



Energy Storage on Board of Rail Vehicles

The Climate is Right for Trains

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***MITRAC* Energy Saver**

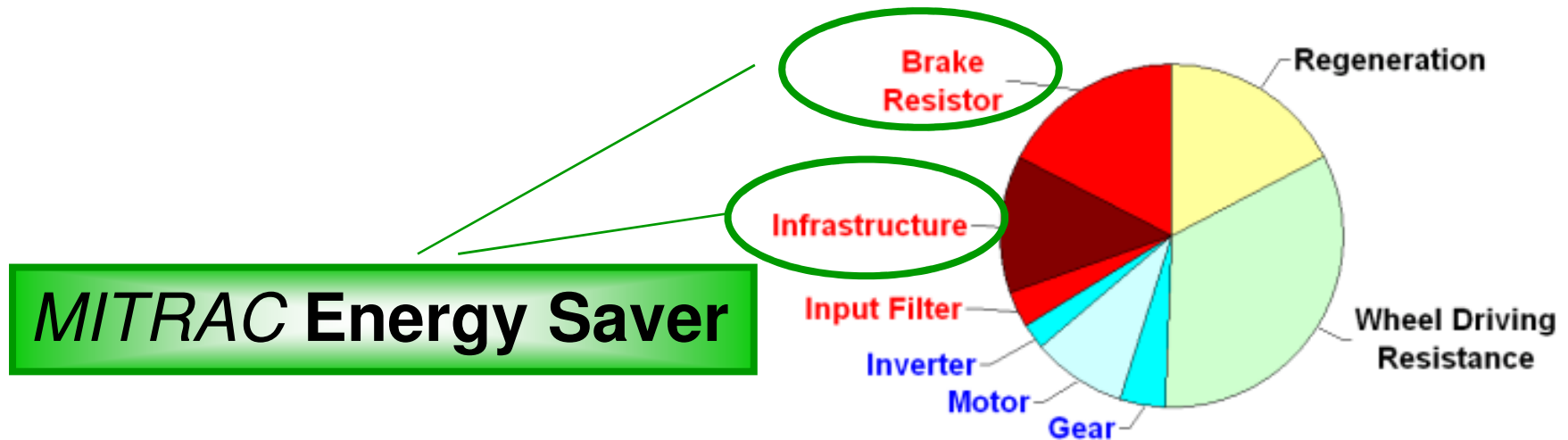
Content

- Introduction**
- Experience *MITRAC* Energy Saver**
- 1st Series Delivery of Energy Saver**
- Catenary Free Operation**
- Metro Application**
- Summary**

MITRAC Energy Saver

Energy consumption of rail vehicles

- **Energy costs are significant:**
 - energy costs per Metro approx. 350 000 Euro/yr (~230t train)
 - energy costs per LRV approx. 30 000 Euro/yr (~50t LRV)
- **Relative distribution of traction energy consumption**
 - example of a metro

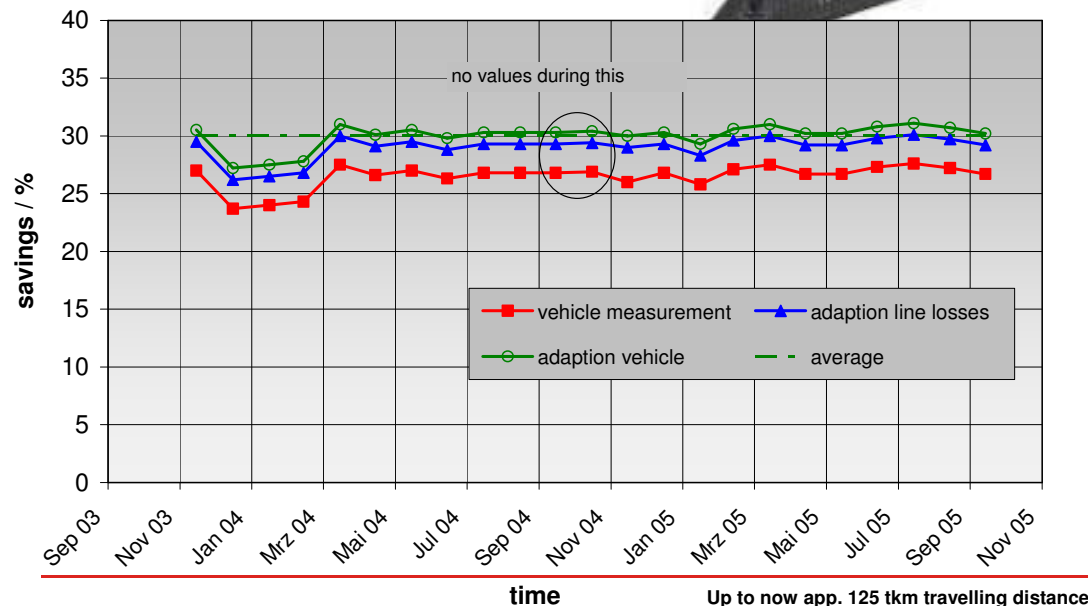
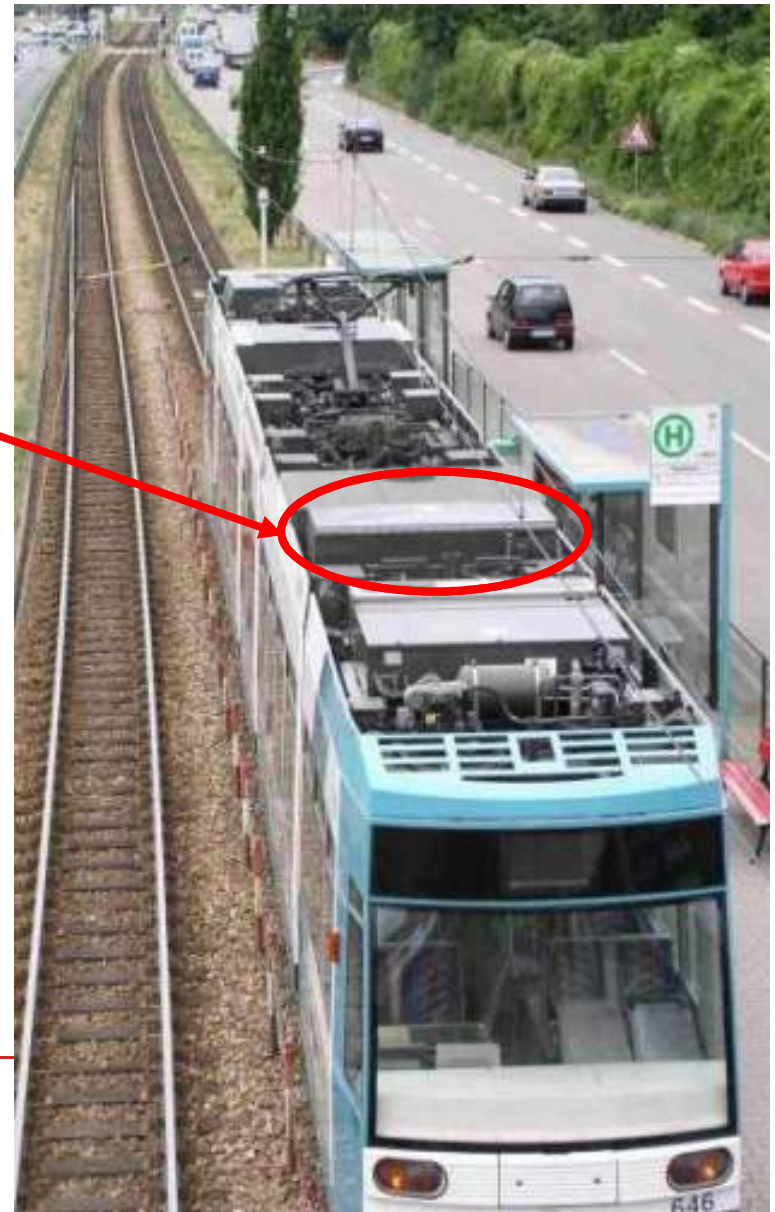


