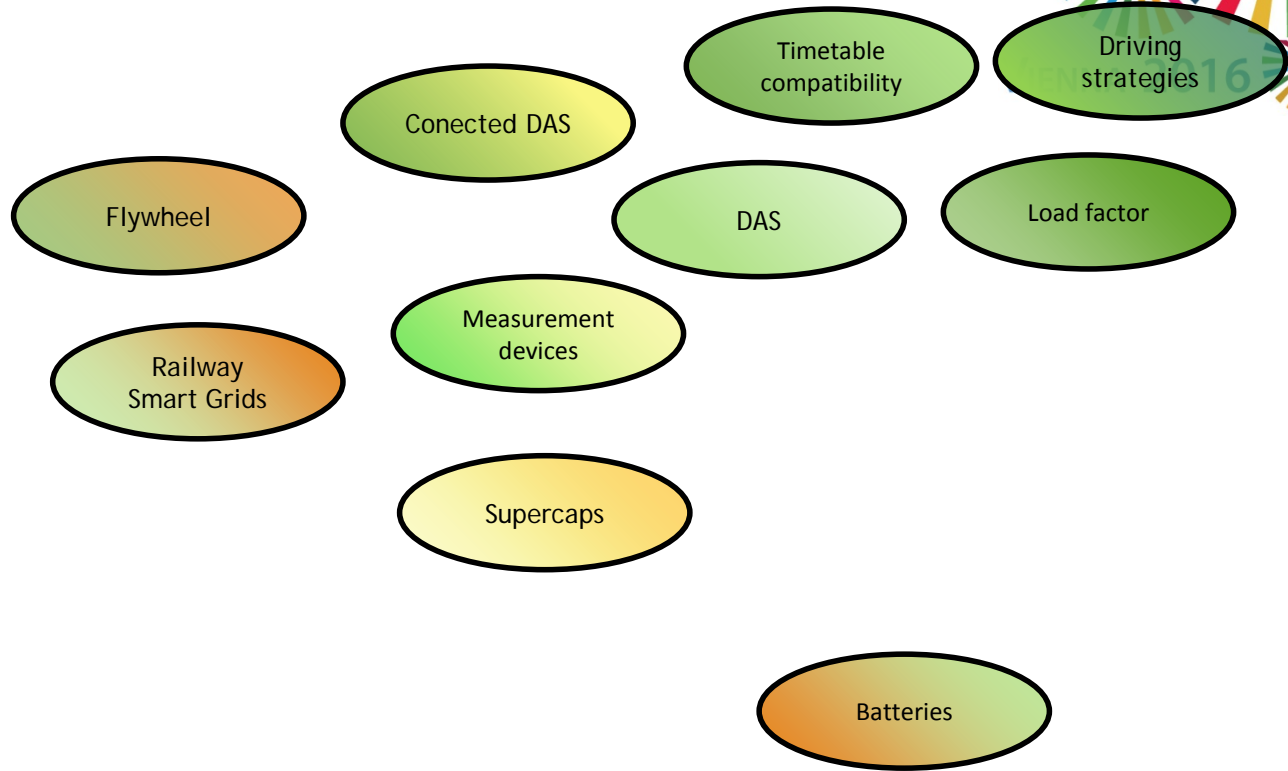


- This section includes driving strategies and the way to improve them. Some driving strategies to reduce energy consumption are explained. Driving advisory system (DAS) and its benefits are exposed too.
- Different energy accumulators and their characteristics and benefits are also explained in this section.
- Besides the need of the implementation of a Railway Smart Grid and how it works (or should work) and its benefits are included.



