UIC ENERGY EFFICIENCY DAYS 2014

ANTWERPEN, 16 - 19 JUNE

THE FUTURE OF EUROPEAN DIESEL TRACTION

FLEET SCENARIOS, EMISSION REDUCTION & ENERGY EFFICIENCY POTENTIALS

Dr. Roland Nolte IZT Institute for Futures Studies & Technology Assessment

Energy Efficiency, the best fuel to move our trains!

PRESENTATION OUTLINE

- Introduction
- Sustainability Study
- Sustainability Impact Assessment & EE
- Conclusions

GENERAL OBJECTIVES

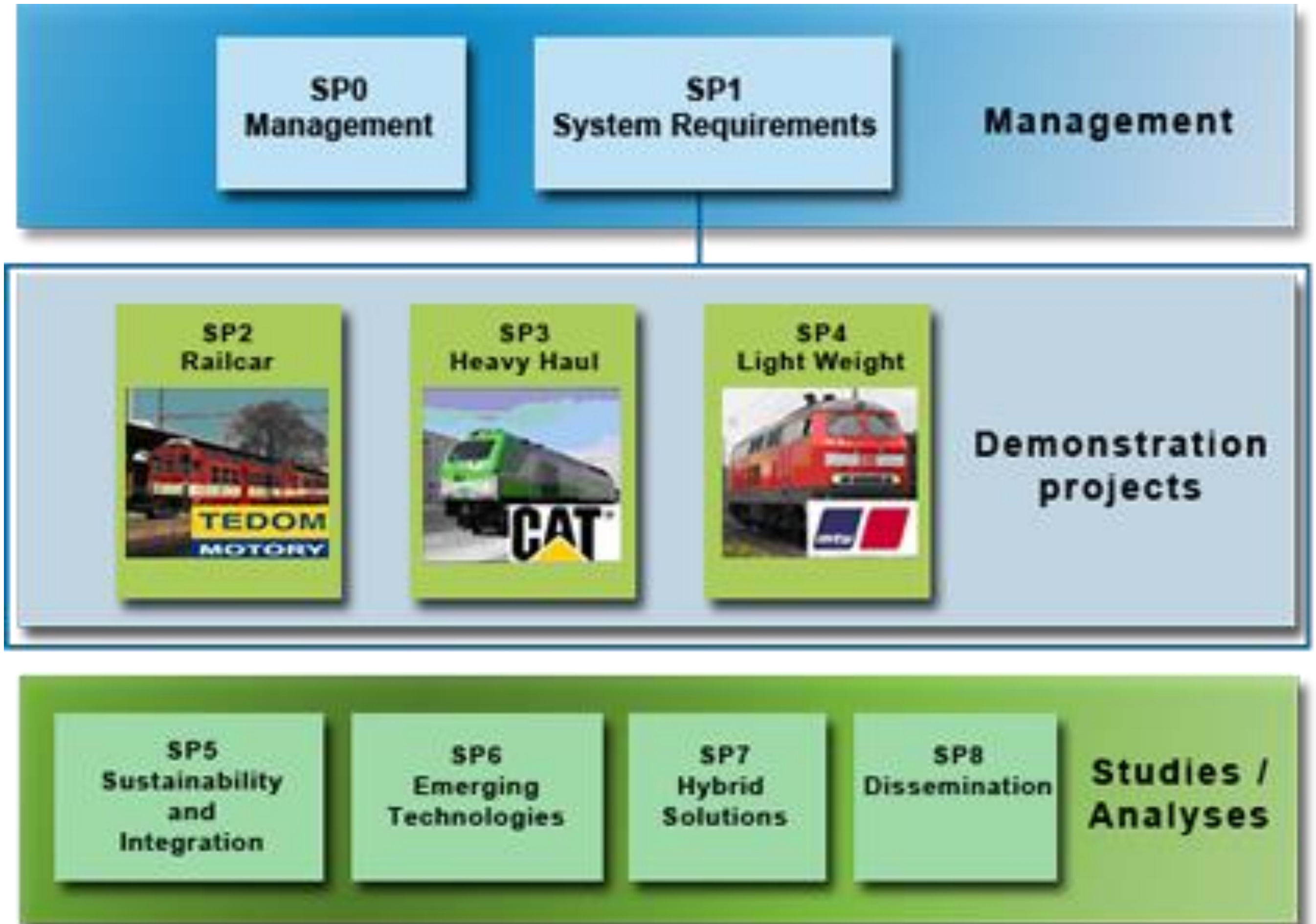
CleanERD

- Demonstrate the feasibility and reliability of railway rolling stock powered with stage IIIB diesel engines, scenarios beyond IIIB

SP Sustainability & Integration

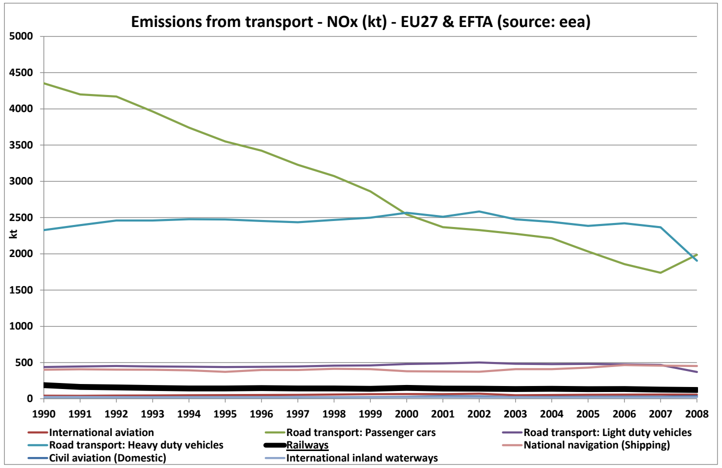
- Reliable rail diesel vehicle **fleet and emissions scenarios**
- Cost/ Benefit Analysis and **Sustainability Impact Assessment**
- **Recommendations** on future emission reduction approaches

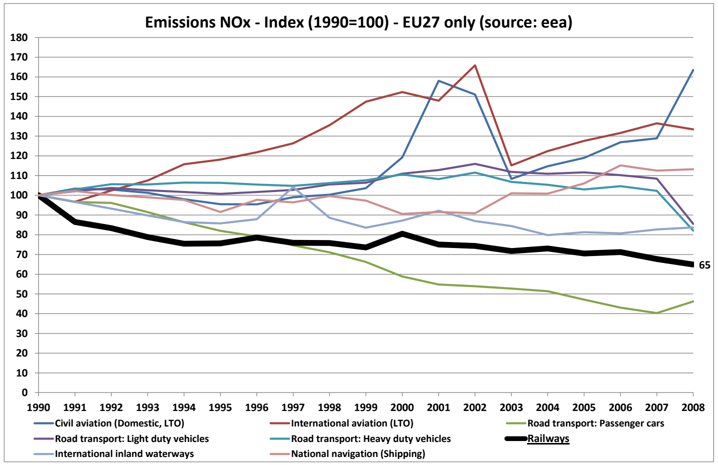
PROJECT STRUCTURE



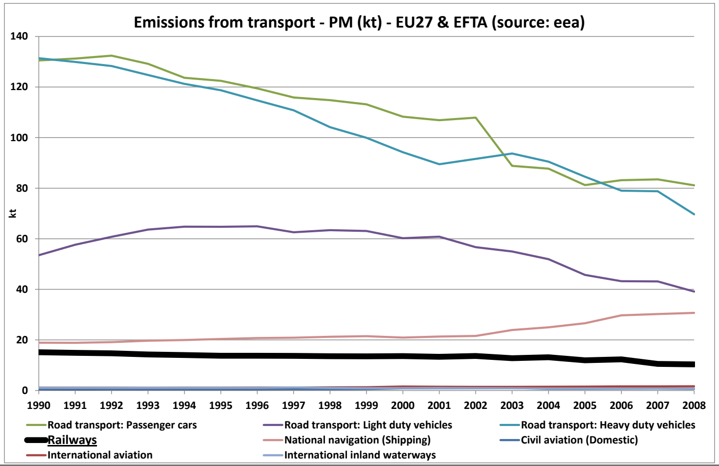
Current Status: NOx & PM emissions from transport

