

Claus Doll

**Climate change and innovation in
vehicle technology - the case of hybrid
electric vehicles**

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applied infrastructure
research - InfraDay,
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TU Berlin



Structure

1. The hybrid propulsion technology
2. Assessment of climate impacts
3. Innovation potentials
4. Markets and competition
5. Conclusions



Introduction to the hybrid propulsion technology

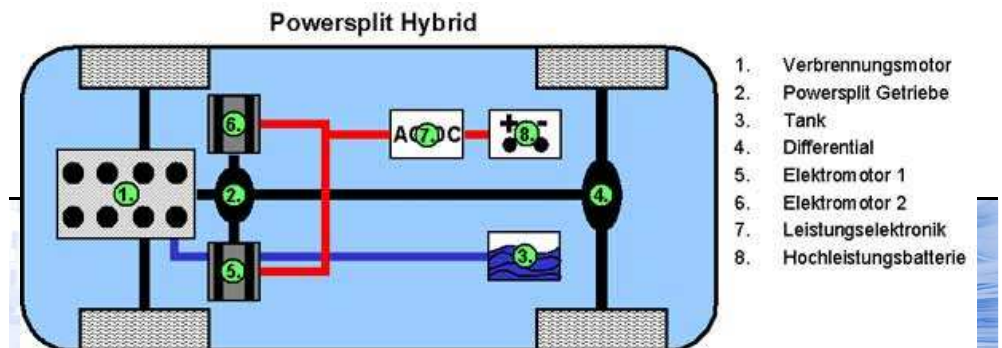
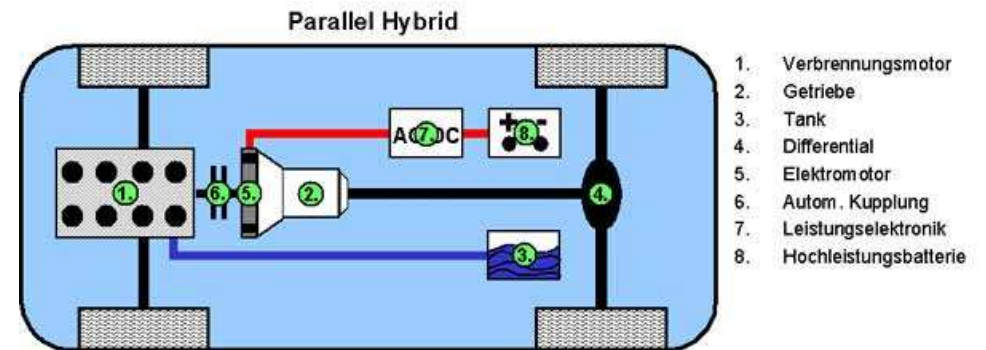
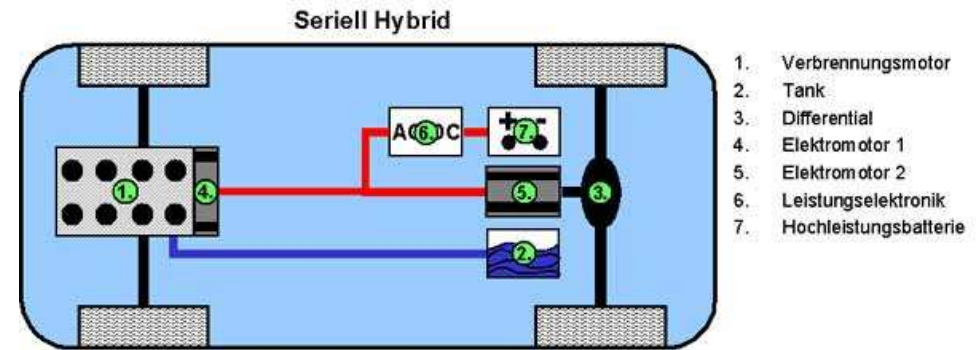
1. Low efficiency of combustion engines at low speeds or during acceleration, but long range and fast fuelling
 2. High efficiency of electric motors across a wide speed range, but short range and slow fuelling of batteries
 3. Ability of batteries to use brake energy (recuperation), but extra battery weight has to be moved around
 4. Full (or strong) hybrids can drive fully or partly emission and noise free in local areas
- Hybrid cars are a suitable concept for mainly urban traffic with frequent start-stop cycles and shorter driving ranges



Introduction to the hybrid propulsion technology

Types of hybrid car technologies:

