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# PT Buses in Germany on the Way to pure Electromobility

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urban Development", Bucharest, 13 May 2010

# Holistic environmental Protection as an overriding Objective

## Local Emissions

- EU Exhaust Gas Emission Limits for HDV (88/77/EC resp. 2005/55/EC)
- EU Air Quality Directives (Immissions) (96/62/EC, 1999/30/EEC, 2000/69/EC)
- „Environmental Zones“

## Global Emissions

- „Kyoto Protocol“
- EU Biofuels Directive (2003/30/EC)
- CO<sub>2</sub> Emission Trade (2003/87/EC; PT exempted)
- EU Hydrogen and FC Technology Platform

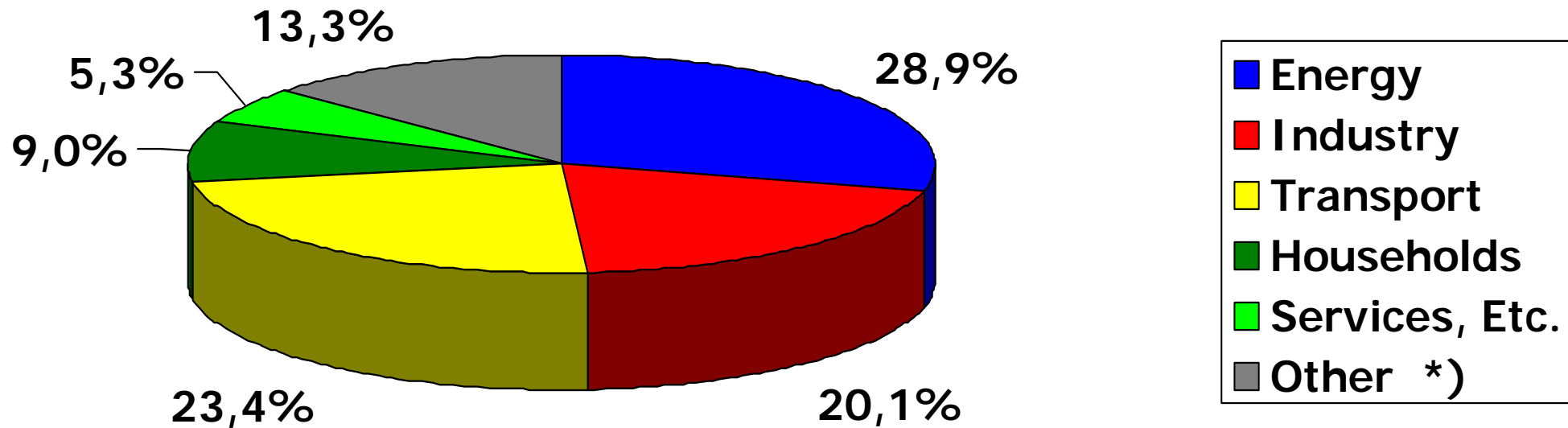
## Noise Emissions

- EU Noise Reduction (2002/49/EC)
- Noise Cadastre
- Germany: „Blauer Umweltengel“: 77 dB(A)

## Energy Consumption

- „Green Books“, „White Books“
- Resource Conservation (Efficiency)
- Brake Energy Recuperation (FP7 Projekt on Hybrids)
- Regenerative Energies (e.g. HYFLEET:CUTE, 2001/77/EC)

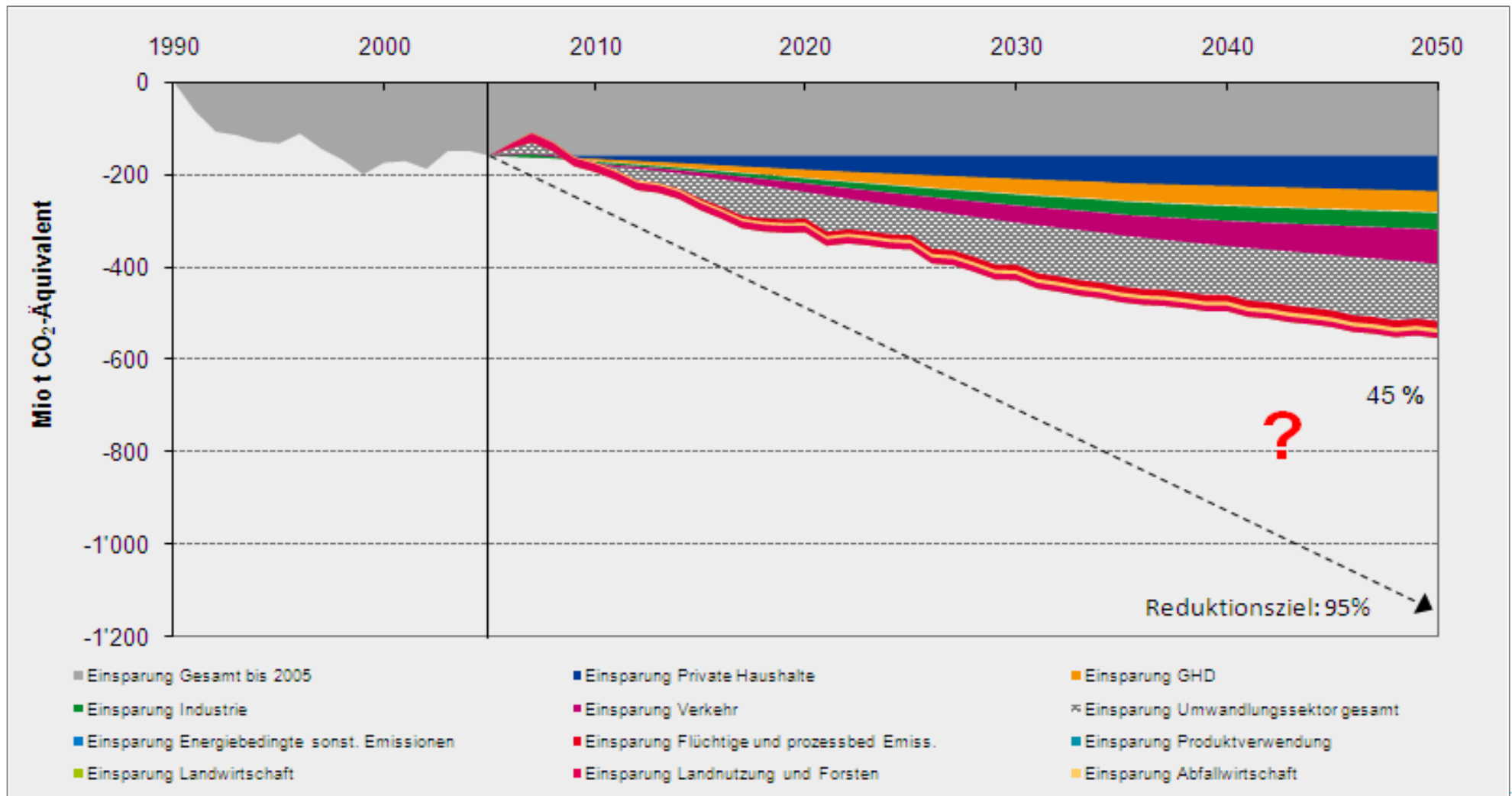
# GHG Emissions by Sector (EU-27)



\*) Solvent Use, Fugitive, Waste, Agriculture

Source: EU Energy and Transport in Figures, Statistical Pocketbook, 2007/2008

# German Strategical Climate Protection Plan




Sources: Prognos, Ökoinstitut, Ziesing; 2009

# National Electromobility Platform and National Electromobility Development Plan

Ministry of  
Commerce  
(BMWi)

Joint Office  
Electromobility  
of the  
Federal Government  
(GGEMO)

Ministry of  
Transport  
(BMVBS)