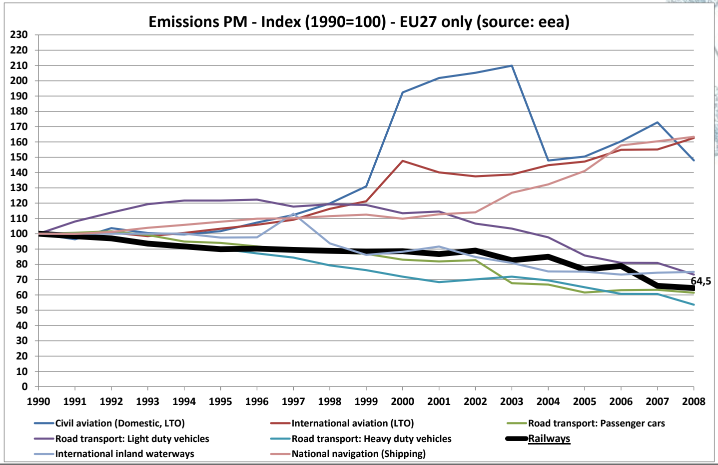
Rail's diesel share of total NOx emissions is 2.5%, reduction by 35% (1990-2008)





Rail's diesel share of total PM emissions is 4.5%, reduction by 35% (1990-2008)





PRESENTATION OUTLINE

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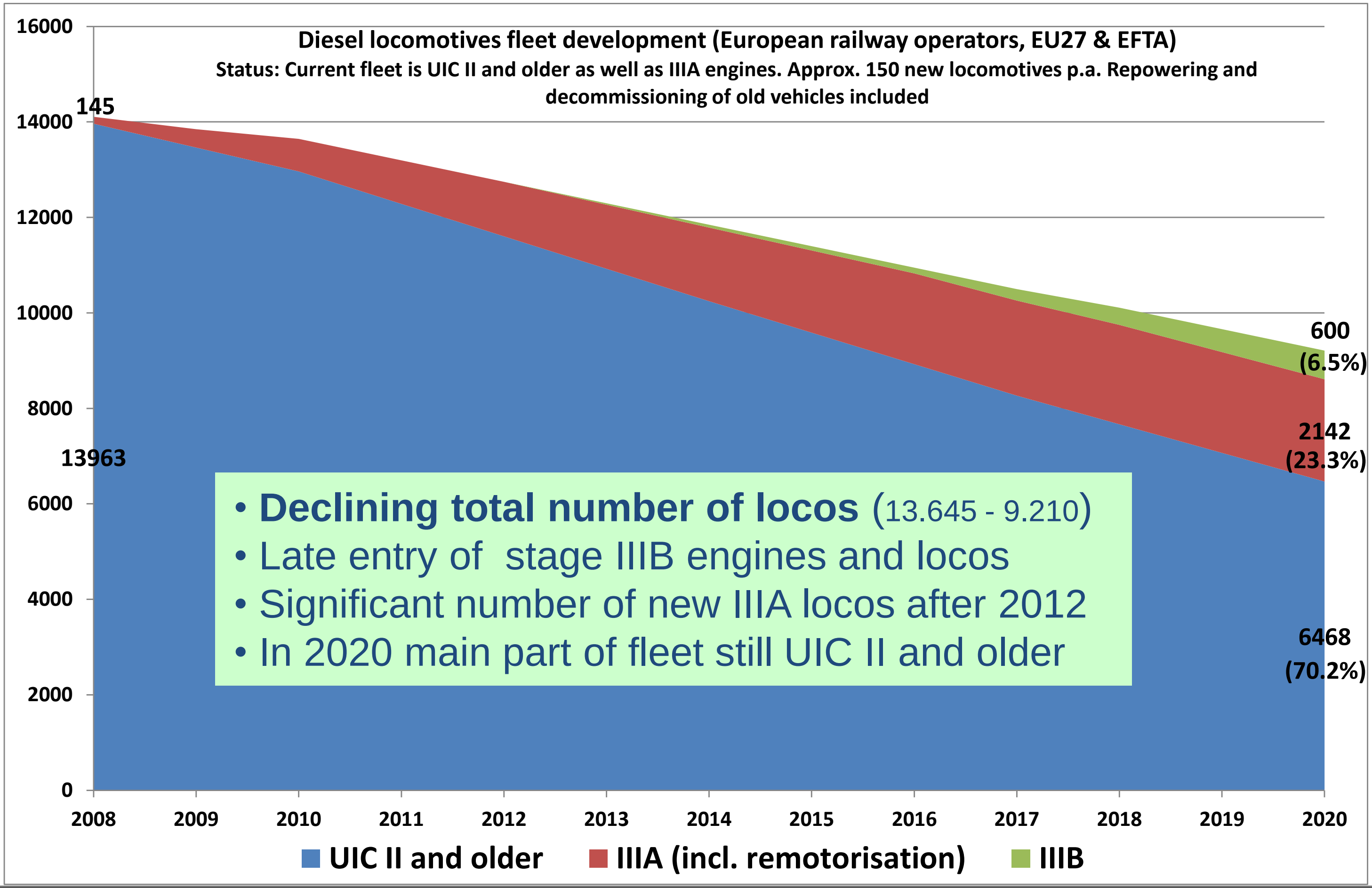
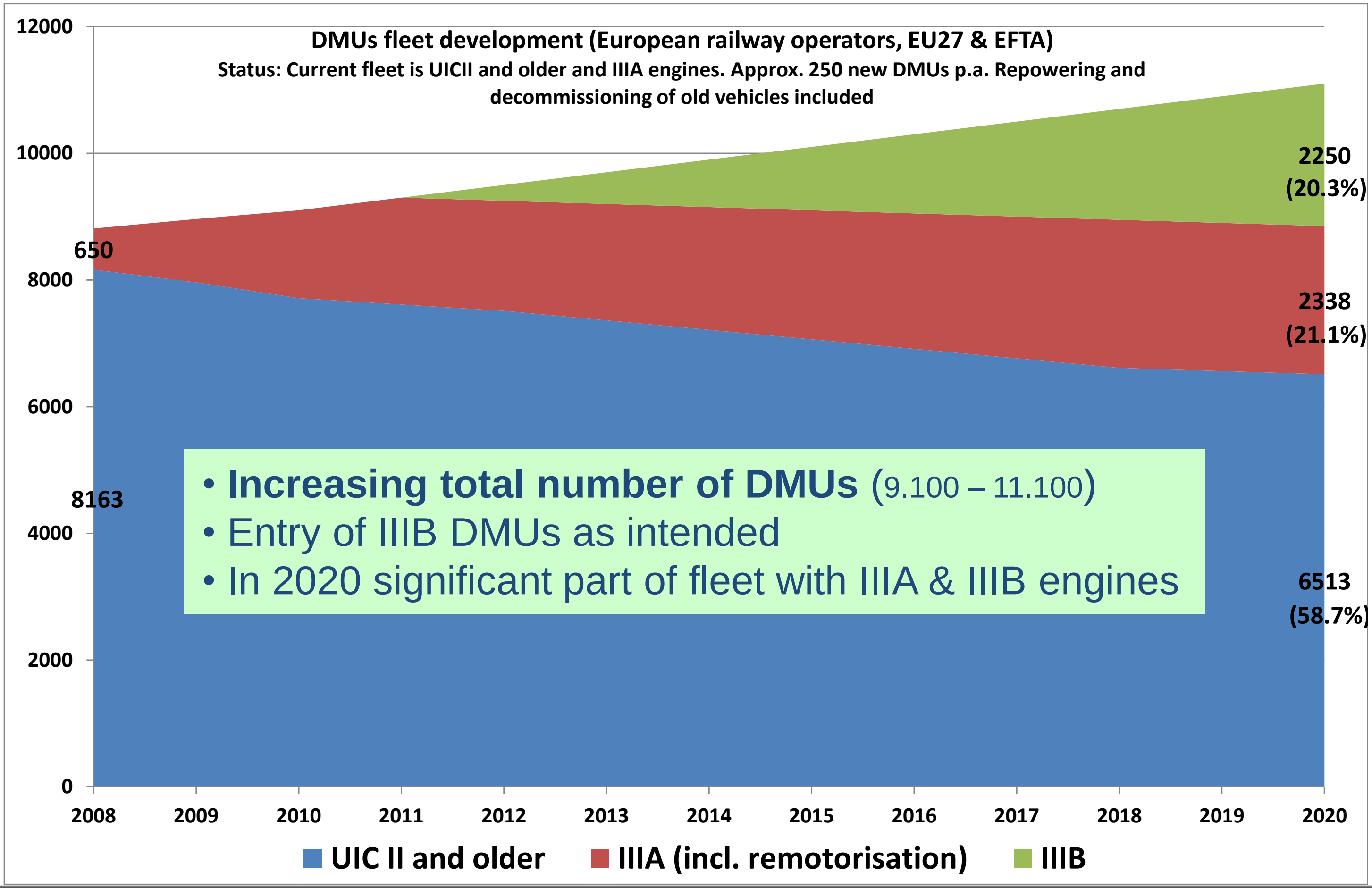
- Sustainability Study
- Sustainability Impact Assessment & Energy Efficiency
- Conclusions