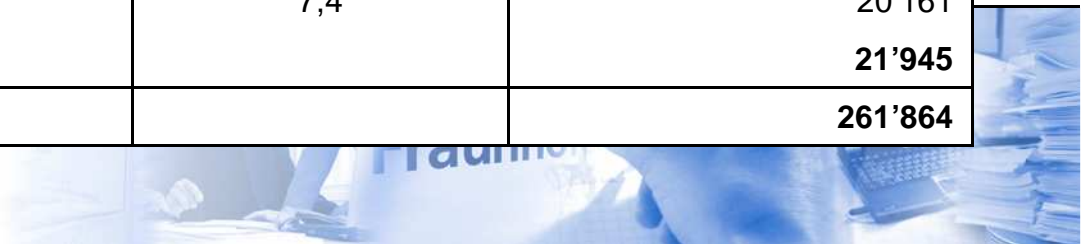
1. Mild hybrids: electric motor supports acceleration (booster)
2. Full hybrid: electric motor takes over at low speed, combustion engine is considerably down-sized
3. Parallel hybrid: power of electric and combustion engine is added for propulsion
4. Serial hybrid: Combustion engine charges the battery, propulsion by electric motor only
5. Power split (Toyota): two e-motors for generation and propulsion with planetary gear for power adding
6. Plug-in hybrid: Big battery with long range, which has to be loaded at the grid electricity network (→ vehicle to grid concept)



Current commercial hybrid car models

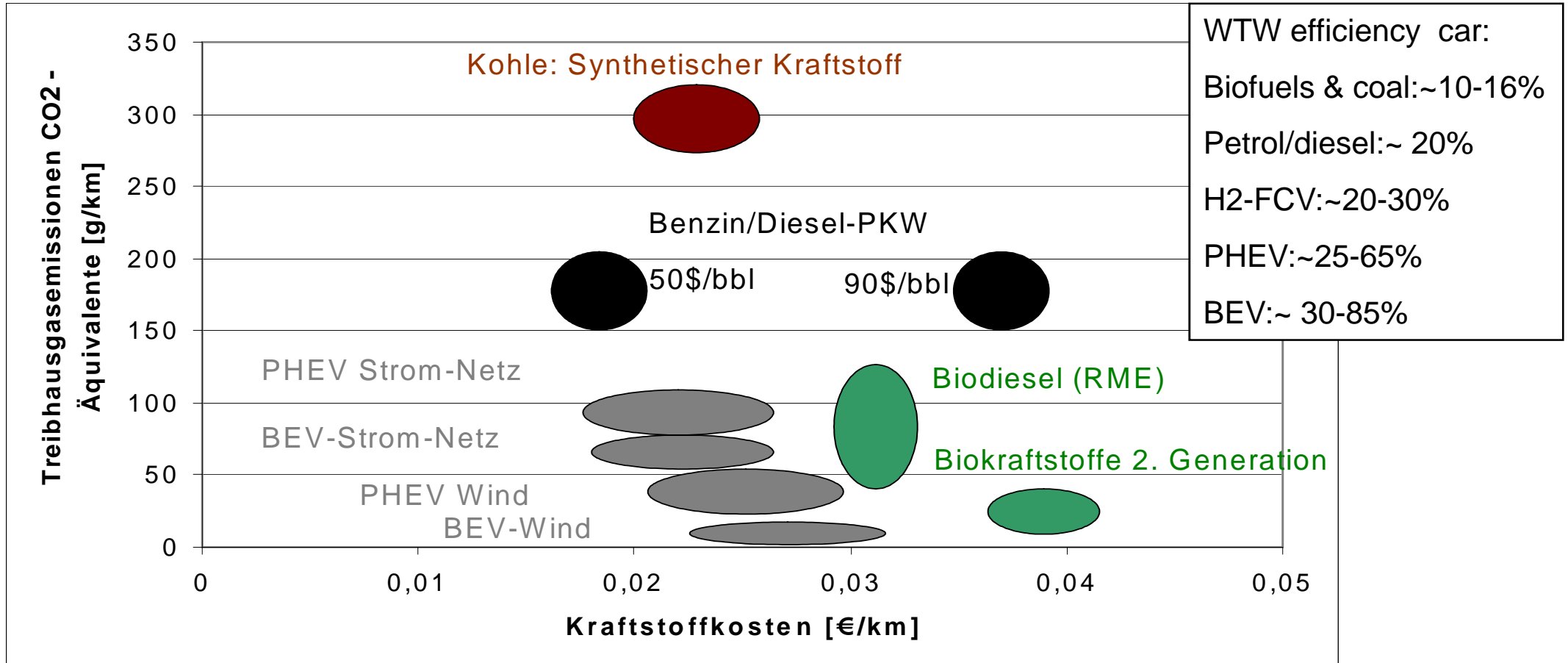
Sales and fuel efficiency indicators for some hybrid models (USA 2006)

Market and model	Fuel consumption outside urban areas	Fuel consumptions in urban areas	Vehicles sold in the USA 2006
	l/100 km		Units
TOYOTA Prius	4,6	3,9	106'971
TOYOTA Highland	8,8	7,6	31'485
TOYOTA Camry	6,2	5,9	31'341
TOYOTA total			169'797
HONDA Accord	8,2	11,8	5'598
HONDA Civic Hybrid	4,6	4,8	31'253
HONDA Insight			722
HONDA total			37'573
FORD Mercury Marriner	10,3	13,1	
FORD Escape+Marriner	8,2	7,2	22'549
LEXUS GS450h	8,4	9,5	1'784
LEXUS RX400h	8,8	7,4	20'161
LEXUS total			21'945
OVERALL			261'864