 Die Bundesregierung

**Nationaler Entwicklungsplan Elektromobilität  
der Bundesregierung**

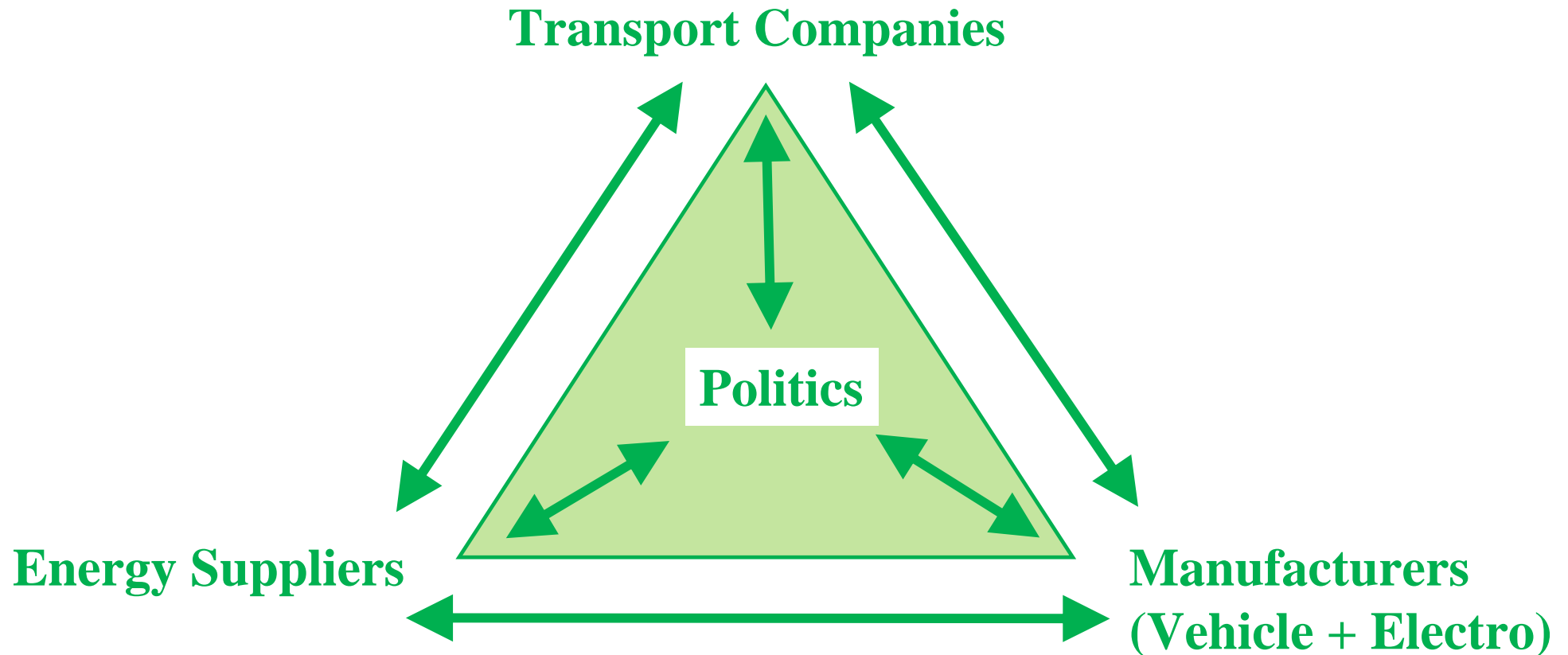
August 2009

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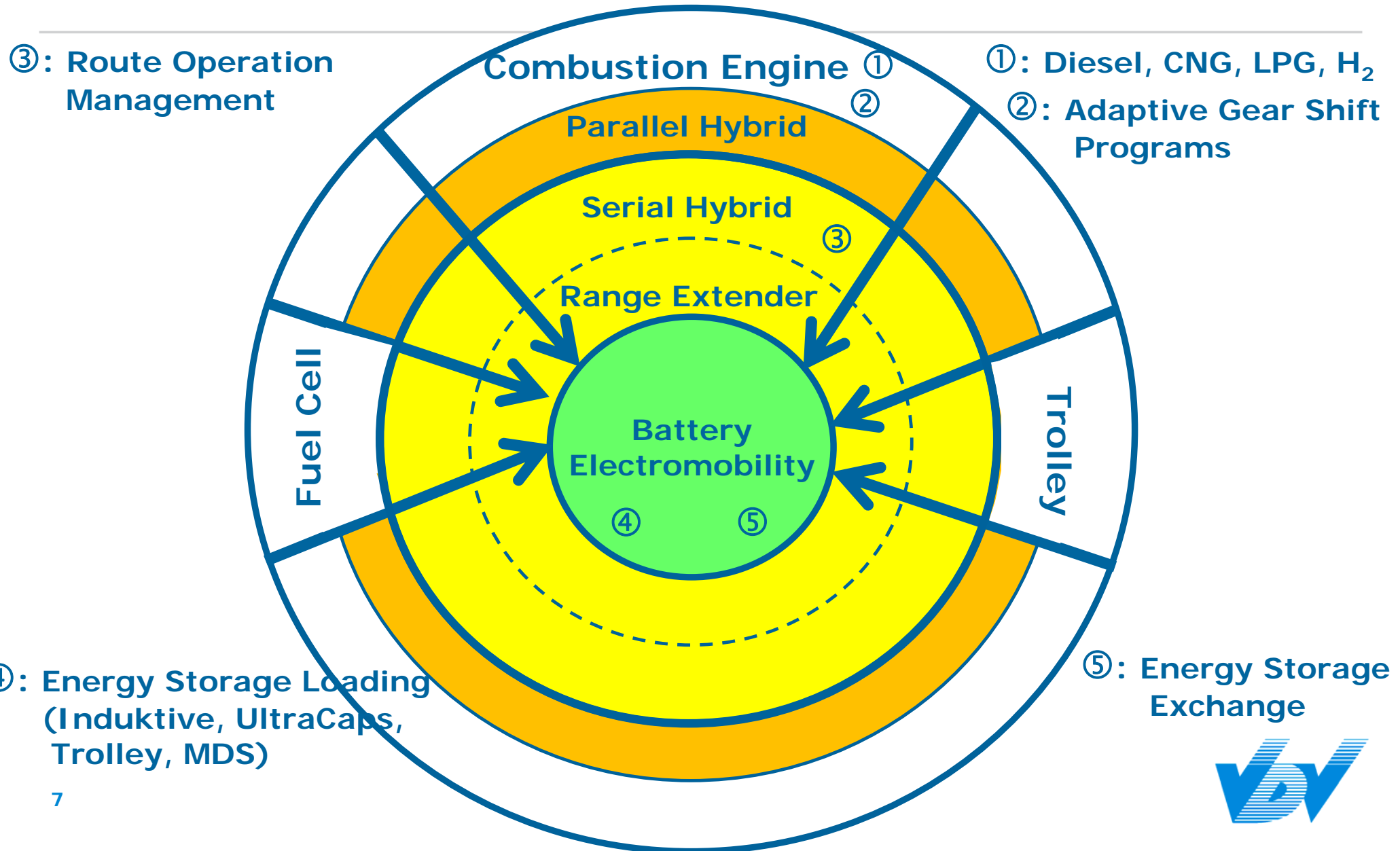
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# Interactions of the Stakeholders with Advantages and Risks for every Stakeholder

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# Future Steps of Electromobility in Public Transport