Efficiency

Measured related to energy management

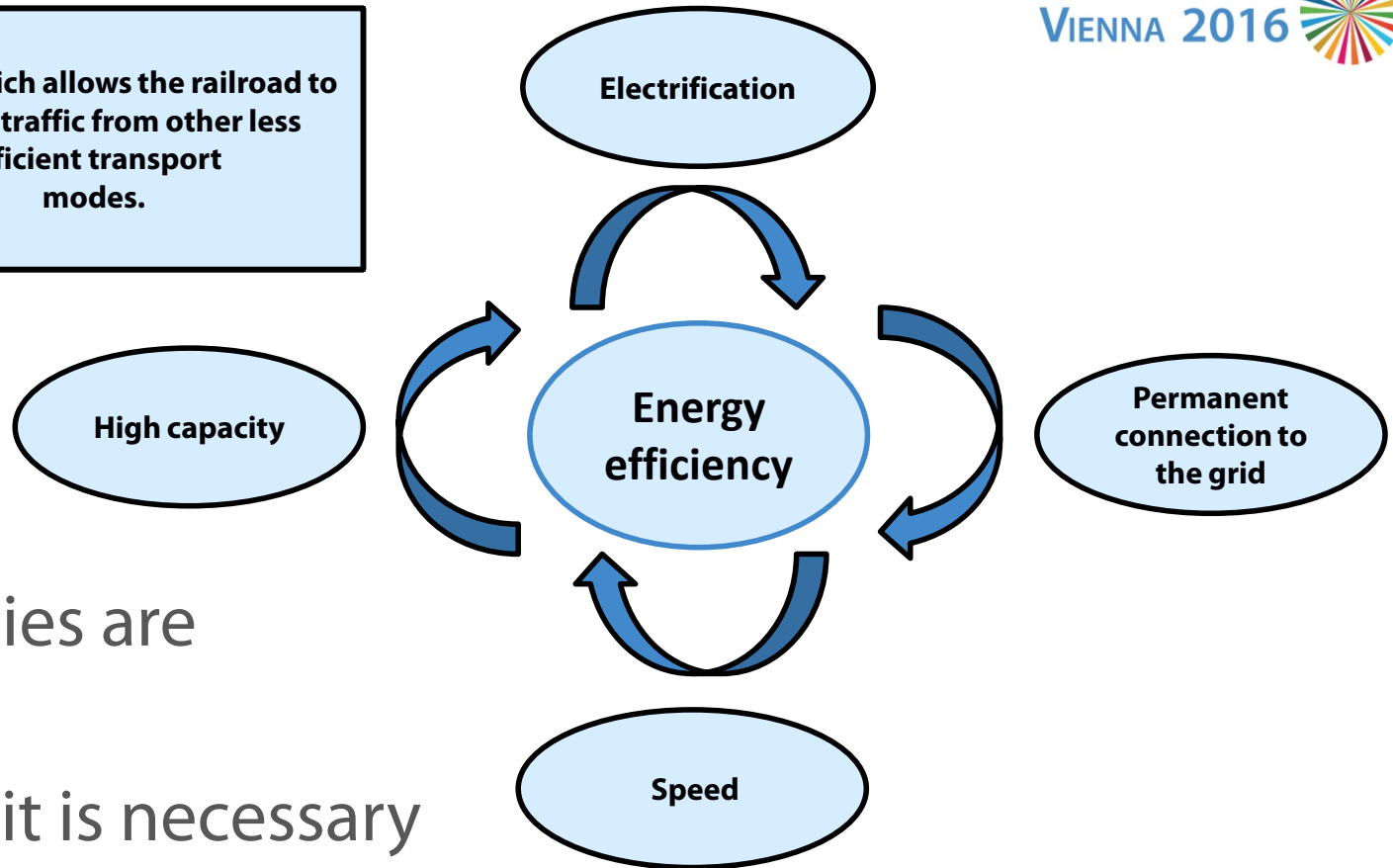


Investment

As a conclusion..



Speed, which allows the railroad to capture traffic from other less efficient transport modes.



- All strategies are efficient.
- In railway it is necessary to highlight:



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Thank you for your
attention.

12, 13, 14 October 2016