Assessment of fuel costs and CO2 emissions

Alternative Antriebspfade und Kenngrößen (PKW, ohne Steuern, heutige Energiepreise)

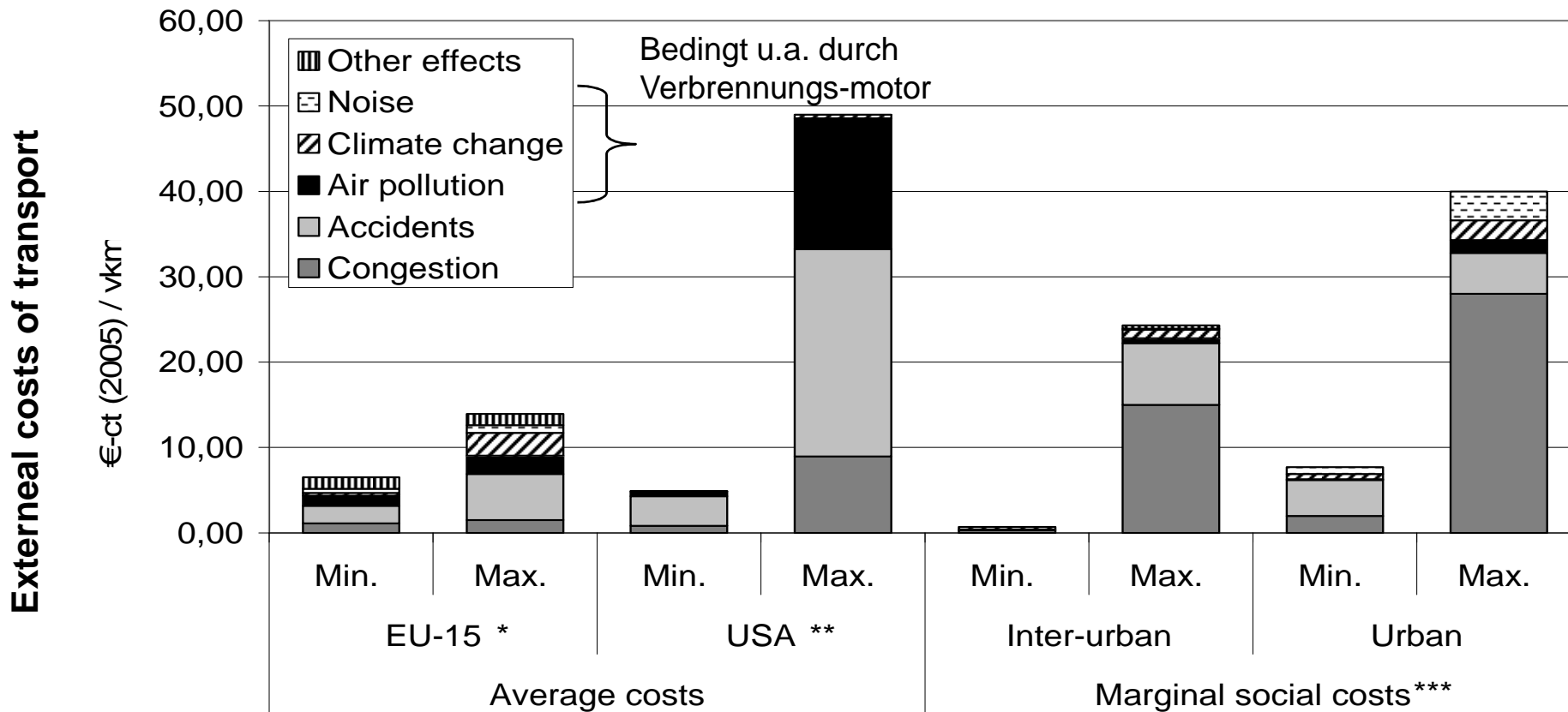


WTW: Well-to-Wheel, PHEV: Plug-in Hybride, BEV: Elektrofahrzeuge, H2-FCV: Brennstoffzellenfahrzeuge