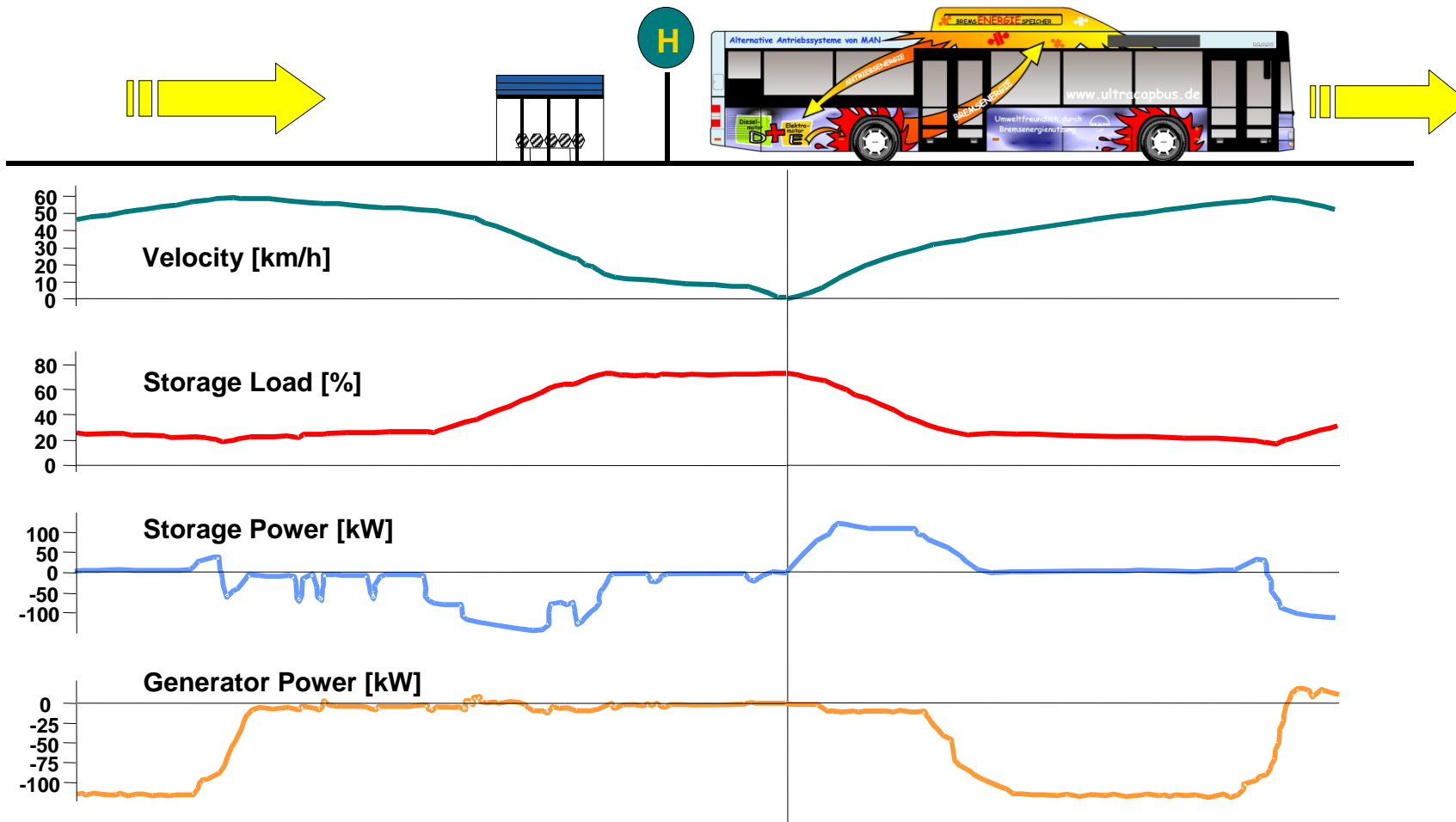


# Next Step in PT: Hybrid Drives

## Approaching Stops

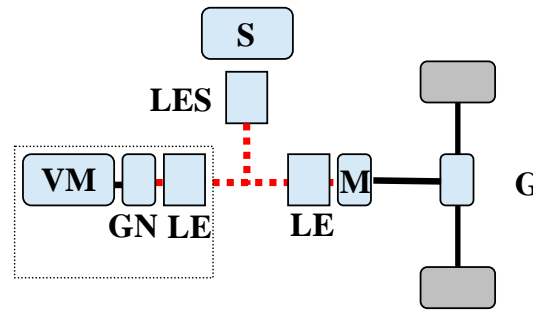
## Leaving Stops

Source: MAN

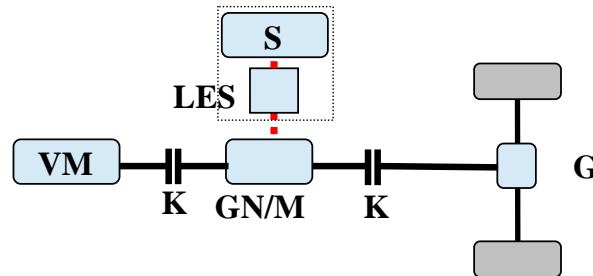


# Hybrid Concepts

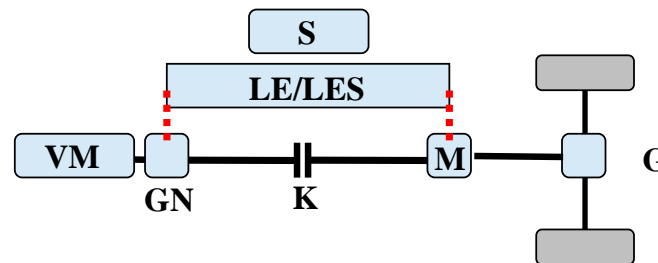
## Serial Hybrid



## Parallel Hybrid



## Mix (Power branched)



————— mechanical

..... electrical

**VM** Combustion Engine

**GN** Generator

**LE** Power Electronics

**LES** Power