MITRAC Energy Saver

RNV prototype - The Energy Saving LRV in Mannheim

MITRAC Energy Saver a reliable, proven technology

- 4 years revenue service from September 2003 to 2007

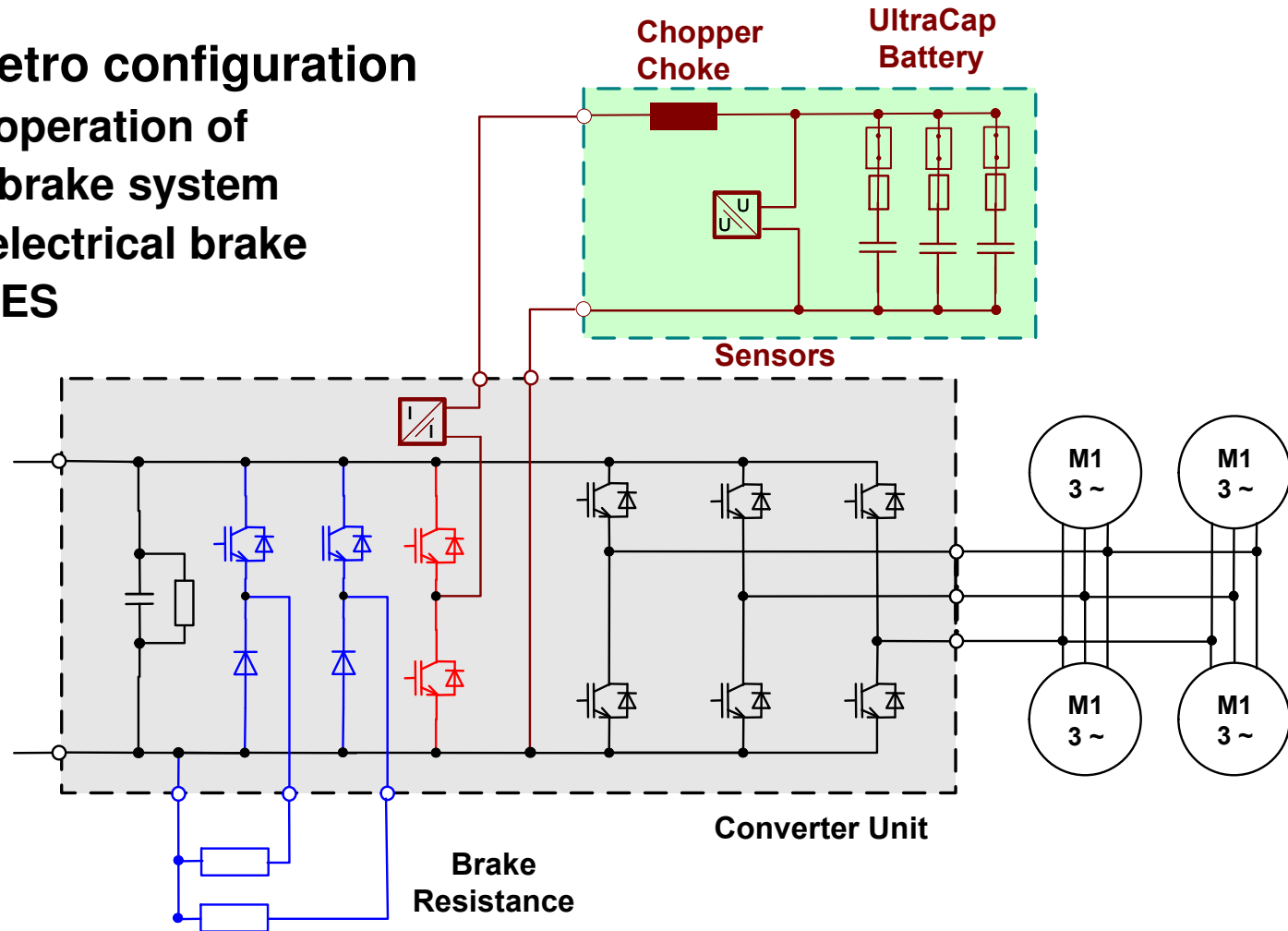


MITRAC Energy Saver

Energy Saver and Drive System

Typical LRV/Metro configuration

- independent operation of ES and drive/brake system
- full rating of electrical brake even without ES

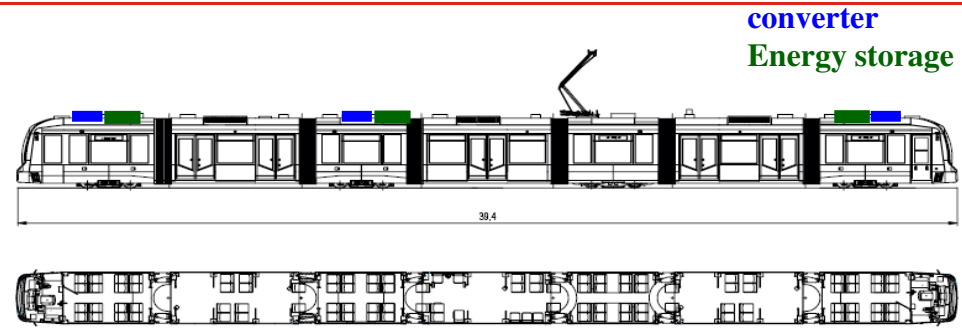


MITRAC Energy Saver

First Series order RNV

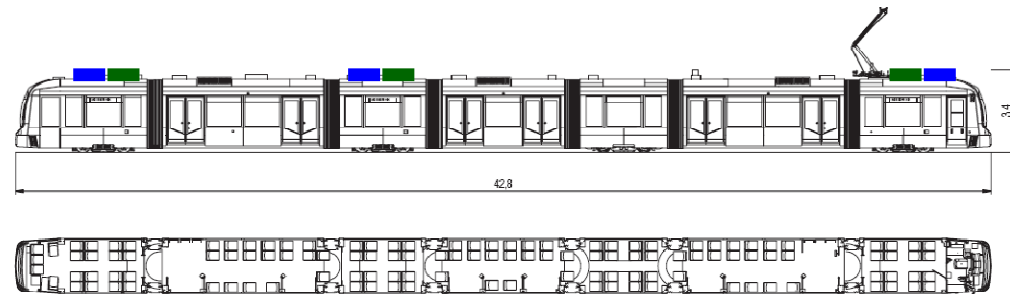