Quelle: Eigene
Berechnungen und
LBST 2007



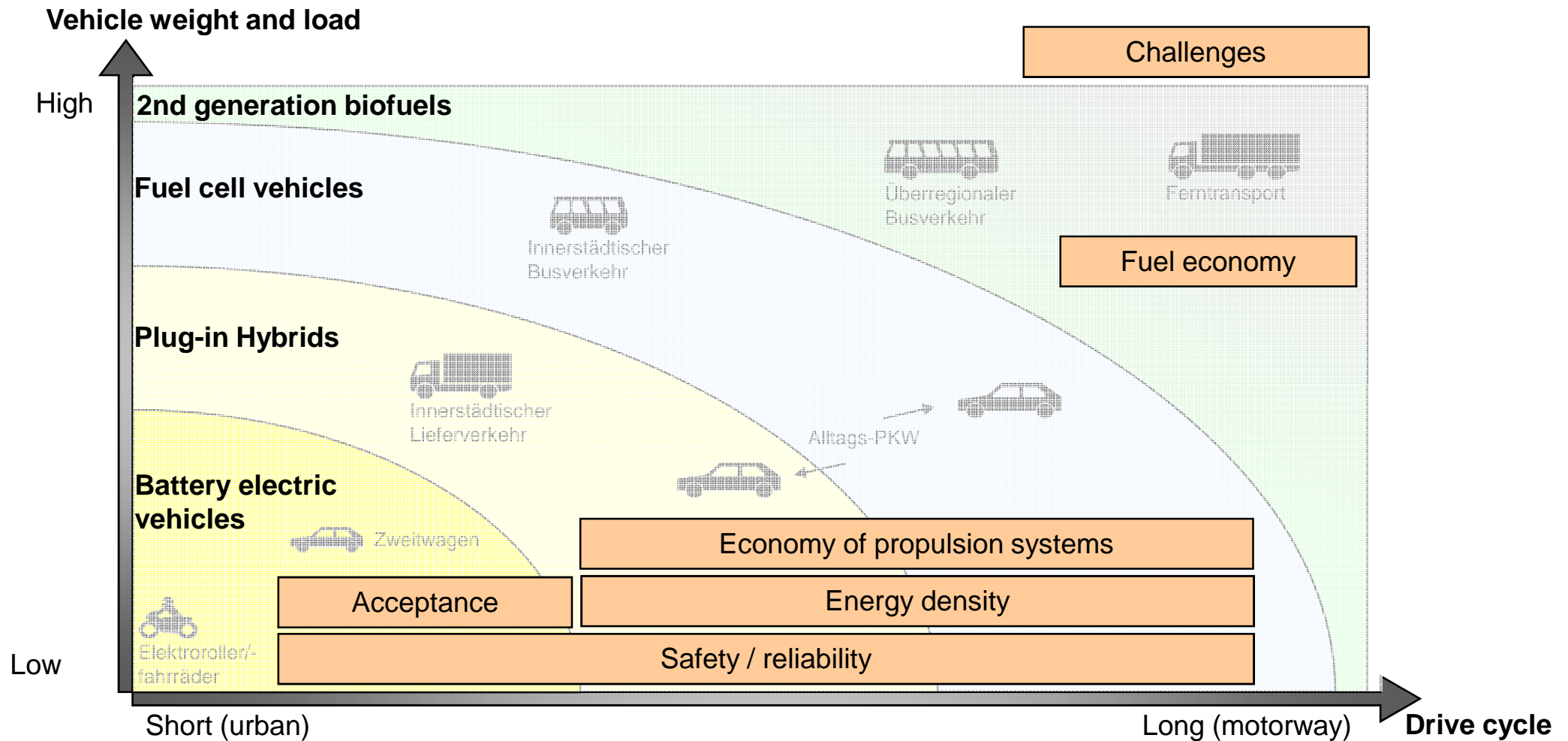
Assessment – Structure and ranges of external cost estimates



* All networks, passenger cars - ** Urban and inter-urban highways, 60% for all vehicle costs - *** Passenger cars
 Data sources: Nash et al. (2003), Maibach et al., (2004 and 2007a, 2007b), DOT (1997), VTPI (2007);
 data has been processed to 2005 Euros by average price indices and exchange rates 2005.