Electronics of Energy Storage

**M** Electric Motor

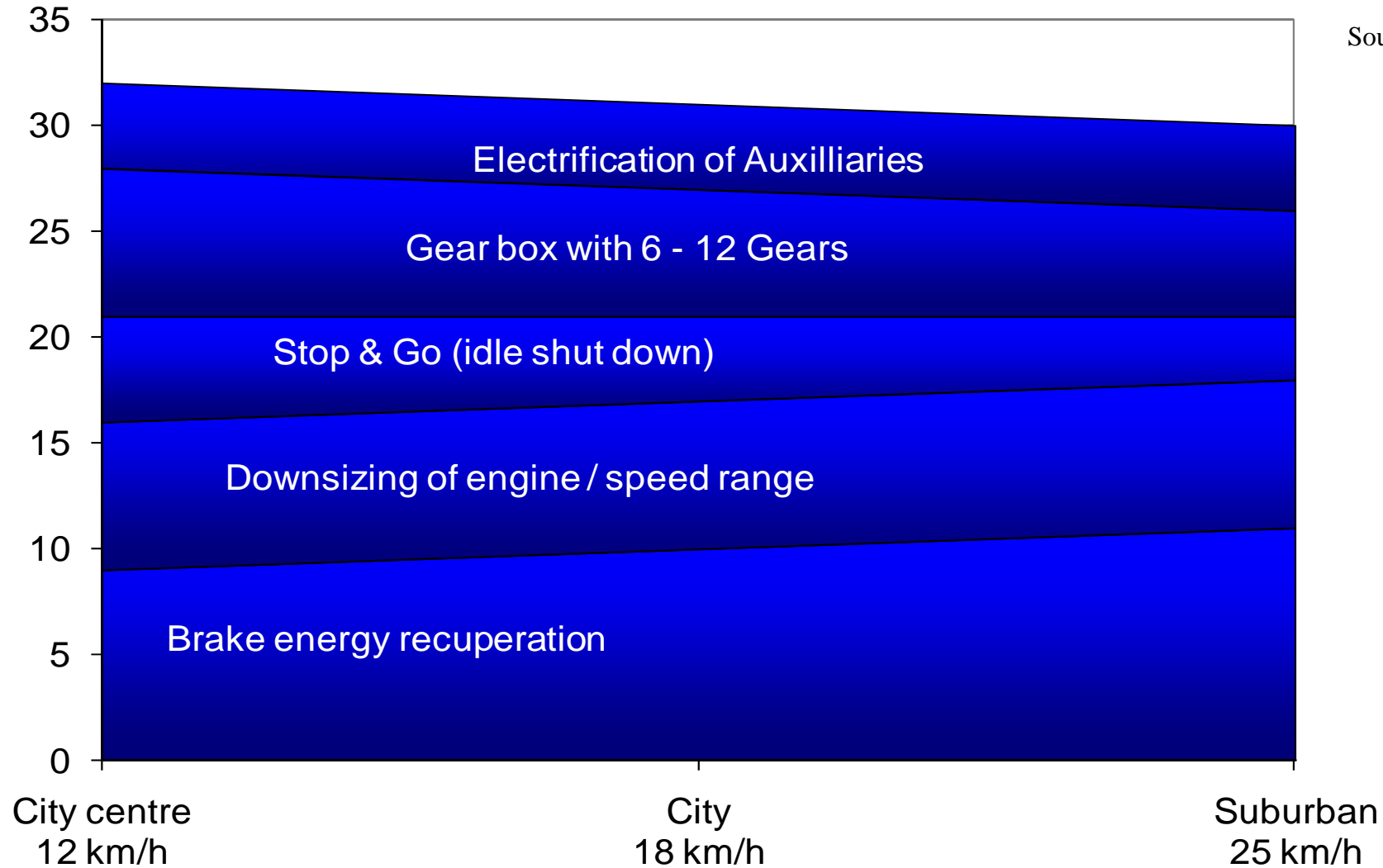
**G** Gearbox

**K** Mecanical Clutch

**S** Energy Storage

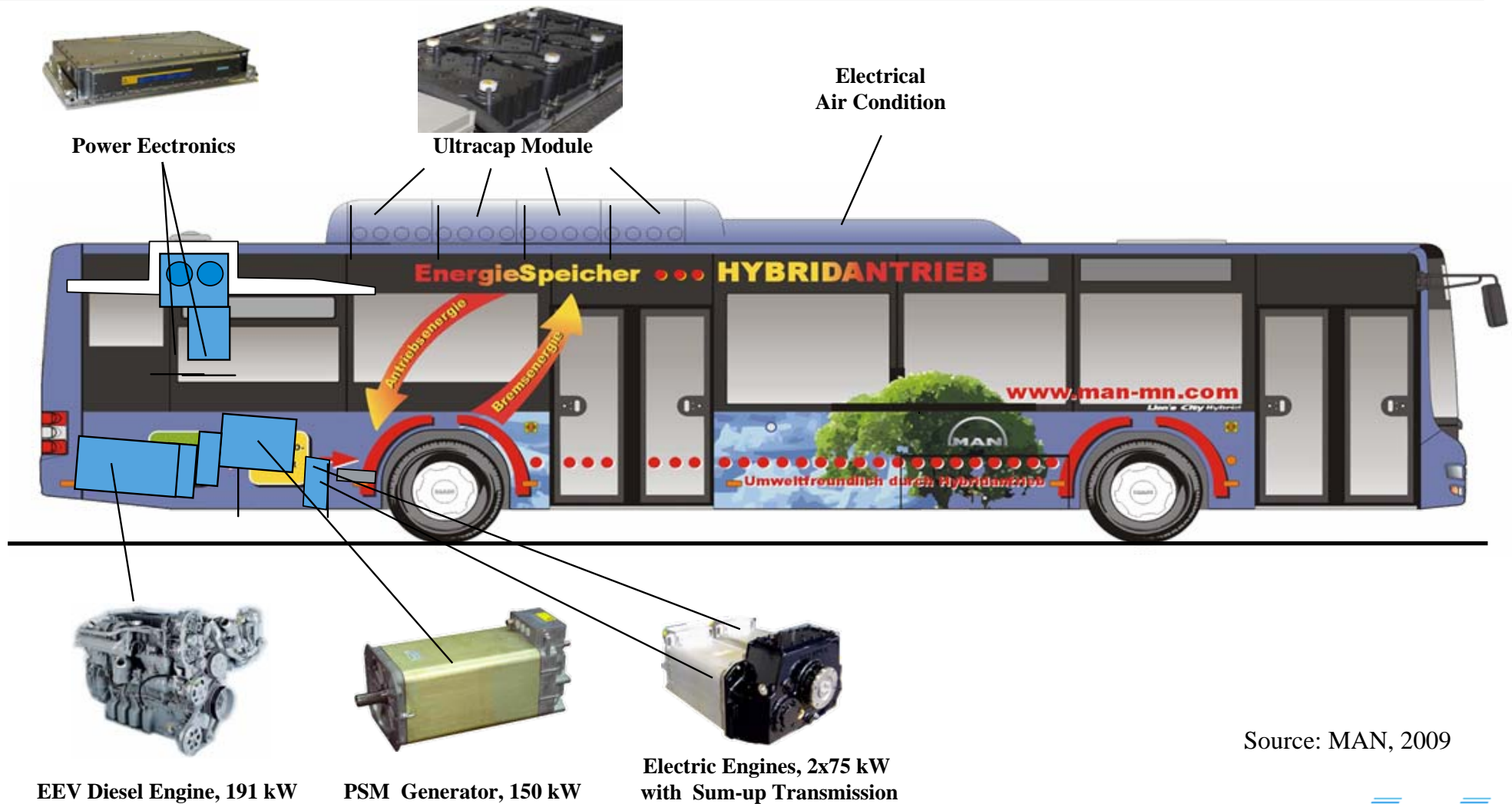
Source: Fraunhofer IVI, 2007

# Hybrid Functionality Factors



Source: Volvo, 2010

# MAN Serial Hybrid Bus with Ultra Cap Storage (IDEAS I)

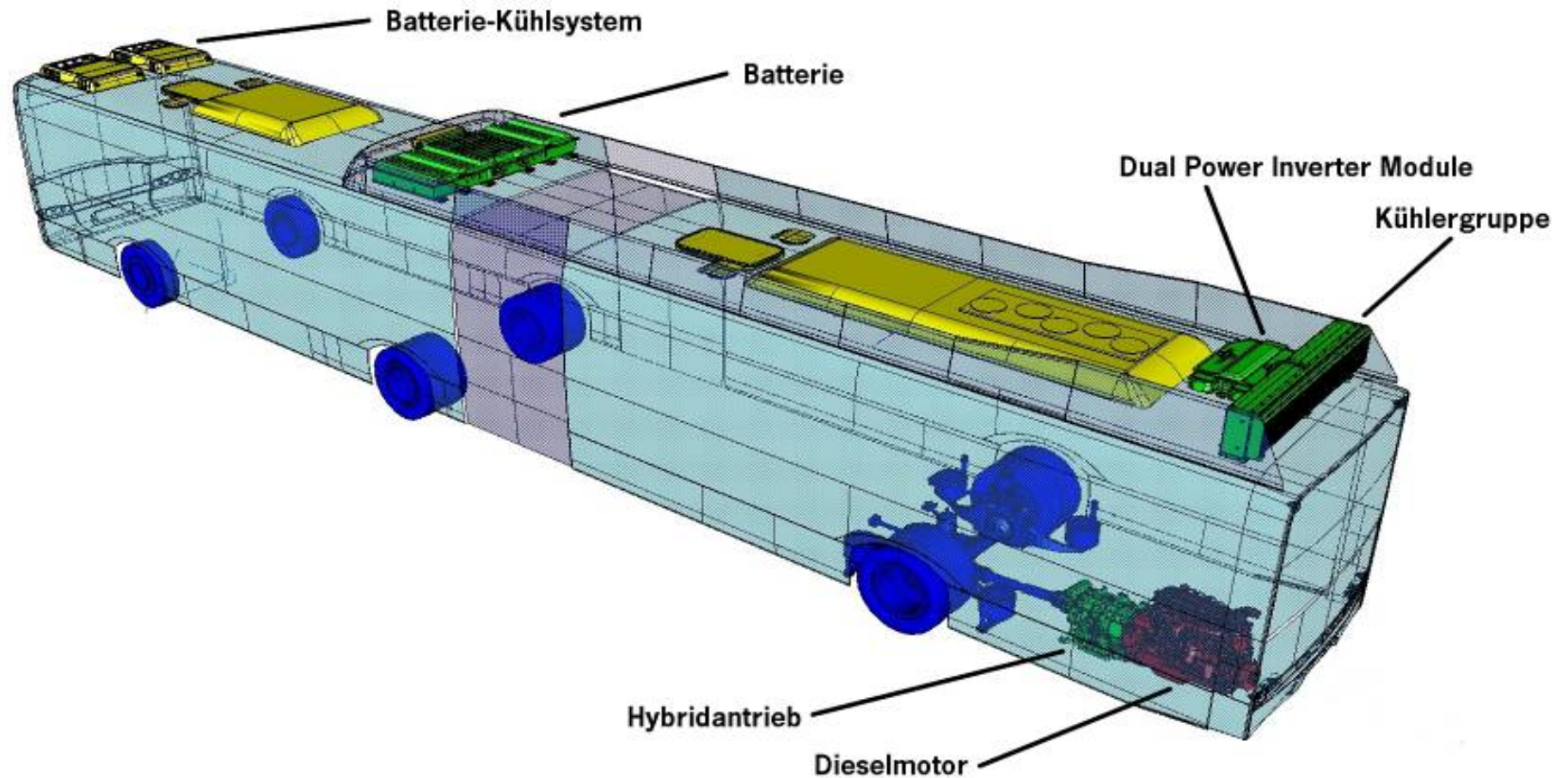


Source: MAN, 2009

# MAN Serial Hybrid Bus with Battery Storage (IDEAS II)



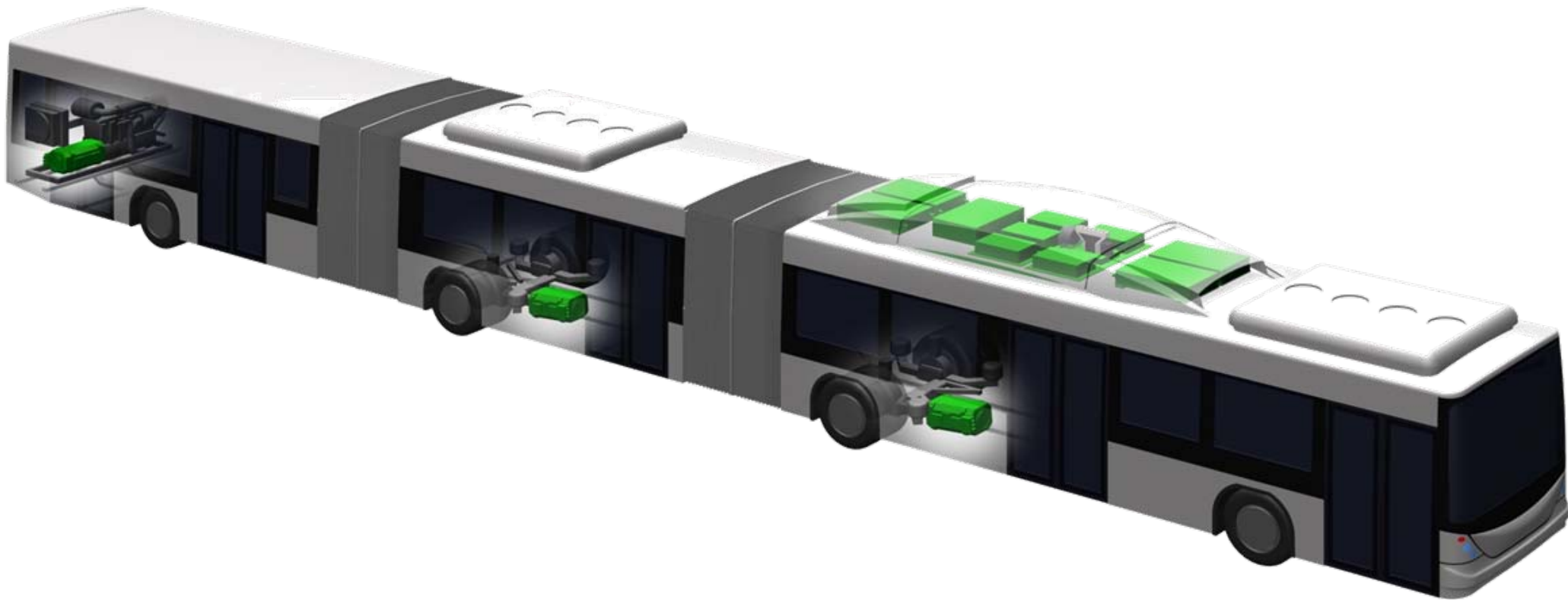