FUTURE DEVELOPMENT OF EUROPEAN RAIL DIESEL FLEET UNTIL 2020 - LOCOMOTIVES



- **Declining total number of locos** (13.645 - 9.210)
- Late entry of stage IIIB engines and locos
- Significant number of new IIIA locos after 2012
- In 2020 main part of fleet still UIC II and older

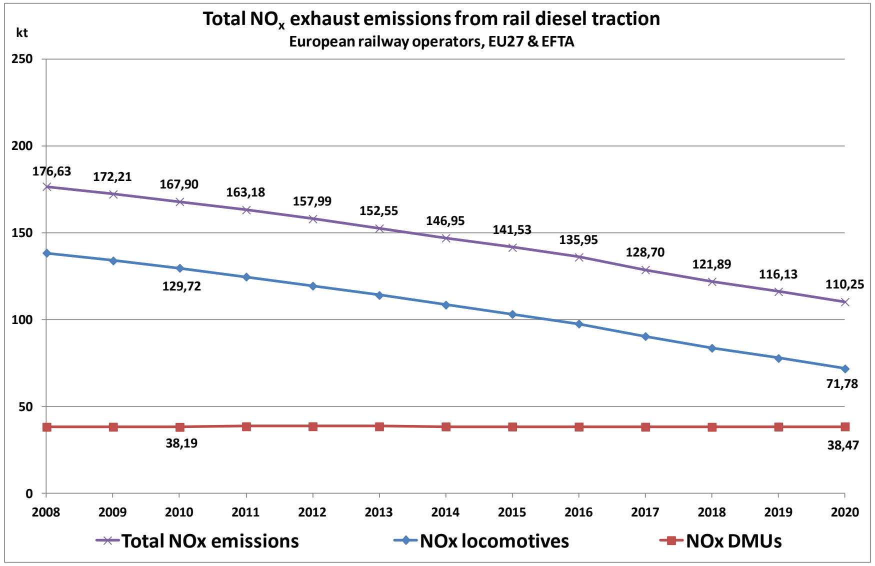
FUTURE DEVELOPMENT OF EUROPEAN RAIL DIESEL FLEET UNTIL 2020 - DMUS

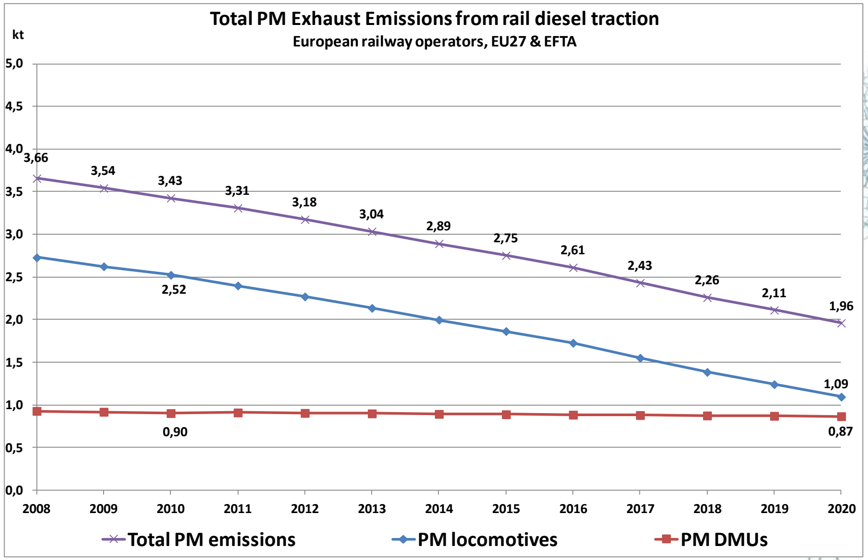


TOTAL EXHAUST EMISSIONS FROM RAIL DIESEL TRACTION UNTIL 2020 – NO_X & PM

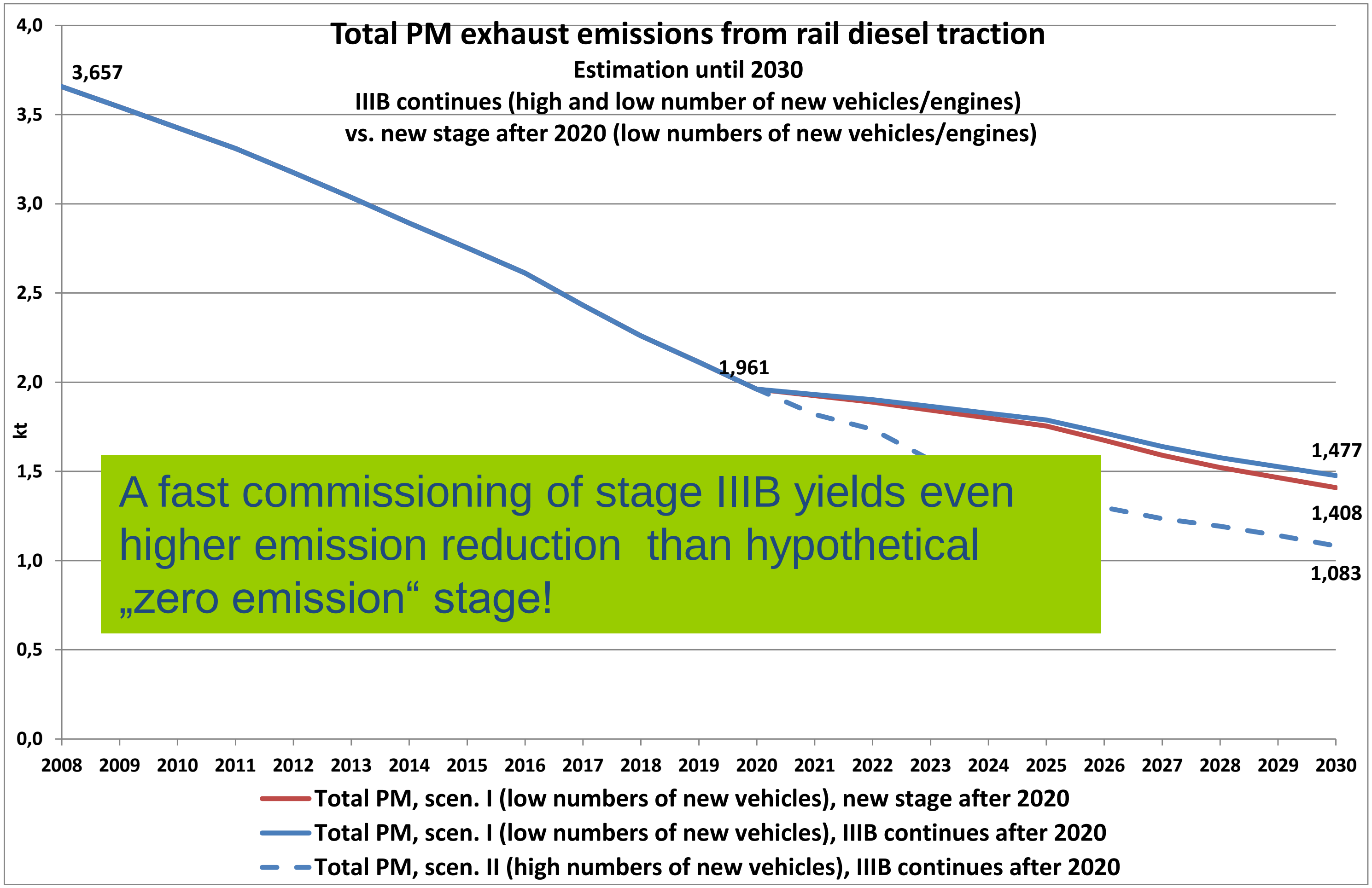
Total NO_x reduction > 35% until 2020
- Decreasing loco numbers
- Introduction of IIIA & IIIB
- Stable NO_x emissions from DMUs despite growing fleet and mileage