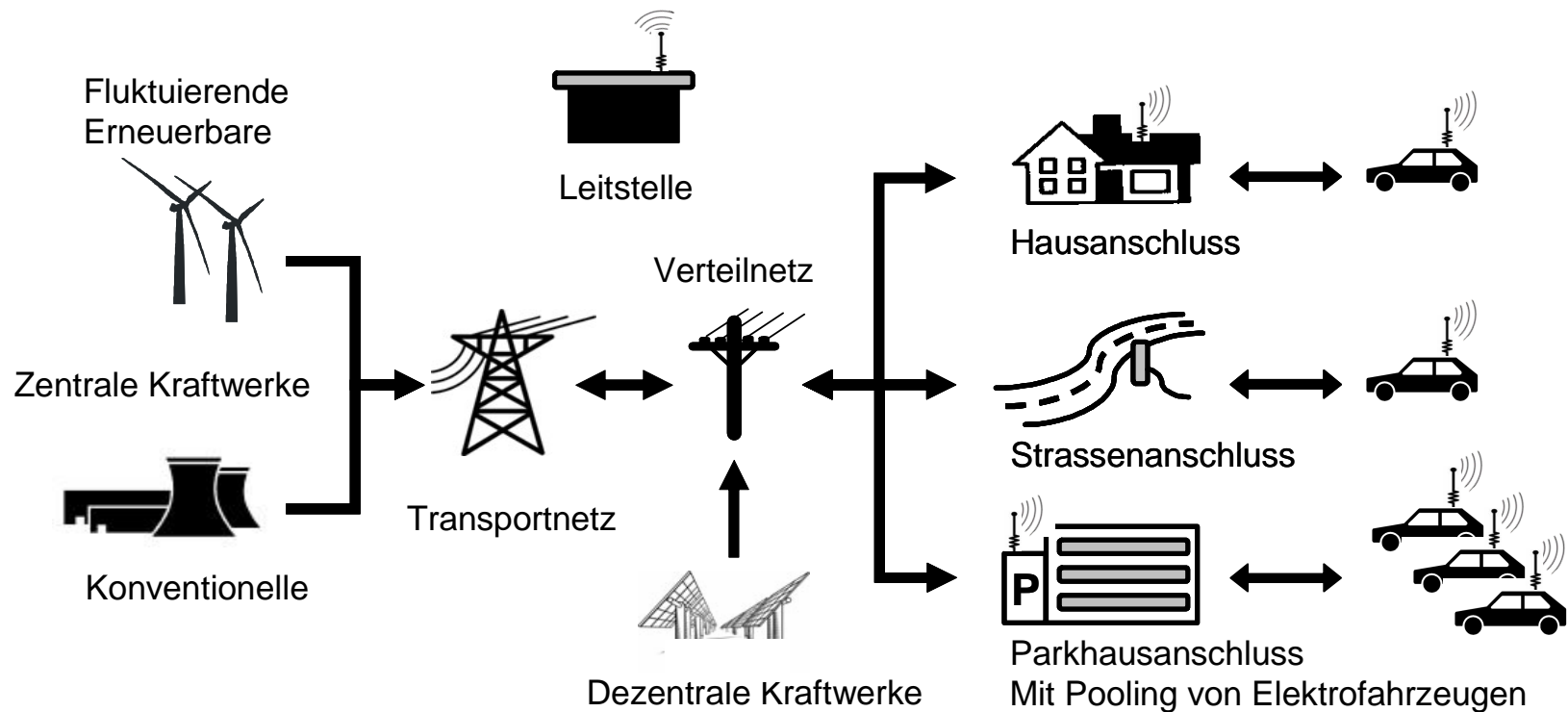
Future development paths and challenges of alternative propulsion systems



The infrastructure dimension of HEVs

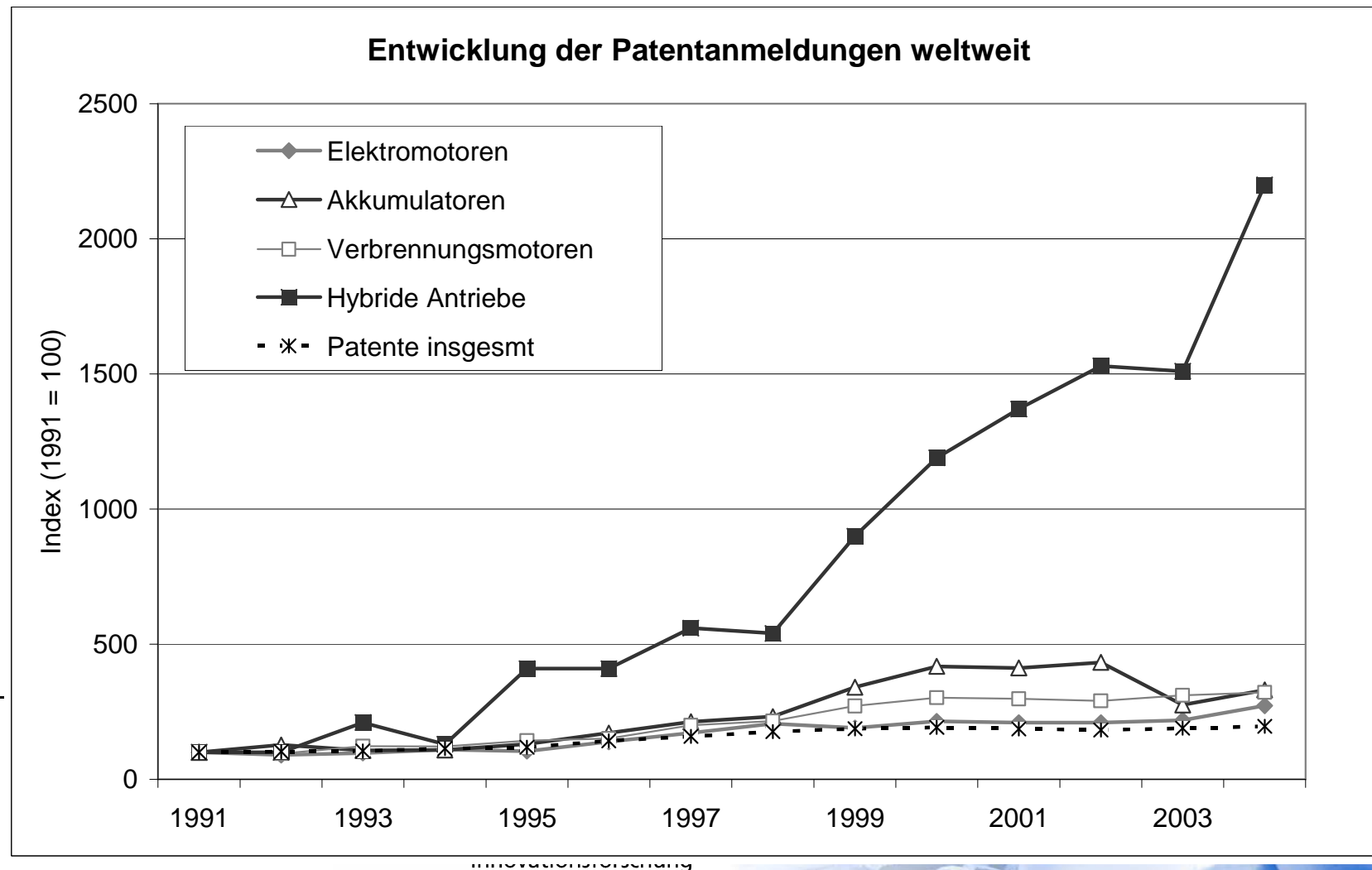
Temporal storage of fluctuating (renewable) energy sources is multiple vehicle batteries.