■ HSB 8 vehicles

- 3 Converter with ES
- Function ES and CFO
- All vehicles delivered and in revenue service



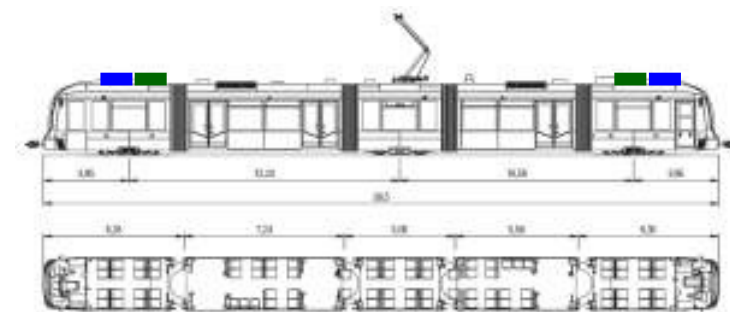
■ MVV 3 vehicles

- 3 Converter with ES
- Function ES



■ OEG 8 vehicles

- 2 Converter with ES
- Function ES and CFO



MITRAC Energy Saver Products ES 510



ES510 - LRV :

Weight : approx 438 kg

Dim. : 1700x670x610

Energy : 2 x 0.5 kWh

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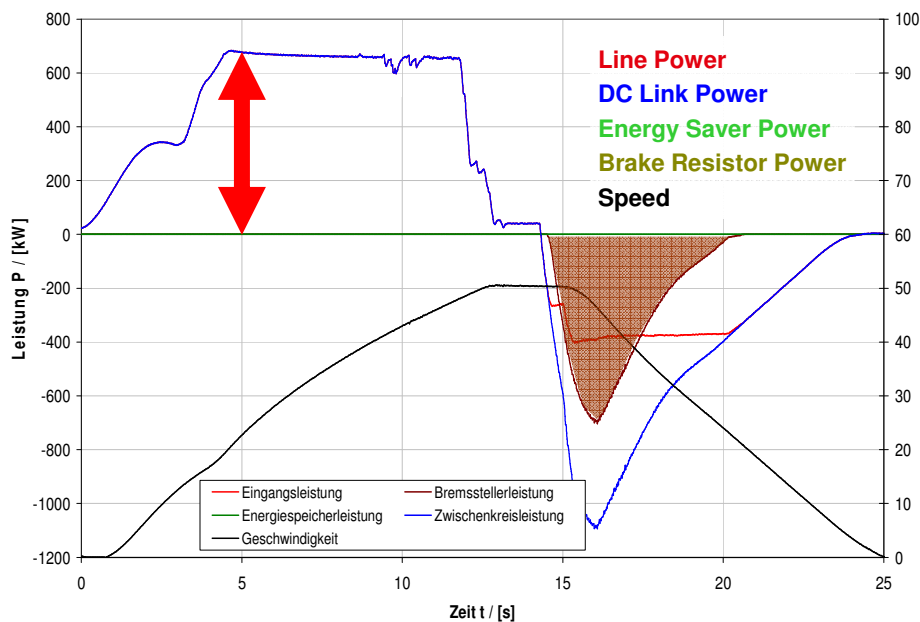
MITRAC Energy Saver