Total PM reduction > 45% until 2020
- Decreasing loco numbers
- Introduction of IIIA & IIIB
- Stable PM emissions from DMUs despite growing fleet and mileage





Scenario: Exhaust emissions from rail diesel traction until 2030 (PM)



A fast commissioning of stage IIIB yields even higher emission reduction than hypothetical „zero emission“ stage!

PRESENTATION OUTLINE

- Introduction
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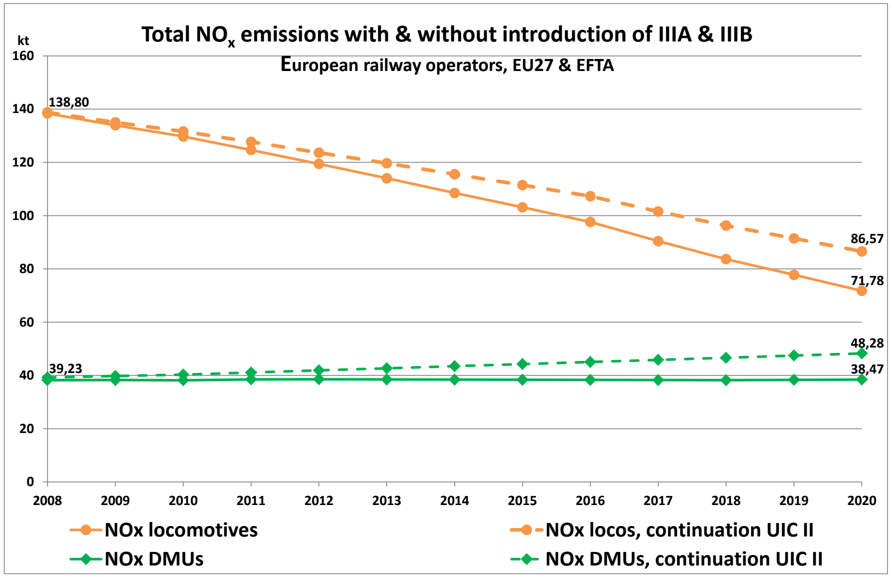
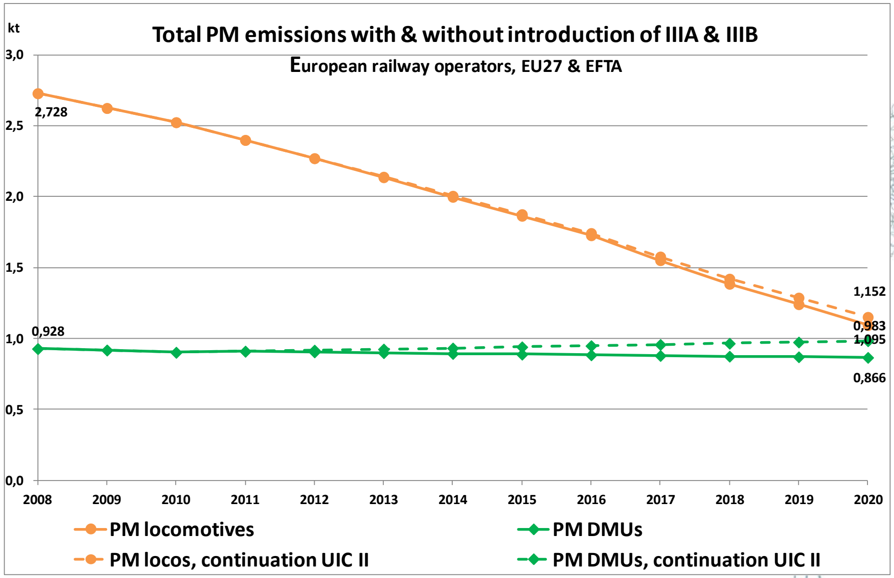
- Sustainability Impact Assessment & EE
- Conclusions

IMPACT OF INTRODUCTION OF STAGES IIIA/IIIB

- **Total NOx reduction ~ 20% until 2020 due to introduction of IIIA & IIIB**

- **Total PM reduction ~ 8% until 2020 (introduction IIIA/B)**
- **Lower than for NO_x** (equal PM performance UIC II & IIIA + good PM performance of UIC I)