# Solaris Power Branched Hybrid Bus with Battery Storage



Source: Solaris, 2009

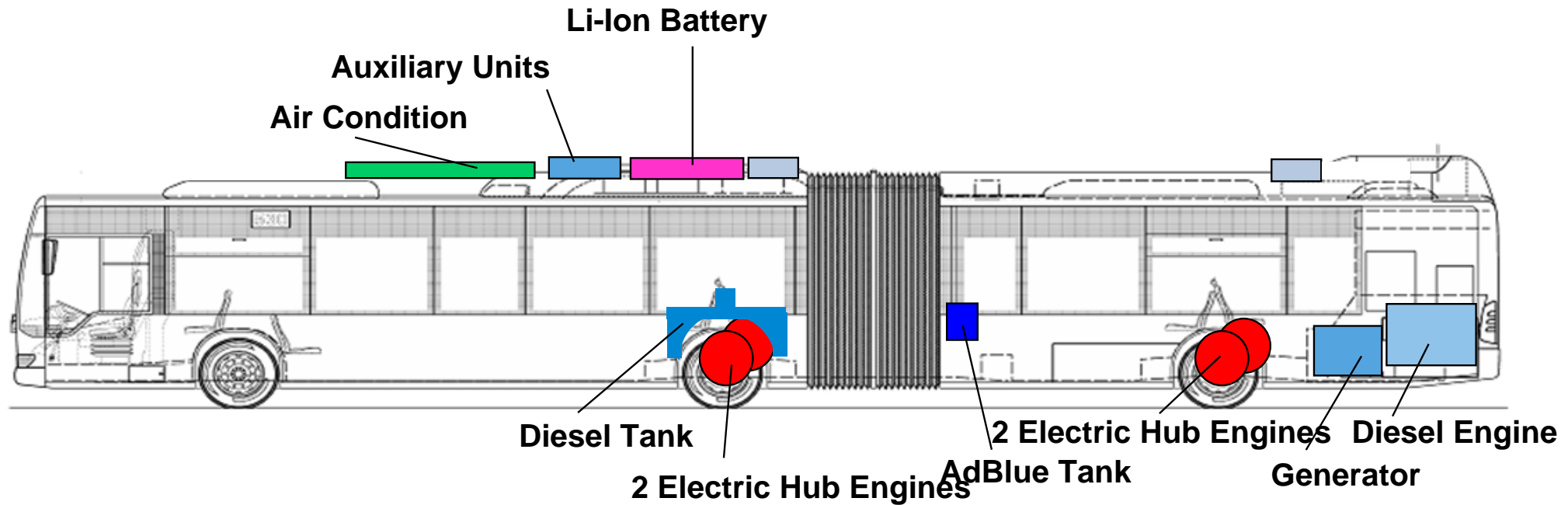
# Hess/Kiepe Serial Hybrid Bus with Ultracap Storage

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Source: Kiepe, 2009

# EvoBus MB Serial Hybrid Bus with Battery Storage



Source: EvoBus, 2009

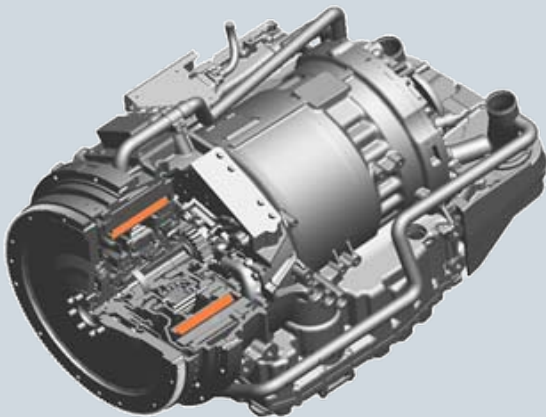
# Synergies concerning all Hybrid Components