Requirement: intelligent power supply infrastructures



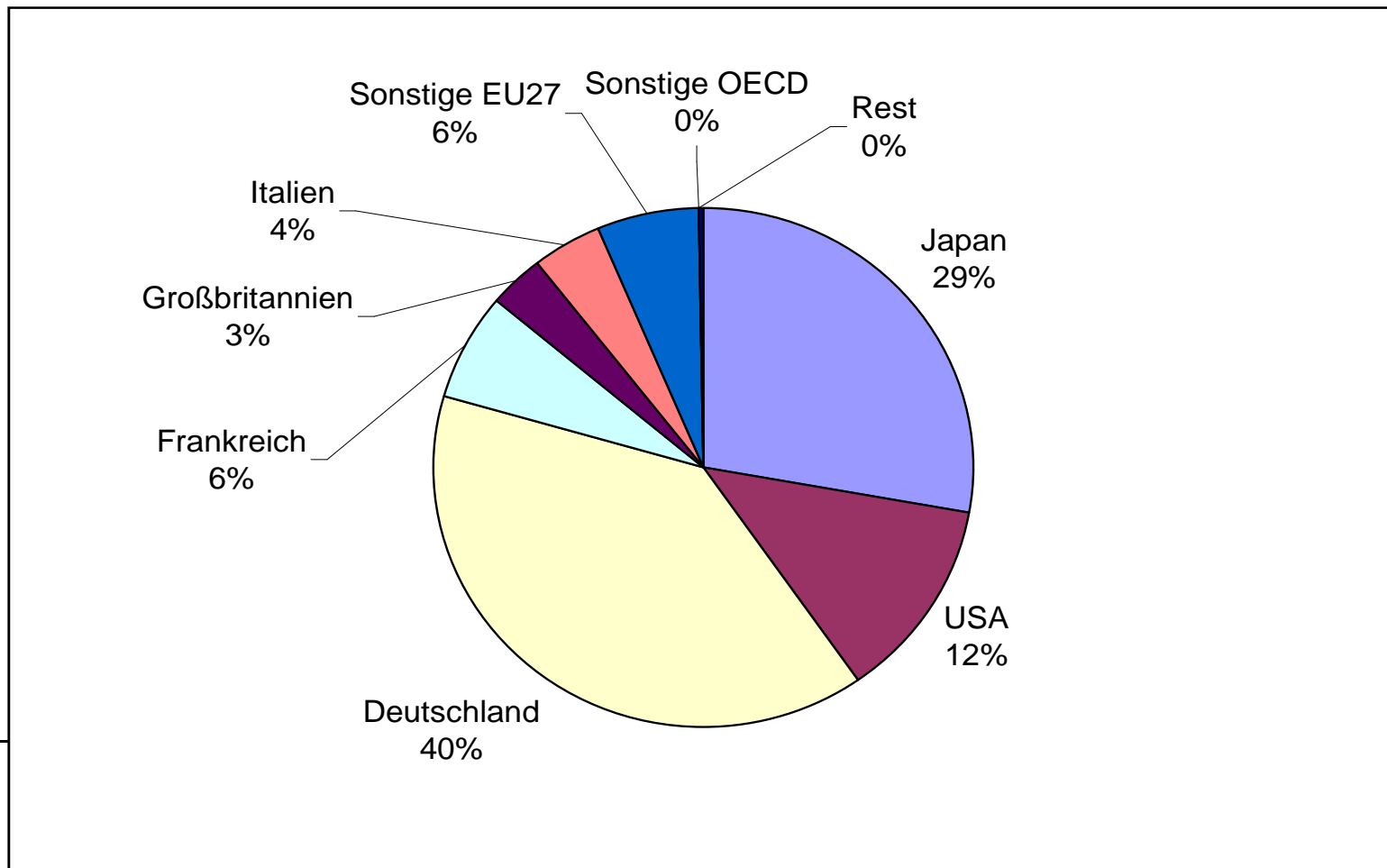
Innovation potentials – patent counts

Index of patent applications of hybrid vehicle technologies and their Components (1991 = 100)