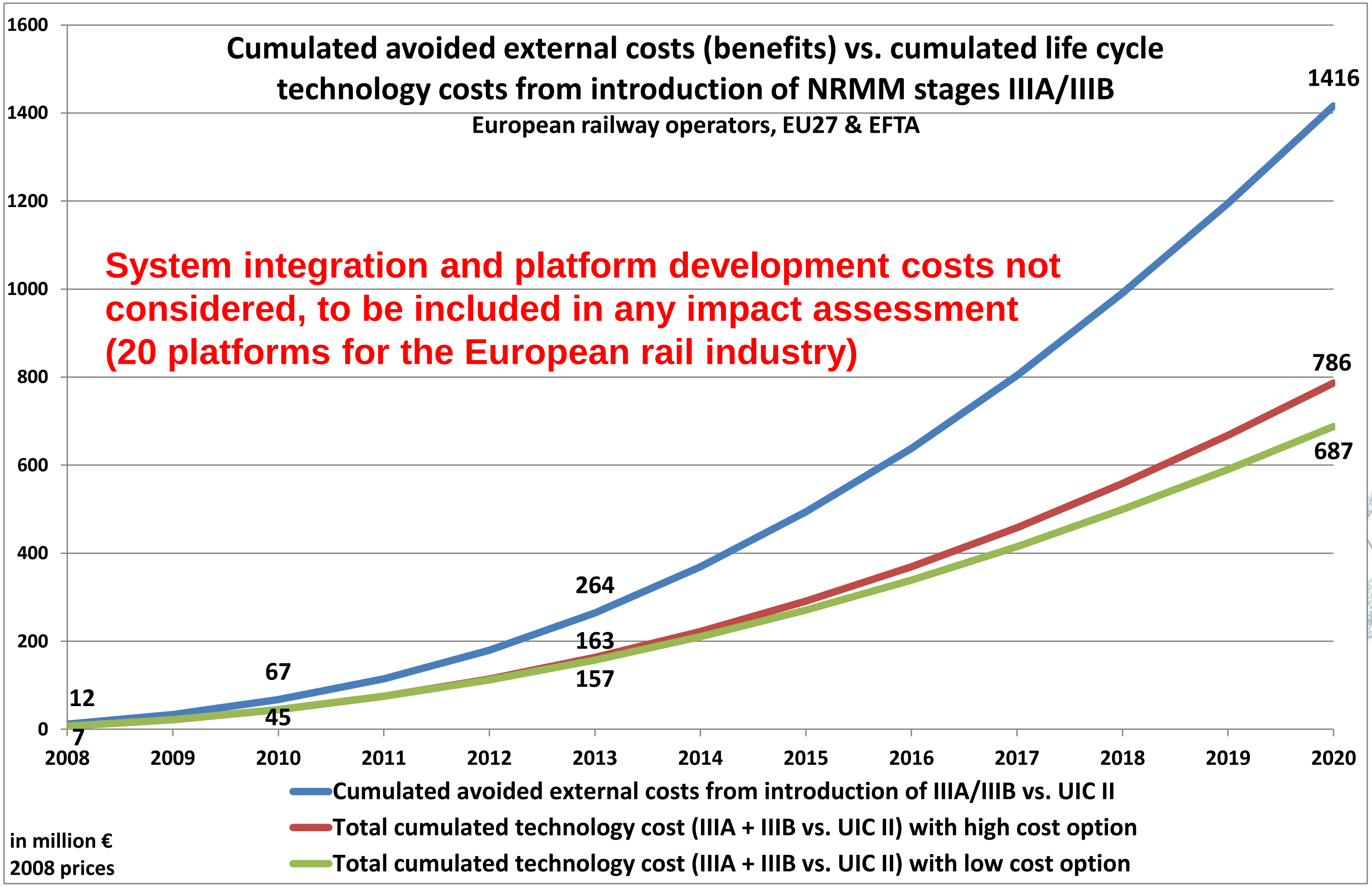




IMPACT OF INTRODUCTION OF STAGES IIIA/IIIB

- Life Cycle Costs for Introduction of Stage IIIA and IIIB
  (cumulated delta costs over 20 years)
- External costs of exhaust emissions from rail diesel traction
  - External costs per ton NO_x and ton PM
  - Weighted European average costs based on performed diesel train mileages per country
- Benefits of exhaust emissions reduction
  - Avoided external costs
  - Per year and cumulated benefits

COST/BENEFIT OF IIIA/IIIB



Energy Efficiency Potentials of Diesel Traction (rolling stock & operation)

- Ecodriving & DAS
  - Saving Potentials of 5 - 20 %
  - Higher Potentials for traffic flow management
- Parked Train Management
  - From low tech to system solutions, 3-10% energy savings
- Reuse of Braking Energy
  - Different Storage Options, 3-10% energy savings
- Smart Energy Management
  - Software changes to systemic approaches, up to 10% savings

Energy Efficiency Potentials of Hybrids

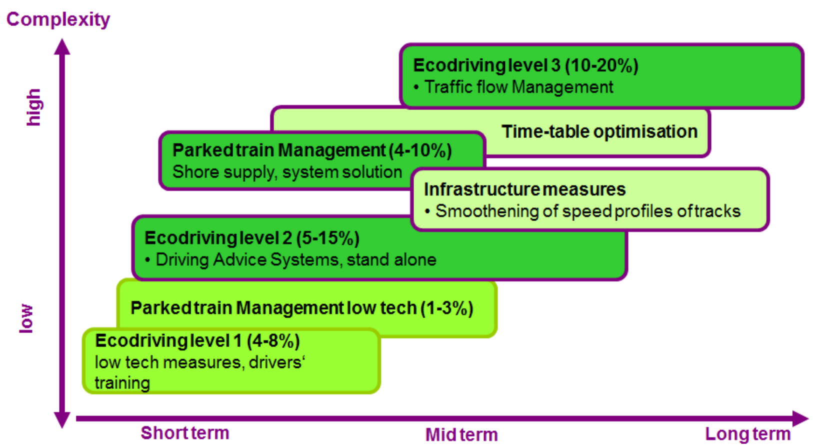
- High Energy Efficiency Potentials of Hybridization
  - Easy reduction of fuel consumption & CO2 up to 20 %
  - Best for Regional Services & Shunters
  - Reduction of NOx and/or PM but: needs good management strategies

- Energy management strategies can improve the benefits
  - Electrification of auxiliaries is necessary
  - Downsizing and replacement is possible
  - Example Shunter: 1.000 kW-560 kW; PM –73%, NOx –57%, Energy –34%

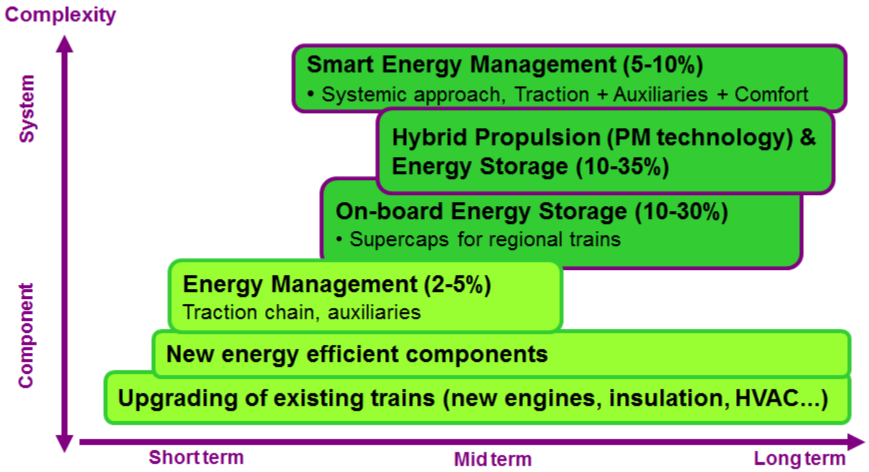
CONCLUSIONS

- 2020: Significant Reduction: Emissions & and Energy Consumption
- Additional reduction of emissions: Accelerated migration of current technologies into fleet (legislation, incentives) + innovation
- Promising Energy Efficiency Potentials for Diesel Traction

Smart Operation



Innovative Rolling Stock



Thank you for your attention!

Dr. Roland Nolte, r.nolte@izt.de

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ENERGY EFFICIENT DIESEL TRACTION
GB MAINLINE RAIL INITIATIVES

NEIL OVENDEN - ATOC

Energy Efficiency, the best fuel to move our trains!

GB Mainline Rail in Context

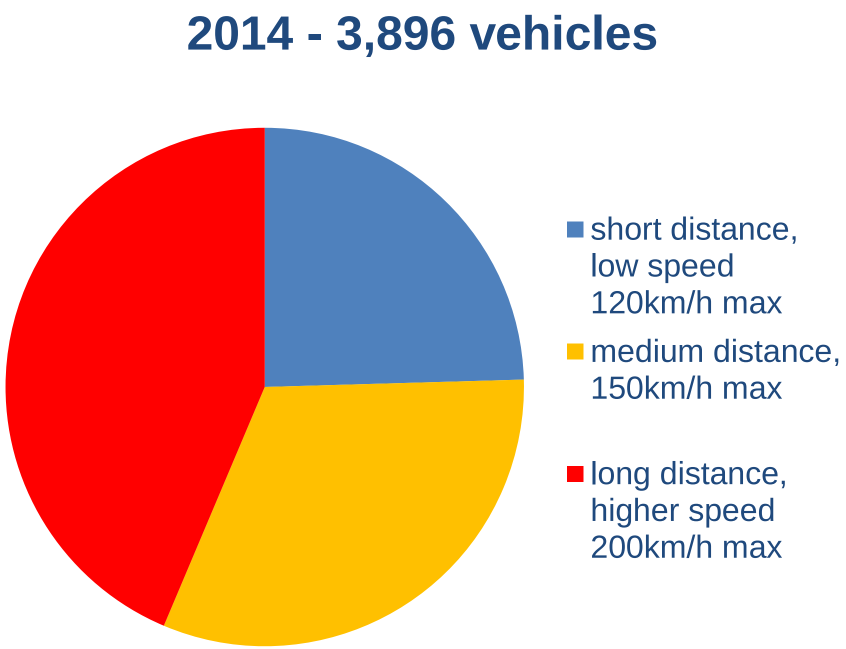
- 45% diesel/gasoil traction (by 2012 annual unit miles)
- 55% electric traction (by 2012 annual unit miles)