ES function during drive cycle

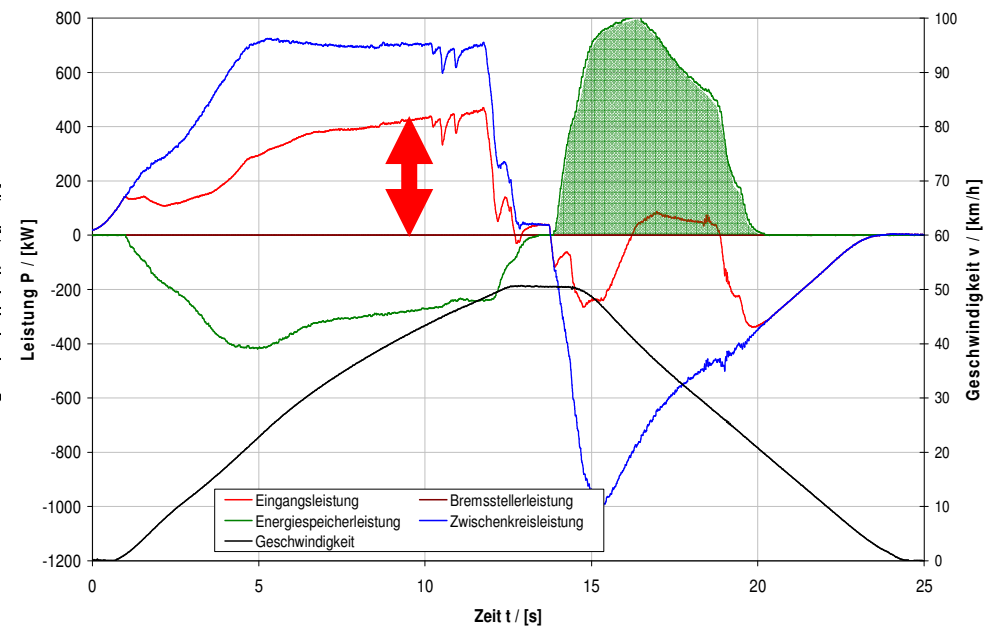
Test run with new RNV vehicle (empty car during commissioning)

- example shows 40% reduced peak power demand from line
- and 30% of energy saving

without Energy Saver



with Energy Saver

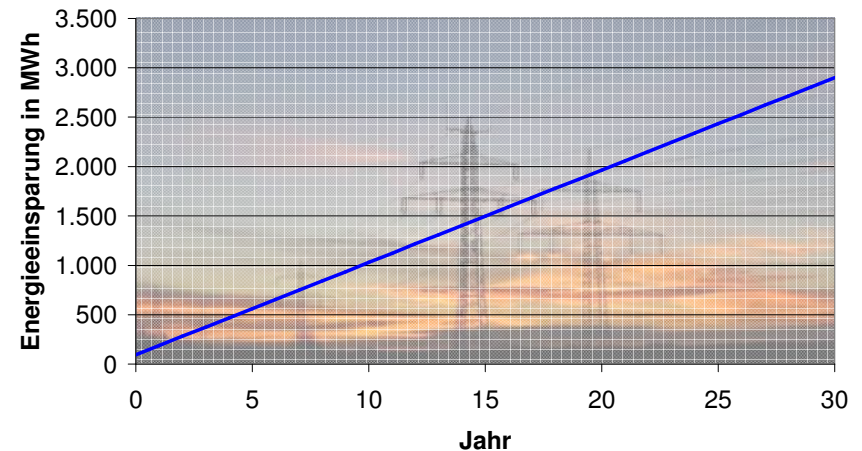


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Energy Saving – Example RNV

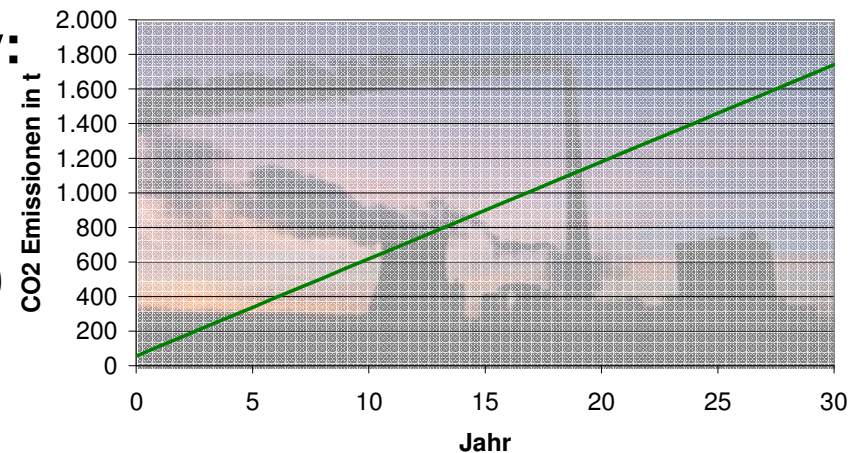
Saved Electrical Energy per LRV:

- **93,5 MWh/Year**
 - Equivalent of electrical household energy consumptions per year of 50 persons
- **2,9 GWh in 30 Years**



Saved CO₂ – Emissions in Germany:

- **56t per year per LRV**
 - Emissions in power generation
 - Equivalent to CO₂ Emissions of 40 modern cars (@140g/km)
- **1'680 t in 30 Years**



- Power generation is expected with CO₂ of 600g/kWh, valid for Germany
- A modern car has emissions of about 140g CO₂ /km, at 10'000 km/Year → 1,4t CO₂/Year

- Energy saving of 2,8 kWh/km per vehicle at 127'000 km/Year
- Typical energy consumption of a 2 person household: 3,8 MWh/Year → 1,9 MWh/Year/Person

MITRAC Energy Saver

Option Catenary Free Operation (CFO)

- **Some cities require due to aesthetic reasons sections with no overhead line:**
 - It is difficult to obtain approval for the installation of overhead lines in front of historical buildings
 - In such cases, this solution makes the introduction or reintroduction of a light rail system much easier
- **Independent Energy source leads to possible additional solutions**





Video

Mitrac Energy Saver- Heidelberg - Neuenheimer Feld

- Institutes refused a new line in their neighbourhood due to electromagnetic emissions
- Electromagnetic DC field is critical
 - Cancer Research Institute uses Electro microscopes
 - Physical technical institutes measure DC fields

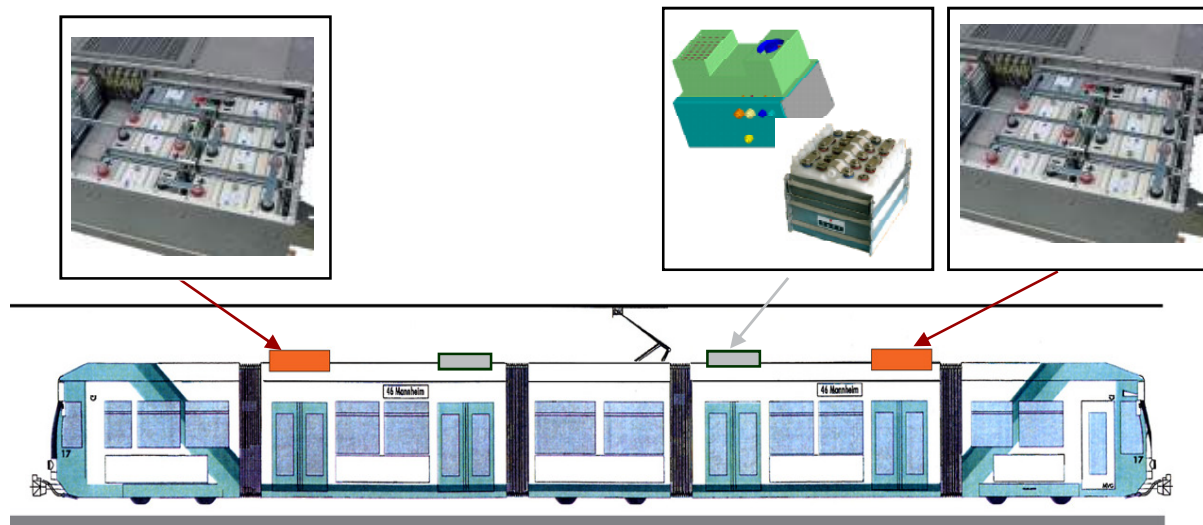


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- MITRAC Energy Saver drastically reduces the magnetic emissions by catenary free operation

MITRAC Energy Saver for Catenary Free Operation

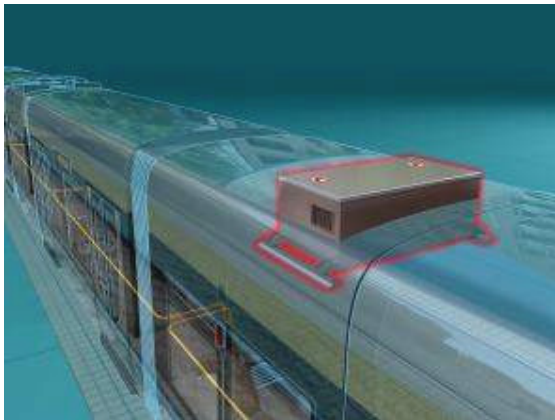
- **MITRAC Energy Saver for traction and AC-Aux in normal operation**
 - installed: 2 x 1 kWh at 400V, 2 x300 kW
- **Vehicle Battery for DC-Aux in normal operation and in exceptional cases (accidents, traffic jams,...)**
 - more than 8 kWh at 24 V installed
 - in an exceptional case the vehicle can be moved just from the battery



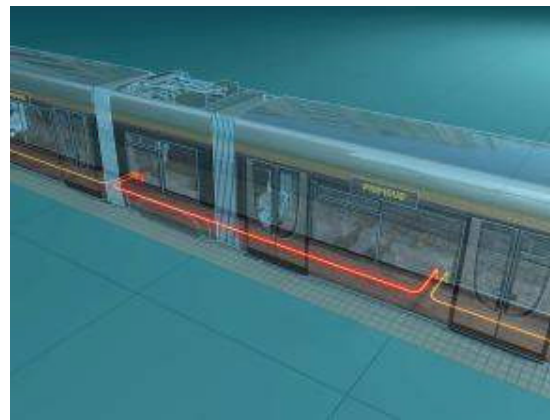
Catenary Free LRV System

Possible solutions for Catenary Free Operation (CFO)