Innovation potentials – patent counts

Patent applications of hybrid propulsion systems worldwide by application country
2000 – 2004

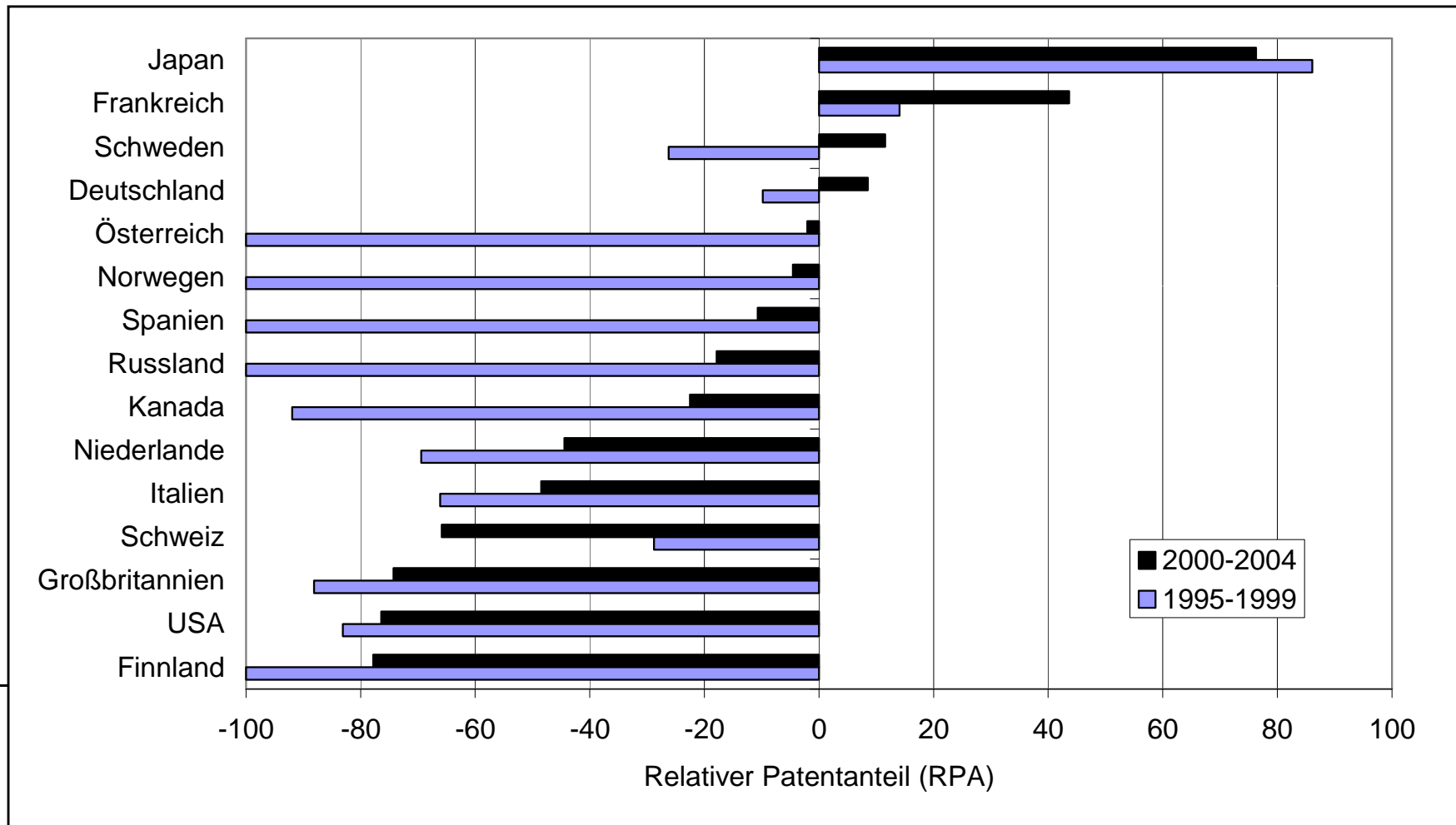


System- und
Innovationsforschung



Innovation potentials – specialisation of RTD

RPA of hybrid propulsion technology and its components 2000 – 2004 in comparison to 1995 – 1999 by country