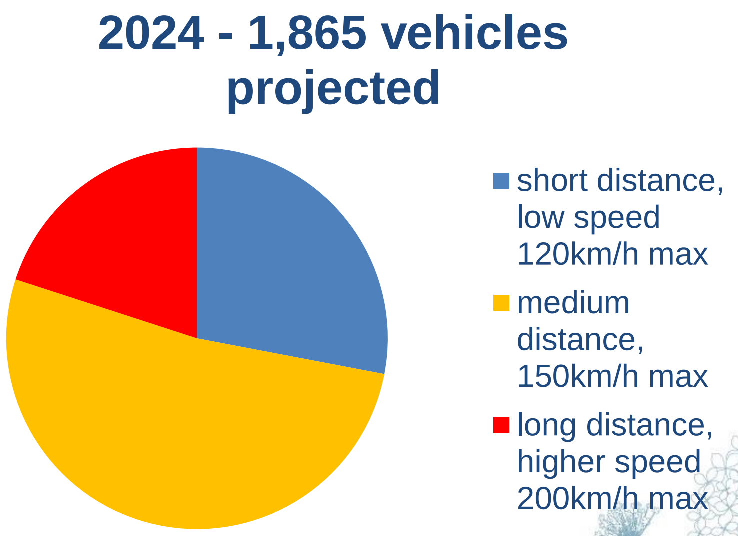
- Electrification to increase over the next 10 years – by 6,400 track km

GB Mainline Passenger Diesel Traction

- 3,896 diesel propelled passenger vehicles (2014)
- Diesel/Gasoil: 489Mlitres p.a. (passenger operations - 2012/13)
- Carbon Emissions: 1.34Mtonnes CO_2 p.a. (passenger operations - 2012/13)
- future decrease due to diesel fleet reduction & energy initiatives

GB Mainline Passenger Diesel Fleet





GB Diesel Energy Initiatives

- Driver Advisory Systems
- New Gearboxes
- Automatic Engine Shutdown
- Fuel Injection & Combustion Improvements

Driver Advisory Systems

- Fitted to 8% of cabs now (S-DAS)
- Fitted to 20% of cabs by end 2014 (S-DAS)
- Further significant fitment during 2015 (S-DAS + C-DAS)
- Energy savings >10%

New Gearboxes

- Replace original hydrodynamic DMU gearboxes with 5 speed automatic gearboxes
- Energy savings >10%

Other Diesel Efficiency Initiatives

- Automatic Engine Shutdown

  5 – 8% energy saving, dependent on train type, route, timetable

- Fuel Injection & Combustion Improvements

  4% energy saving

CONCLUSIONS

- GB train operators are committed to reducing both traction and non-traction energy consumption and emissions, where they have a business case to do so

- It is recognised that there is still much more to do

- GB train operators have delivered and are now reaping the advantages of energy consumption reduction initiatives

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MODELLING OF DIESEL TRACTION CHAIN

WORKSHOP – 18/06/14 – 14H30/16H00

SNCF – CHAUVET FRÉDÉRIC

DIESEL TRACTION CHAIN EXPERT

Energy Efficiency, the best fuel to move our trains!

SUMMARY

1- Energetic and environmental context

2 - Modelling approach

3 - Energetic Macroscopic Representation

4 - Example of application

5 - Conclusions

Energetic and environmental context

ENERGETIC AND ENVIRONMENTAL CONTEXT

- Decrease of amount of fossil energies
- Increase of cost of fossil energies
- Problems with global warming and health impact
  - Evolution of the pollutant limites for diesel engine
  - Decrease of NOX and PM emissions imposed by UIC

➔ **Necessity to reduce the fuel consumption and exhaust emissions of diesel locomotives and DMU**

Energetic and environmental context

- SNCF want to reduce his energy consumption about 20% before 2020
- The fuel consumption represente 21% of the total energy consumption
- Different solutions exist to reach these objectives
  - Stop and Start
  - ESS
  - Heat waste recovery
- Assessment of the return of invest

➔ **Necessity to use modelisation of diesel traction chain**

Modelling Approach of diesel traction chain

MODELLING APPROACH

- Train is a system in interaction with his environment
- Train is composed by different sub-systems
- Train is managed by physical laws
- The future trains will have different energy sources
- The future train need management of energetic exchanges which will be more complex

➔ **Different approaches of modelling are possible**

Modelling approach

- Different possibilities to describe a system:
  – Structural
  – Functionnal
- Different possibilities to connect subsystem :
  – Causal
  – Non-causal
- Different methods to compute the model:
  – Forward approch
  – Backward approch

➔ **A lot of possibilities exist and depend on the aim which is researched**

EMR: PURPOSE, PRINCIPLE AND ADVANTAGES

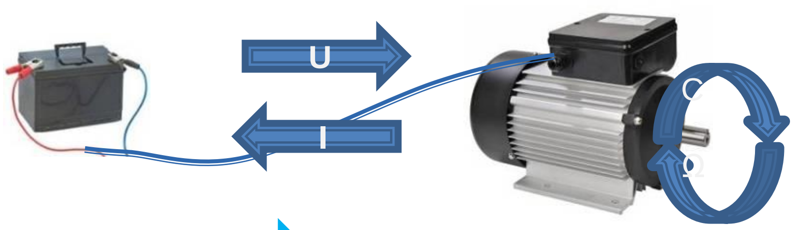
- E as Energetic:
  - Modelling energetic interactions
    - System / environment
    - Between sub-systems
    - Action and reaction links
- M as Macroscopic :
  - Possibility to adjust the model in accordance with the knowledge of the system
- R as Representation
  - Graphic representation

EMR: PURPOSE, PRINCIPLE AND ADVANTAGE

- The principles of EMR are:
  - Systemic representation
  - Causal approch
    - Outputs are an integral function of inputs
- The advantages of EMR are:
  - Graphic representation
  - « Same langage » between specialists
  - Possibility to create library of models (data bases)
  - No specific solver (causal appraoch)
  - Deduction of the control laws by inversion of the model

EXAMPLE: DC MOTOR

Example : DC motor



Action 1
Application of
Voltage U

Action 2
Application of load C

Battery

DC motor

Load

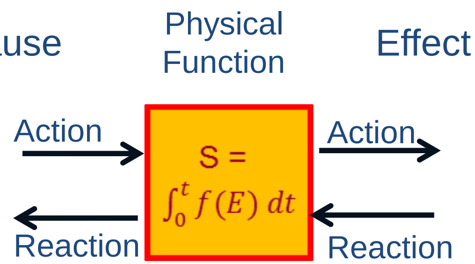
Réaction 1
current I

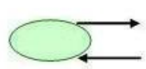
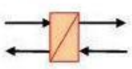
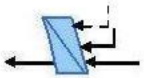
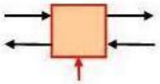
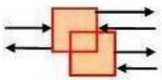
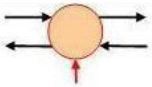
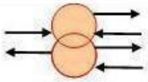
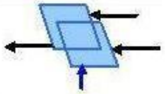
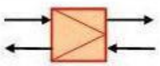
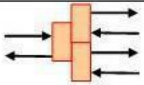
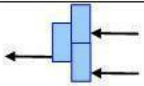
Réaction 2
Rotation speed Ω