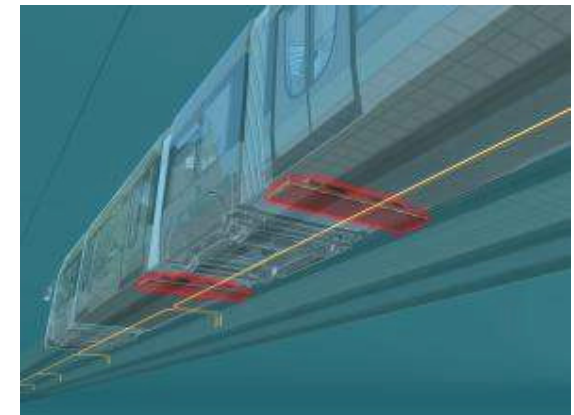
- **MITRAC Energy Saver**
 - CFO sections of 3...400m could be realised with the standard Energy Saver size (longer sections with bigger storage sizes)
- **PRIMOVE – Energy Saver with inductive recharging**
 - Additional inductive power transfer for continuous supply of average power demand
 - Energy Saver to handle peak load



MITRAC Energy Saver for optimized performance



Power cable invisible in the ground for permanent supply



LRV with pick-up device

Metro Simulation with Network and Trains

■ Metro system was simulated

- 8 car trains, 180t empty with 46t average load
- 6 *MITRAC* Energy Saver → 6*1.3kWh
- Infrastructure was taken into account
- Example: 5,5km track with 8 trains

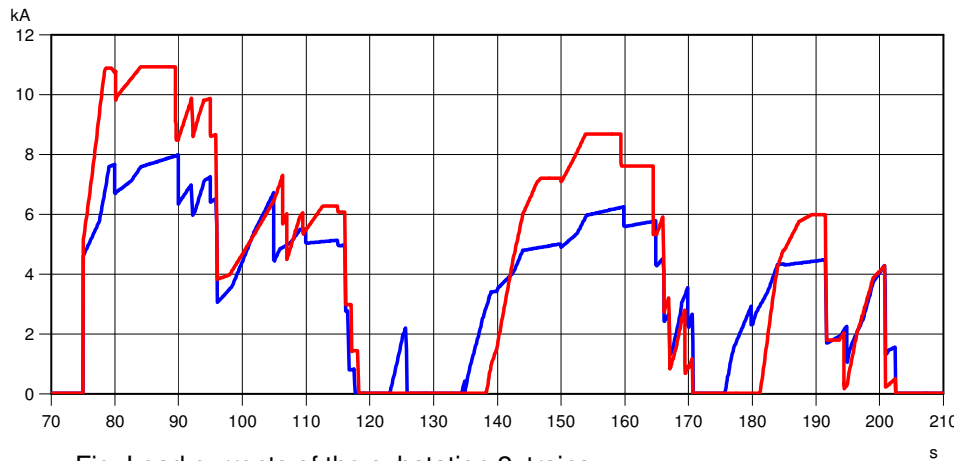
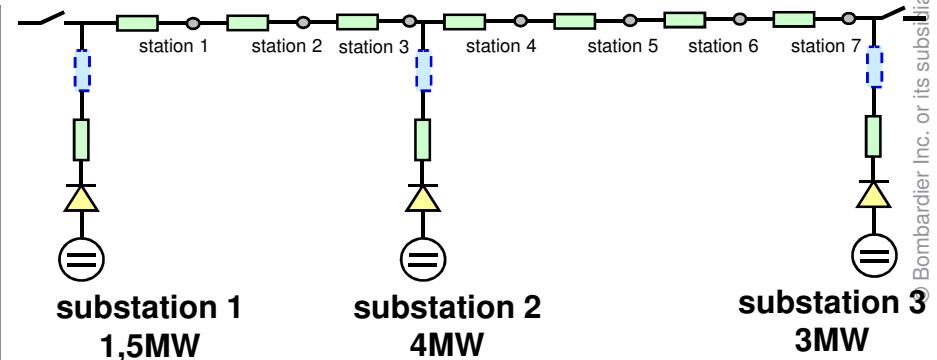


Fig: Load currents of the substation 2, trains
without (red Curve) and with Energy Storage Systems (blue curve)