Source: ZF, 2009

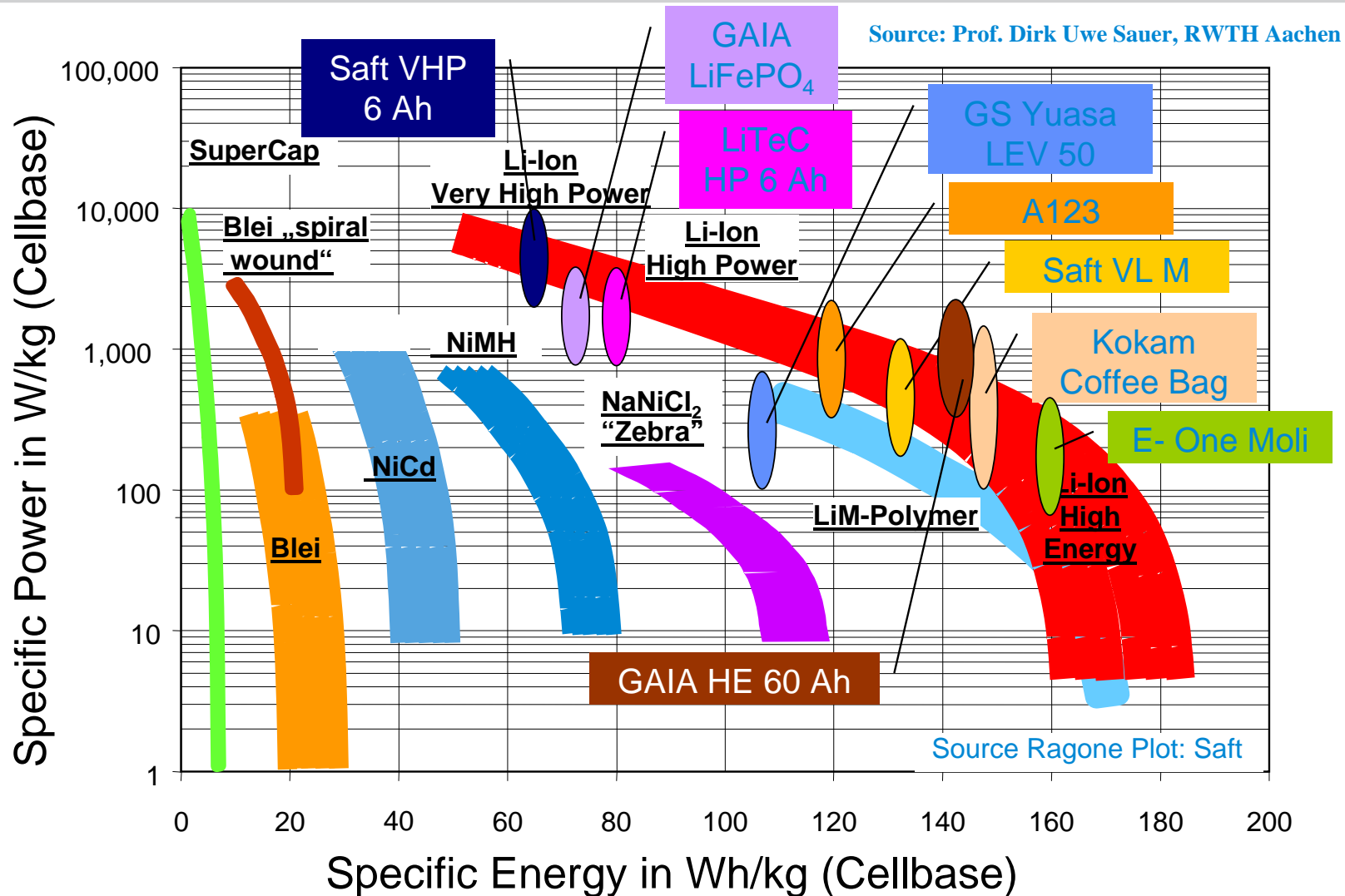


## ■ Essential Components applicable for different Hybrid Systems!

- Electrical Engine
- Power Electronics
- Energy Storage

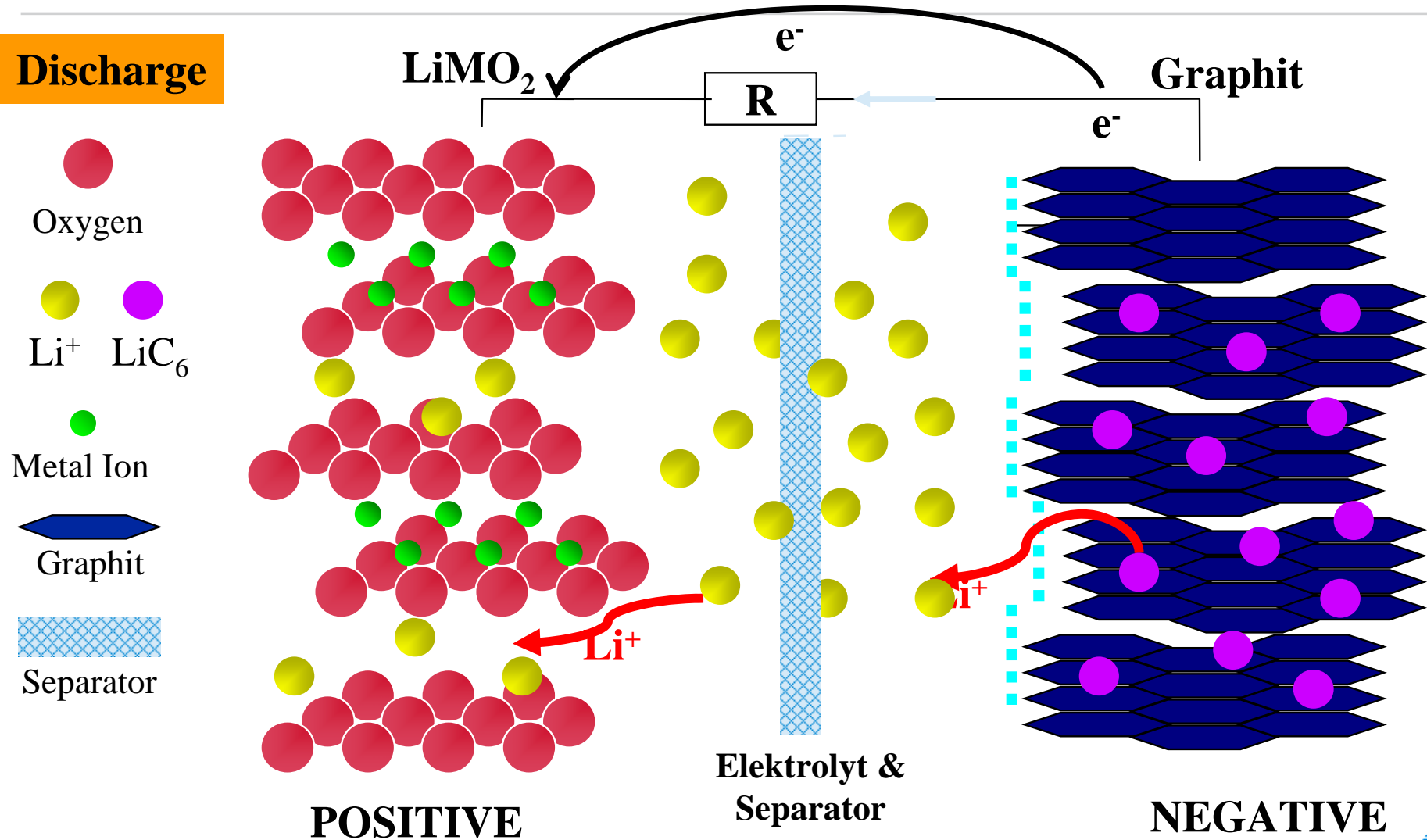


# Storage Characteristics: Gravimetric Power Density vs. Energy