Power input = Action 1 * Reaction 1
= U * I

Power output = Action 2 * Reaction 2
= C * Ω

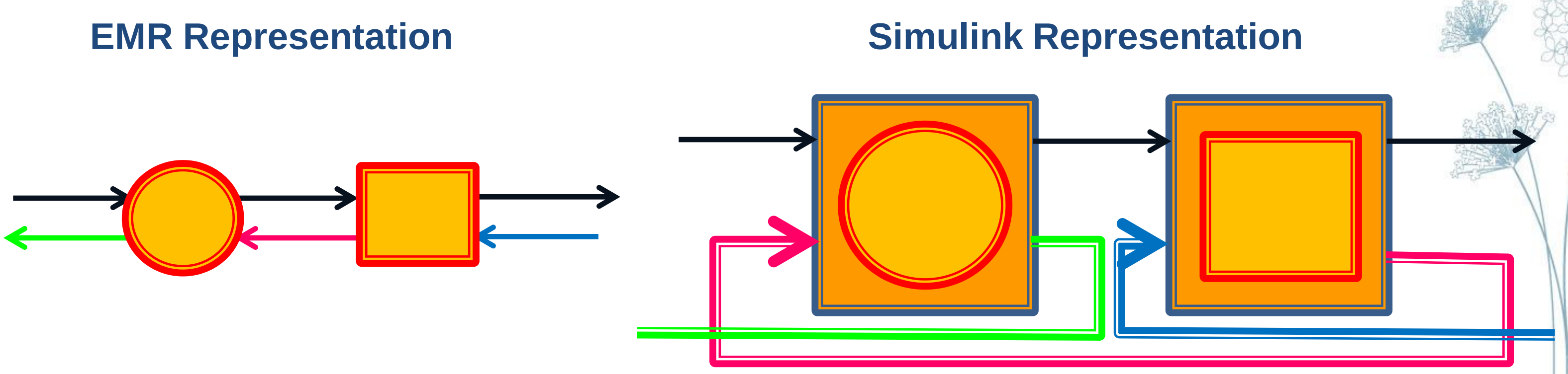
EMR : MODEL REPRESENTATION



	source element (energy source)		accumulation element (energy storage)		Indirect inversion (closed-loop control)
	mono-physical conversion element		mono-physical coupling element (energy distribution)		Direct inversion (open-loop control)
	multi-physical conversion element		multi-physical coupling element (energy distribution)		coupling inversion (energy criteria)
	amplification element		switching element		Inversion of a switching element

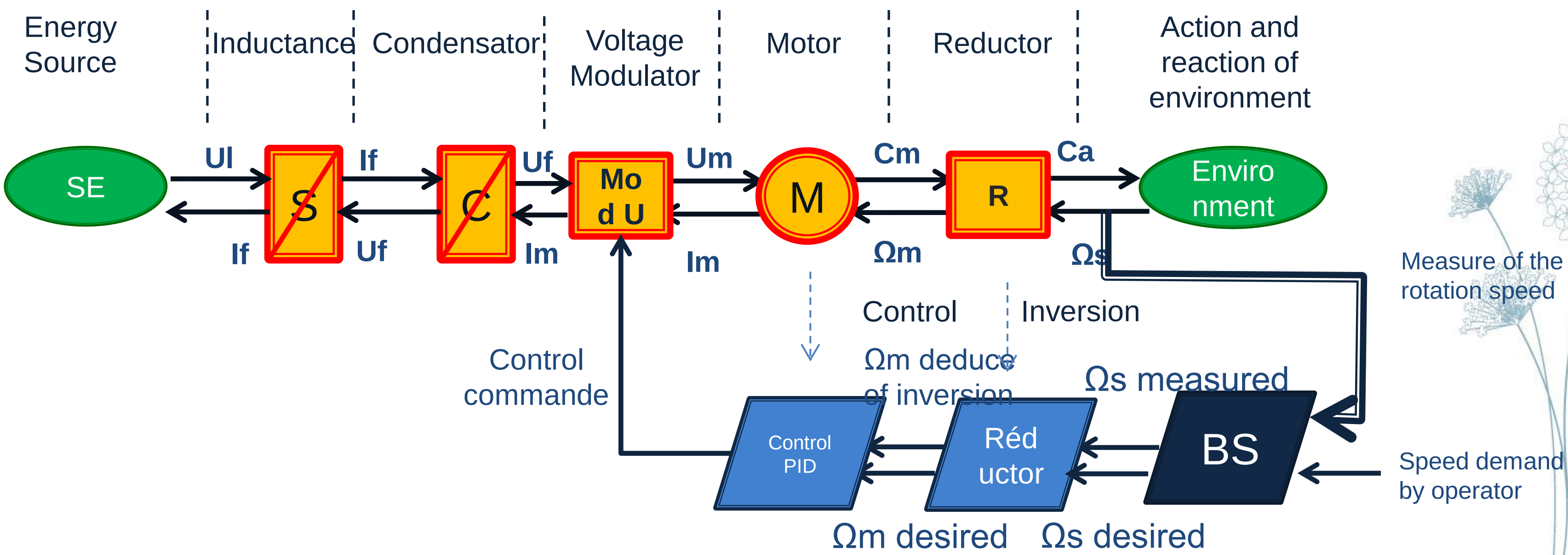
EMR: MODELLING TOOL

- The EMR model is implemented in a modelling tool
- Generally, MATLAB SIMULINK is used



EXAMPLE: DC MOTOR

- An energy source provides power to an electric motor to move a load
- The electric motor involve a shaft after a reductor
- Define the control laws to have a rotation speed whatever the load