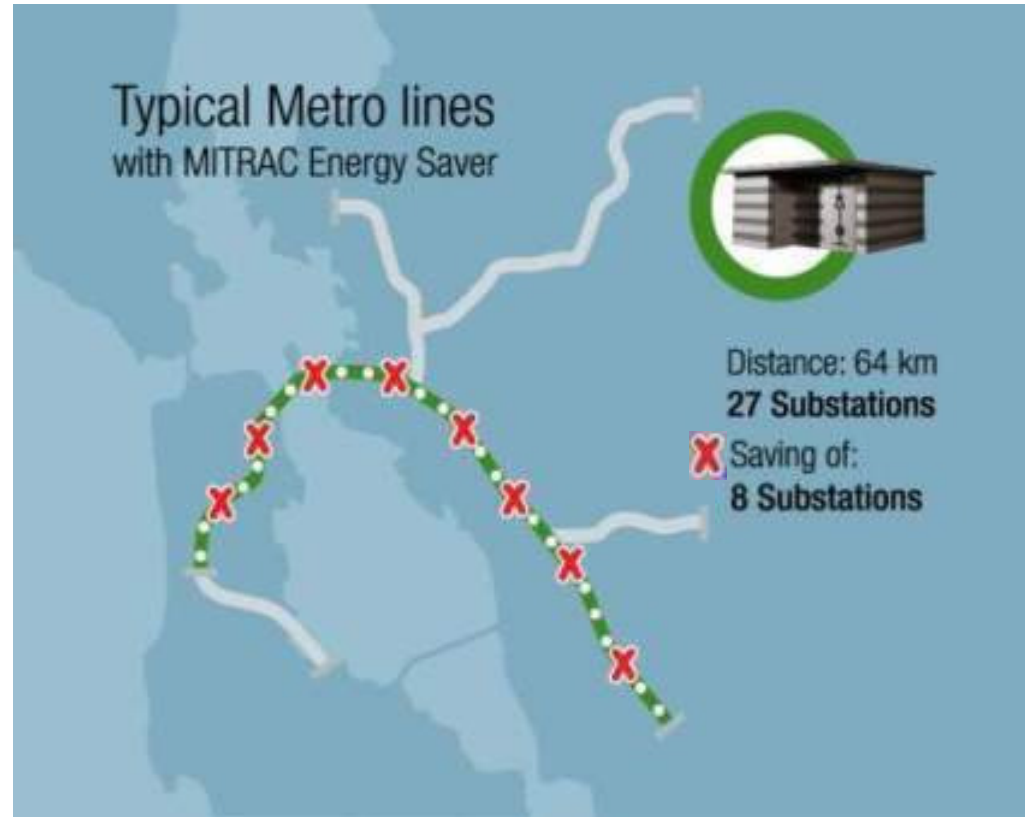


➤ **Leading to 31% reduced RMS current from substations**

Metro: Infrastructure effects

New Lines:

- **30% reduction of substations possible**
 - 8 substations less



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Metro – Return of Investment for *MITRAC* Energy Saver

Application dependent benefits for new vehicles

- A. Infrastructure and energy savings today**
30% substation less 3...4 years

- B. Only energy savings today**
(using 0,1...0,13 €/kWh) 7...9 years

- C. Only energy savings in future (3...7years)** 3...5 years
 - increased energy costs, decreased costs for UltraCaps
 - of course all other applications will benefits from the future trend as well

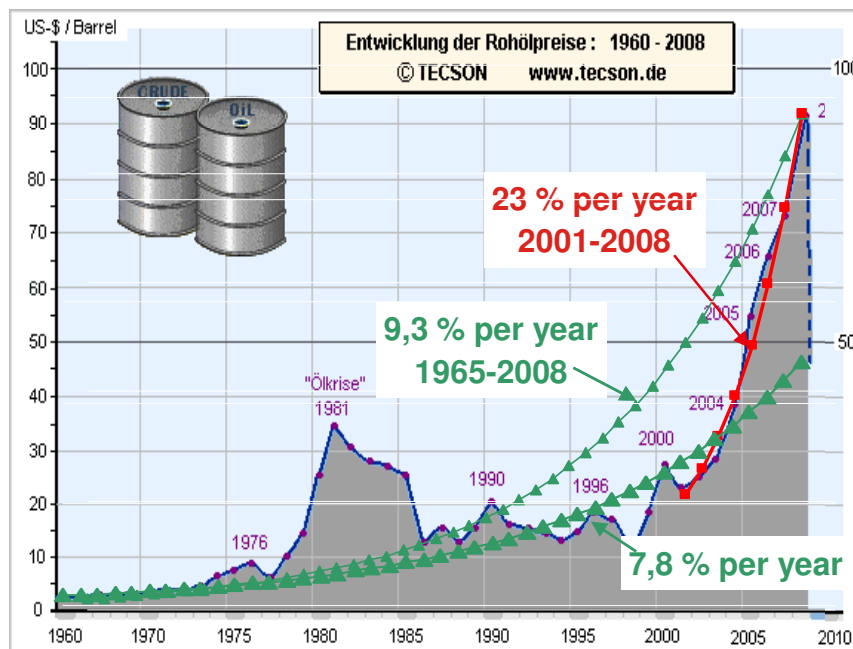
- **New vehicles should be prepared for *MITRAC* Energy Saver, even when the installation is foreseen later**



Energy Costs

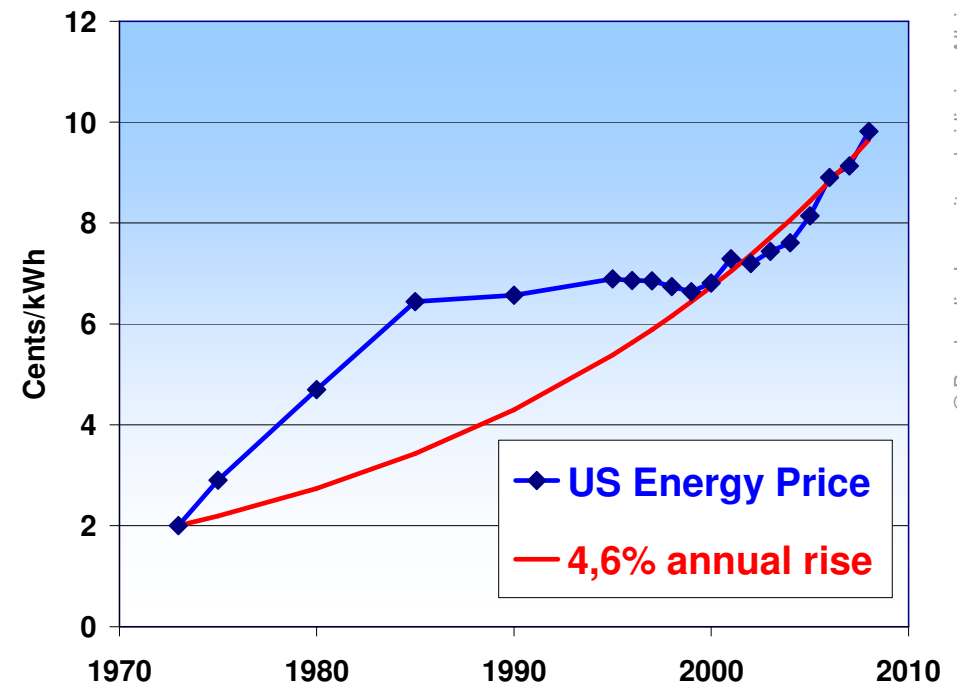
Oil Prices increased by 9,3% per year

- from 3US\$/Barrel in 1965 to 91US\$/Barrel average in 2008
- or 7,8% from 3US\$/Barrel in 1965 to 50US\$/Barrel average in 2009