Density



# Lithium Ion System („Rocking Chair“ Principle)

**Discharge**



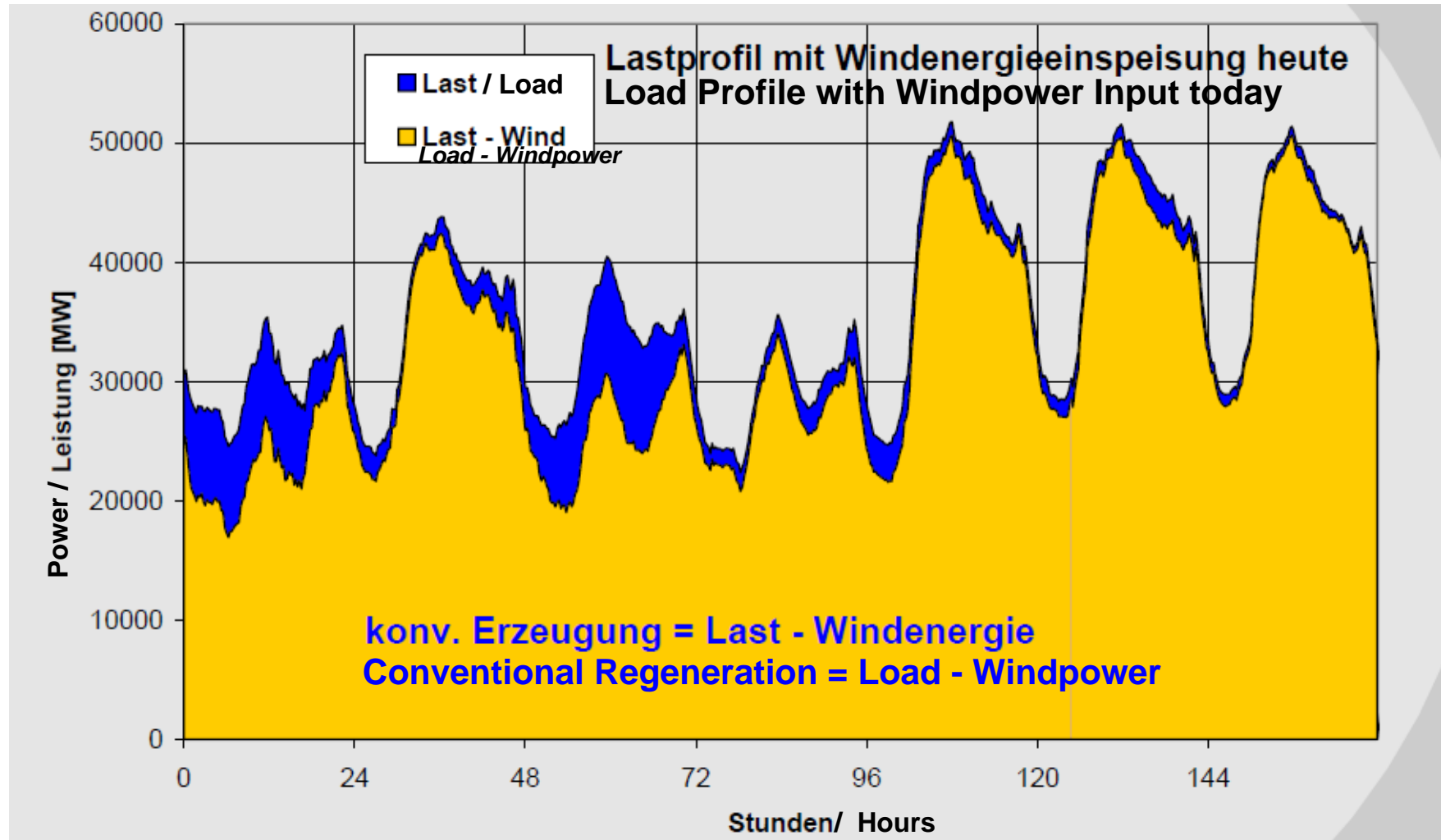
Source: Saft

Verband Deutscher Verkehrsunternehmen



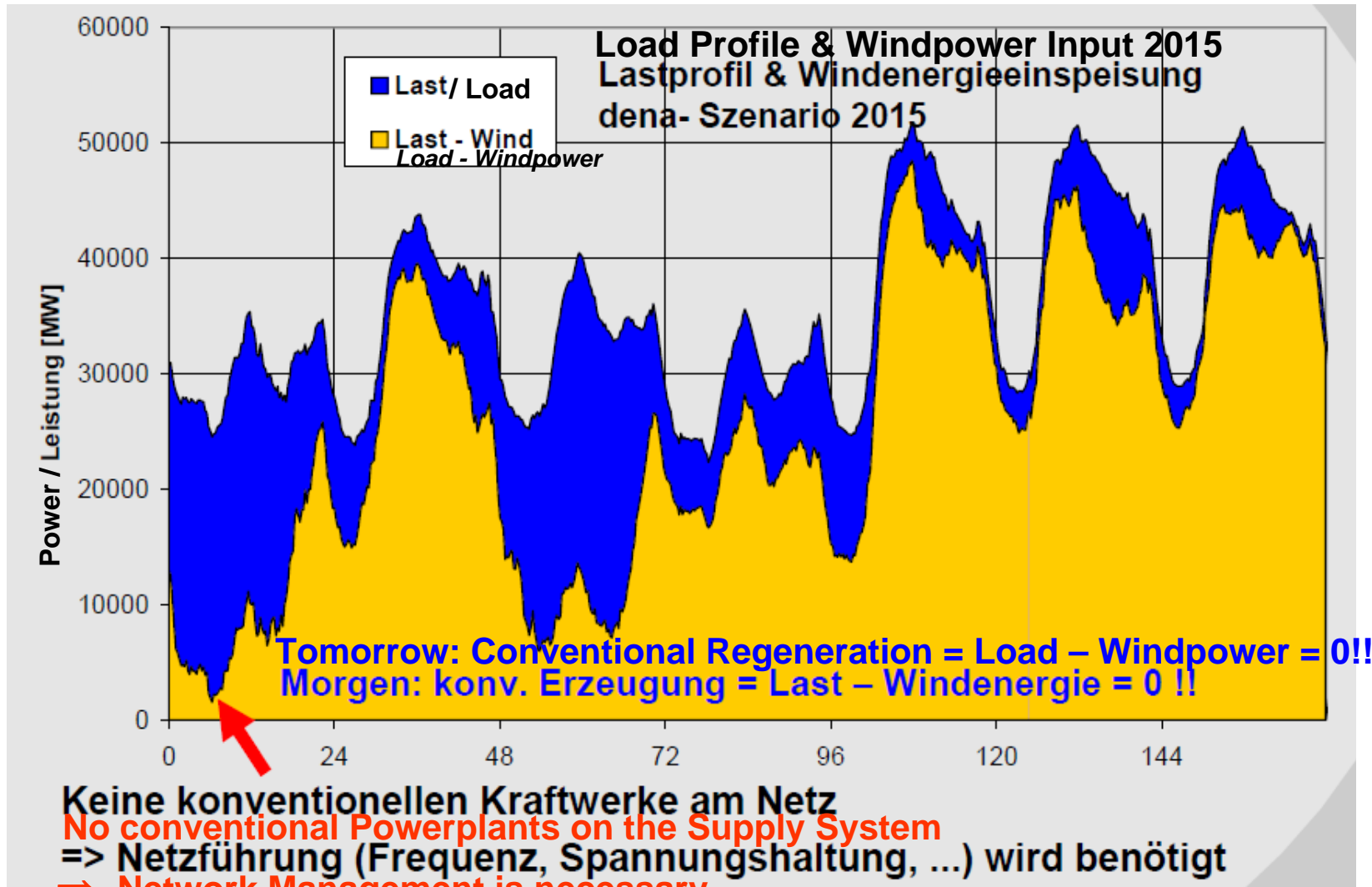
# Challenging Integration of Windpower within the Power Supply System today