Example of Application: Y9000 ECOLOC

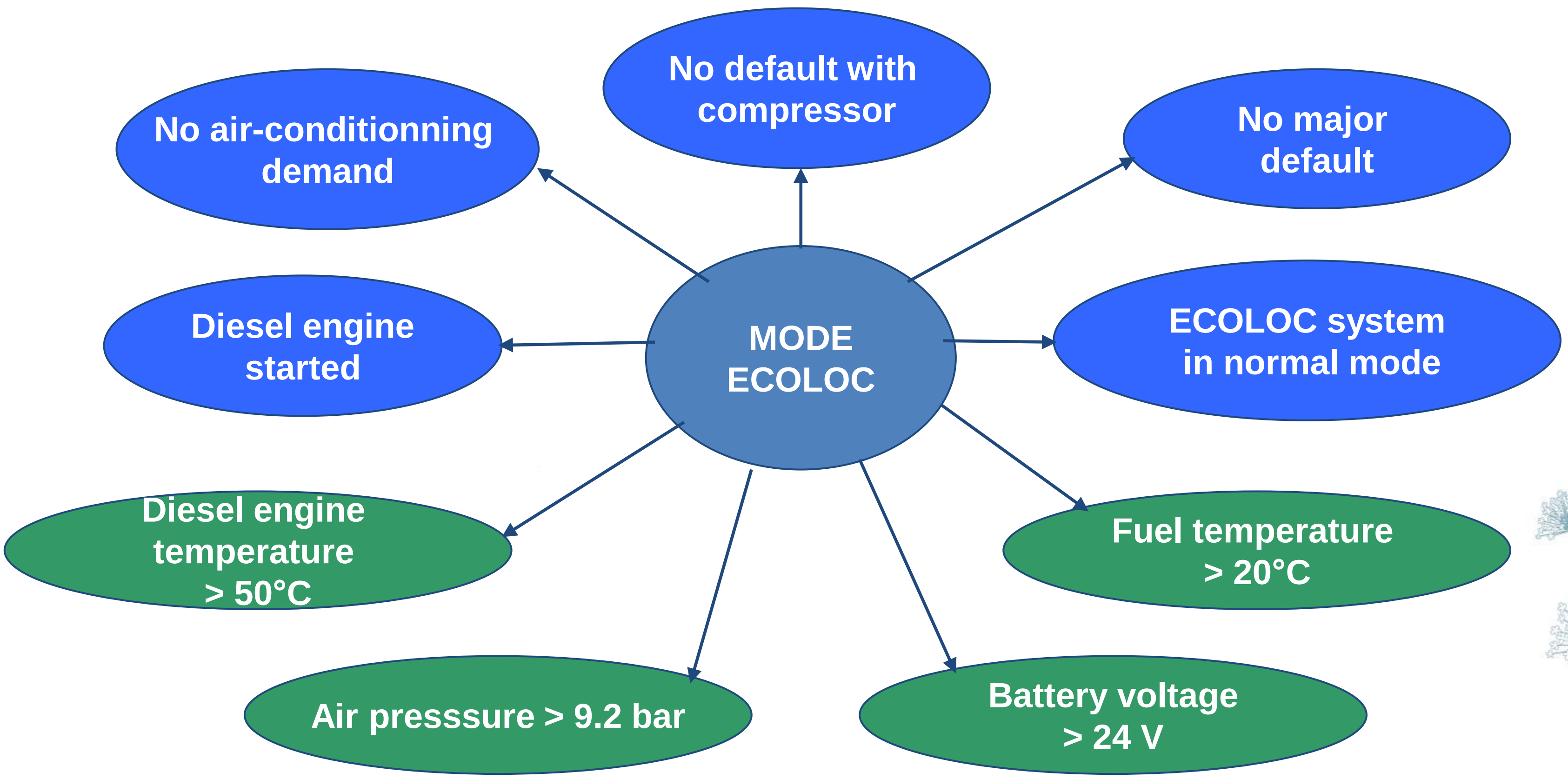
PRESENTATION OF THE Y9000

- Small shunter
- Diesel engin
- 3 hydraulic circuits for auxiliairies

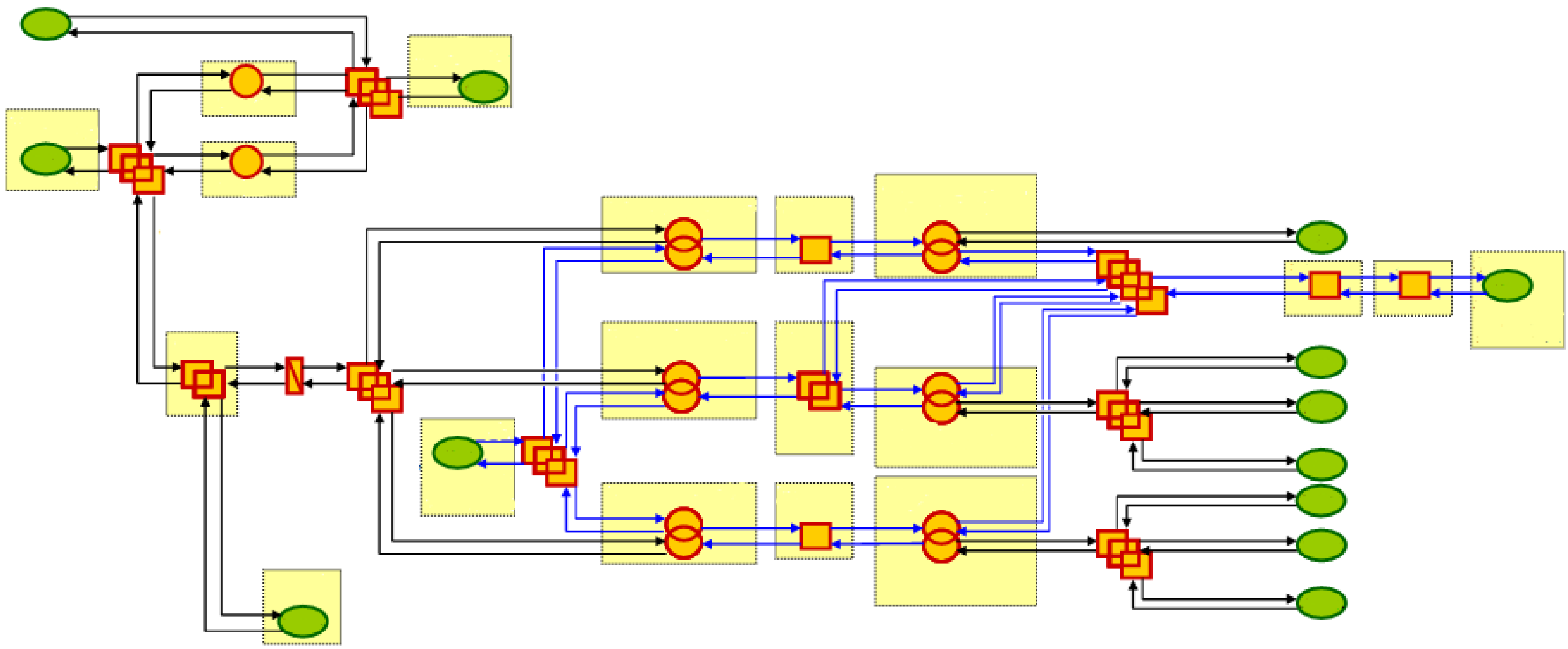
Presentation of ECOLOC system

- Stop and Start system
- Objectives of ECOLOC system:
  - *Reduction of the fuel consumption*
  - *Reduction of CO_2 emissions*
  - *Reduction of exhaust emissions*
  - *Reduction of cost maintenability based on the functionning time interval*
  - *Reduction of the noise*
- Propose to the drive to stop the diesel engine

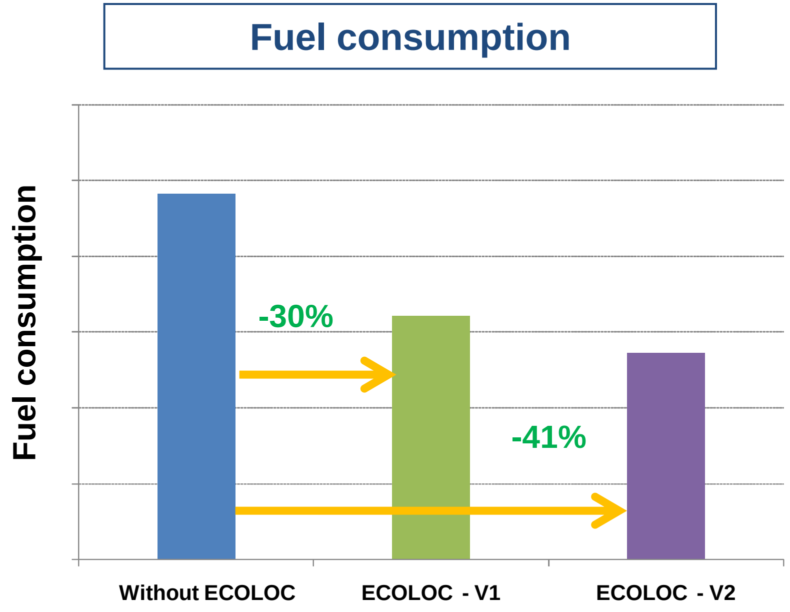
PRESENTATION OF ECOLOC SYSTEM

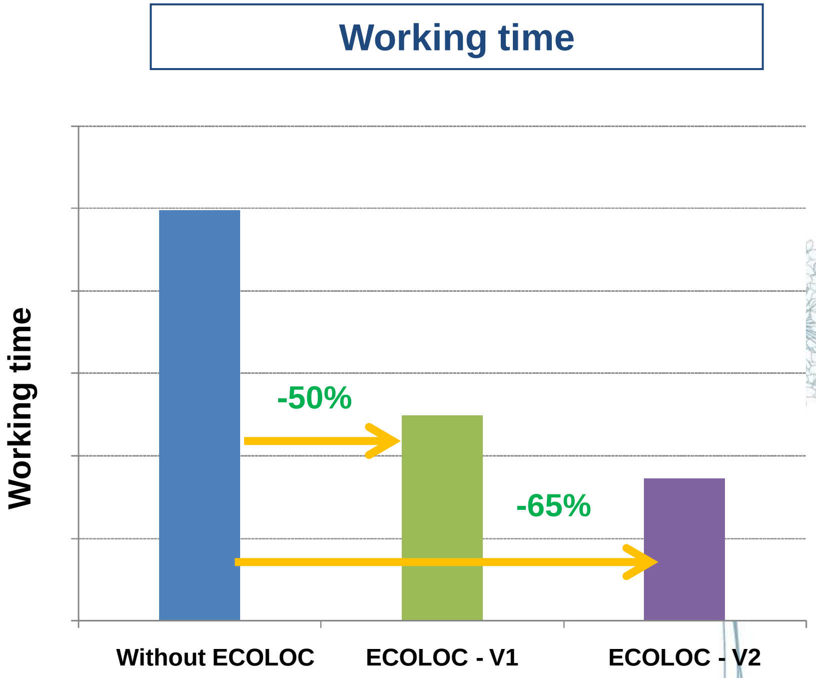


EMR OF THE AUXILIAIRY CIRCUITS OF Y9000



Results of modelling





Conclusions

- SNCF make the choice to used EMR to:
  - Optimise the management of diesel traction chain
  - Reduce fuel consumption and exhaust emission
  - Reduce the cost of maintability due to the maintenance policy based on functionning time intervals
- Diesel traction chain are more and more complex
- The future hybrid solutions need optimization of the control of energetic exchanges

Thank you

for

your attention