Cost trend of electrical energy

- from 2 Cent /kWh in 1973 to 9,8 cent/kWh in 2008 - the el. energy cost increased by factor 5
- 4,6% rise per year



Source: eia, Department of Energy, Washington, DC

MITRAC Energy Saver

Benefits from using MITRAC Energy Saver



LRV
Light Rail Vehicle

- **15 - 30% Energy saving**
- **30...50% Reduced Power from substations**
 - potential infrastructure savings – e.g. less substations
- **Catenary free operation**



Metro

- **15 - 30% Energy saving**
 - less tunnel heating
- **25...40% Reduced Power from substations**
 - potential infrastructure savings – e.g. less substations
- **Rescue in tunnel**



DMU
Diesel Multiple Unit

- **15 - 35% Energy saving**
 - similar Emission Savings – e.g. CO₂
- **20...70% additional power „Booster effect“**
 - 30% higher acceleration from 0 to 100 km/h

Thank you for your attention



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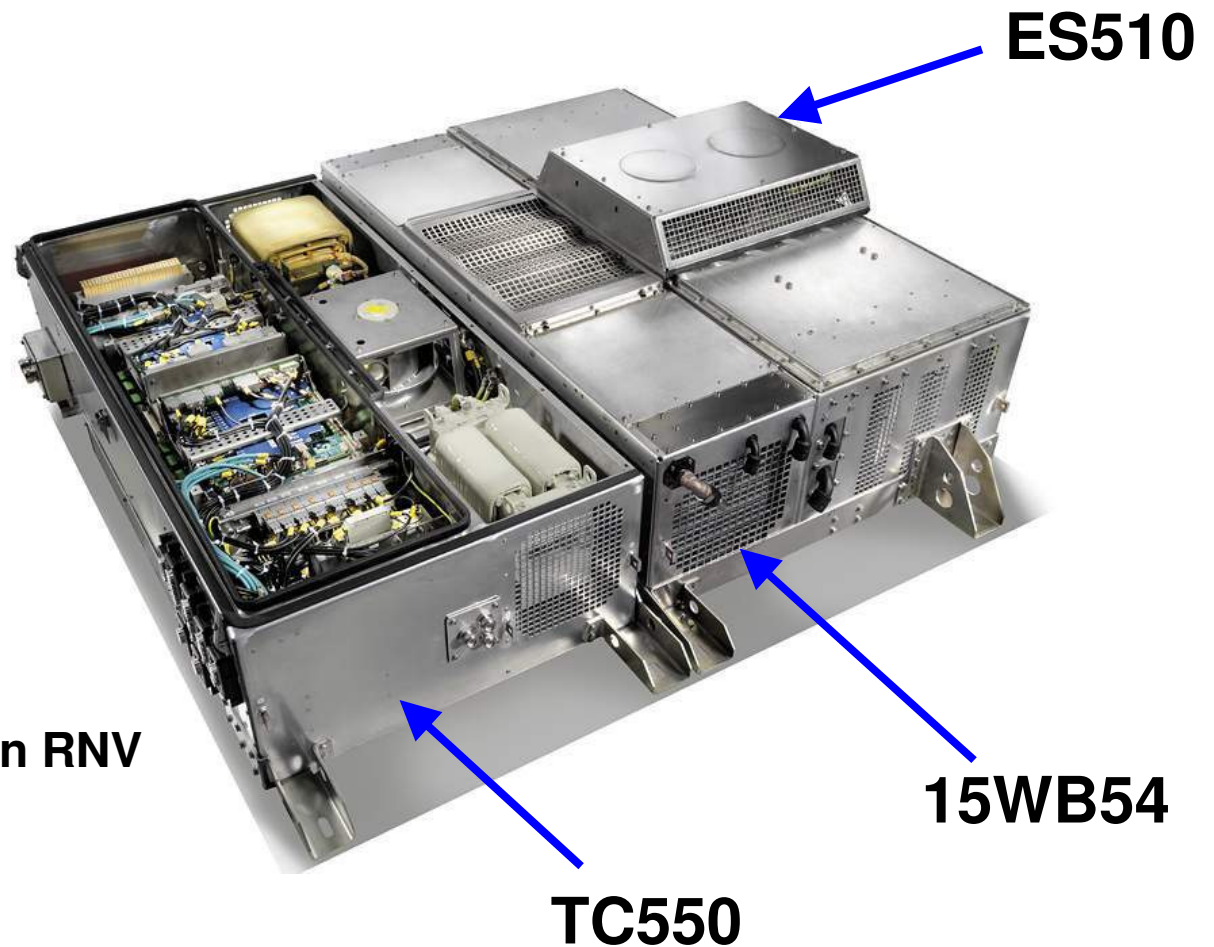
Thank you for your attention



MITRAC Energy Saver

Integrated in traction system

- **Modular concept**
- **scalable in size and power**
- **integration of Energy Saver**
- **first series application RNV**



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