*Herausforderung bei der Netzintegration von Windenergie heute*



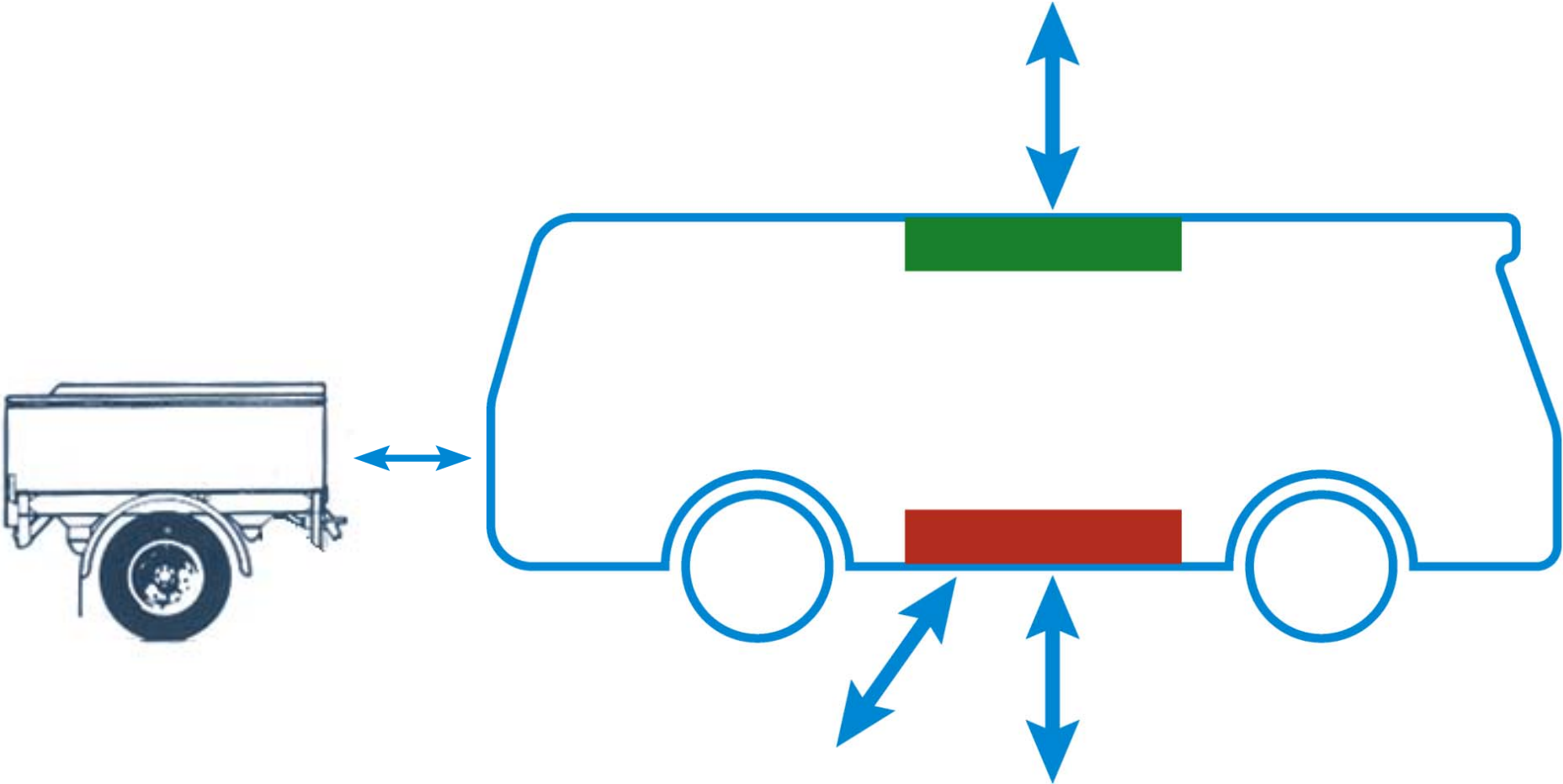
# Challenging Integration of Windpower within the Power Supply System tomorrow

*Herausforderung bei der Netzintegration von Windenergie (Szenario)*



# Step 2: Pure Electromobility: Possible Battery Exchange Solutions

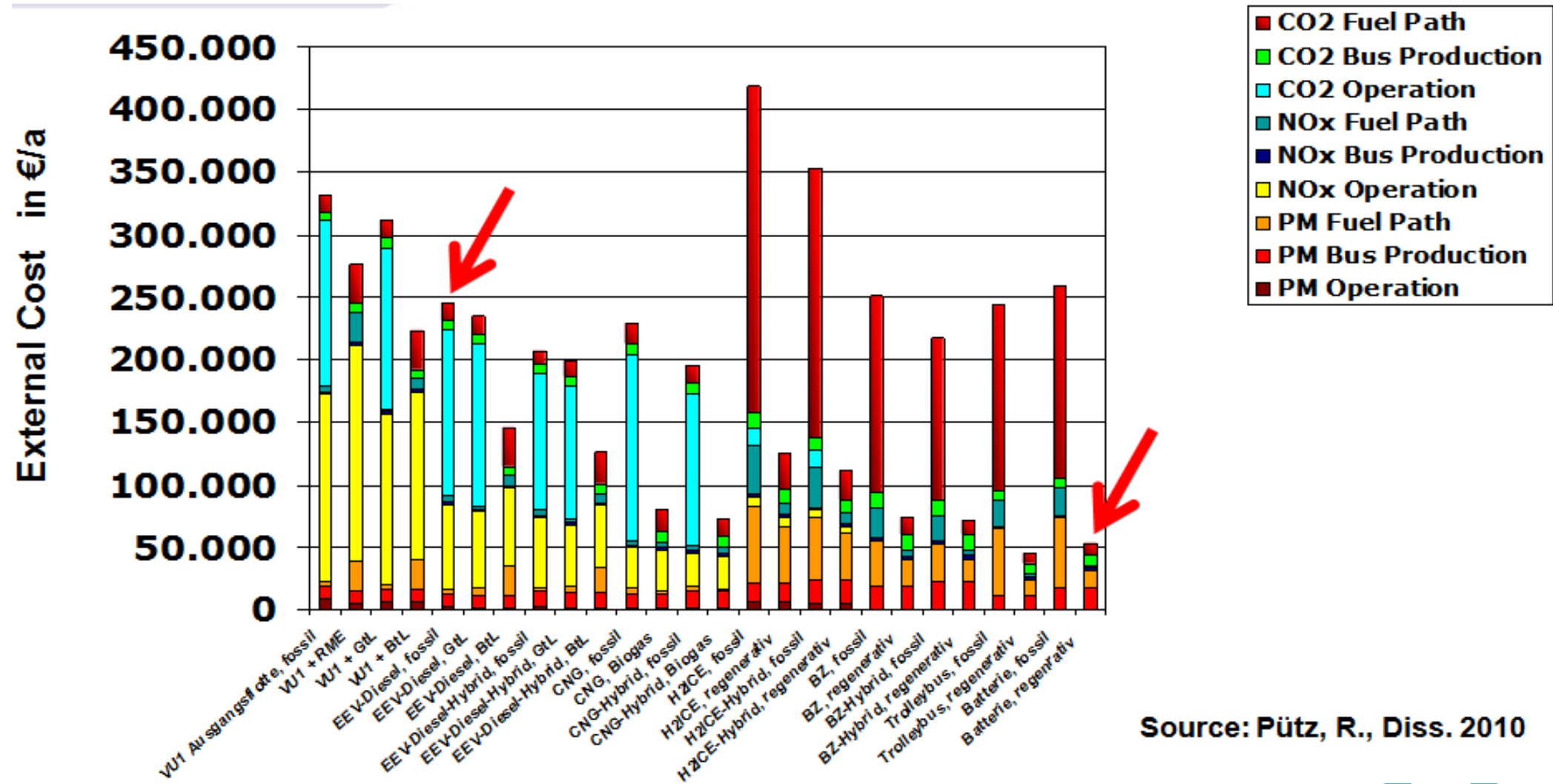
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# Electromobility: Bus with Battery Storage (Storage Exchange and/or Loading Technologies)



# System related External Cost of a PT Bus Fleet with 64 Buses within the whole Life Cycle (17 a)



Source: Pütz, R., Diss. 2010



# ... more about both ecological and economical Optimisation of Bus Fleets

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# Public Transport – The ideal Partner for Introduction of the Electromobility

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- Handling of the batteries through highly qualified personnel
- Optimal loading technology systems in depots/workshops
- In contrast to cars with buses quick return on invest of the high investment cost by long duration of daily operation
- Load management in electrical networks through virtual storage capacities due to battery exchange technology
- Analogous considerations apply also to other local vehicle fleets (garbage trucks etc.)

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**Thank you for your attention!**

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