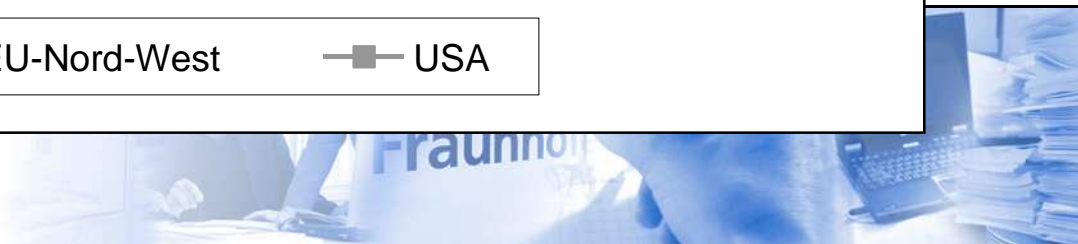
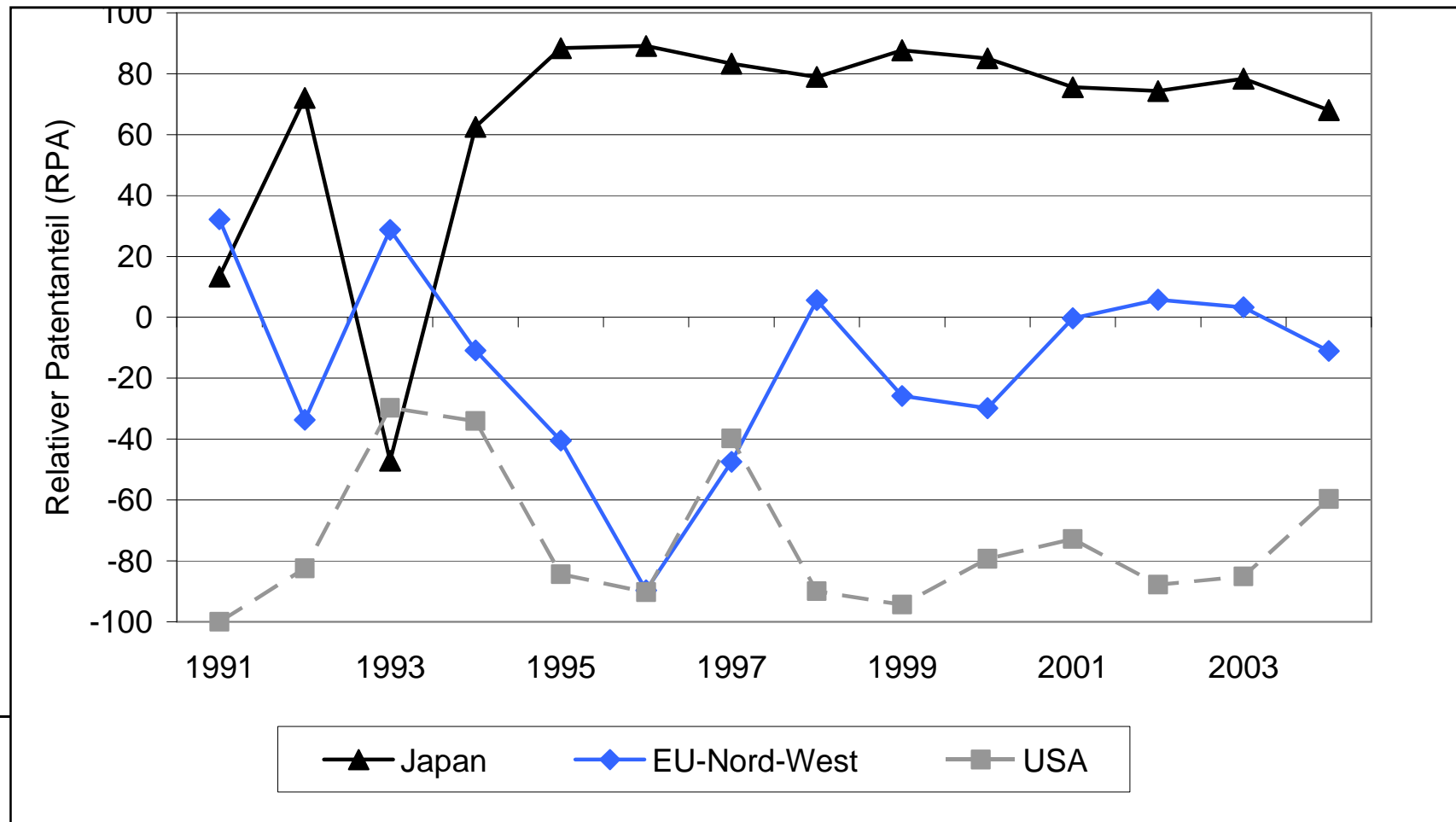


System- und Innovationsforschung



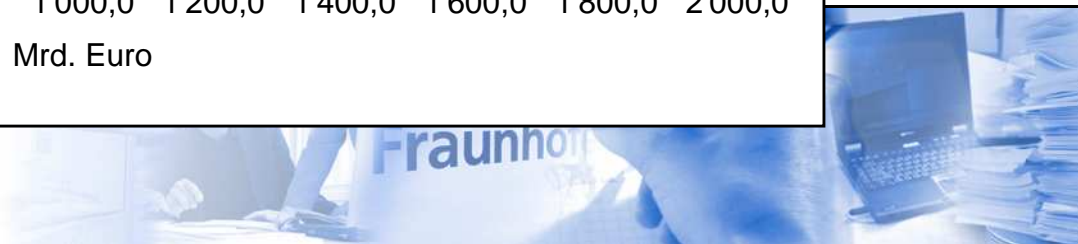
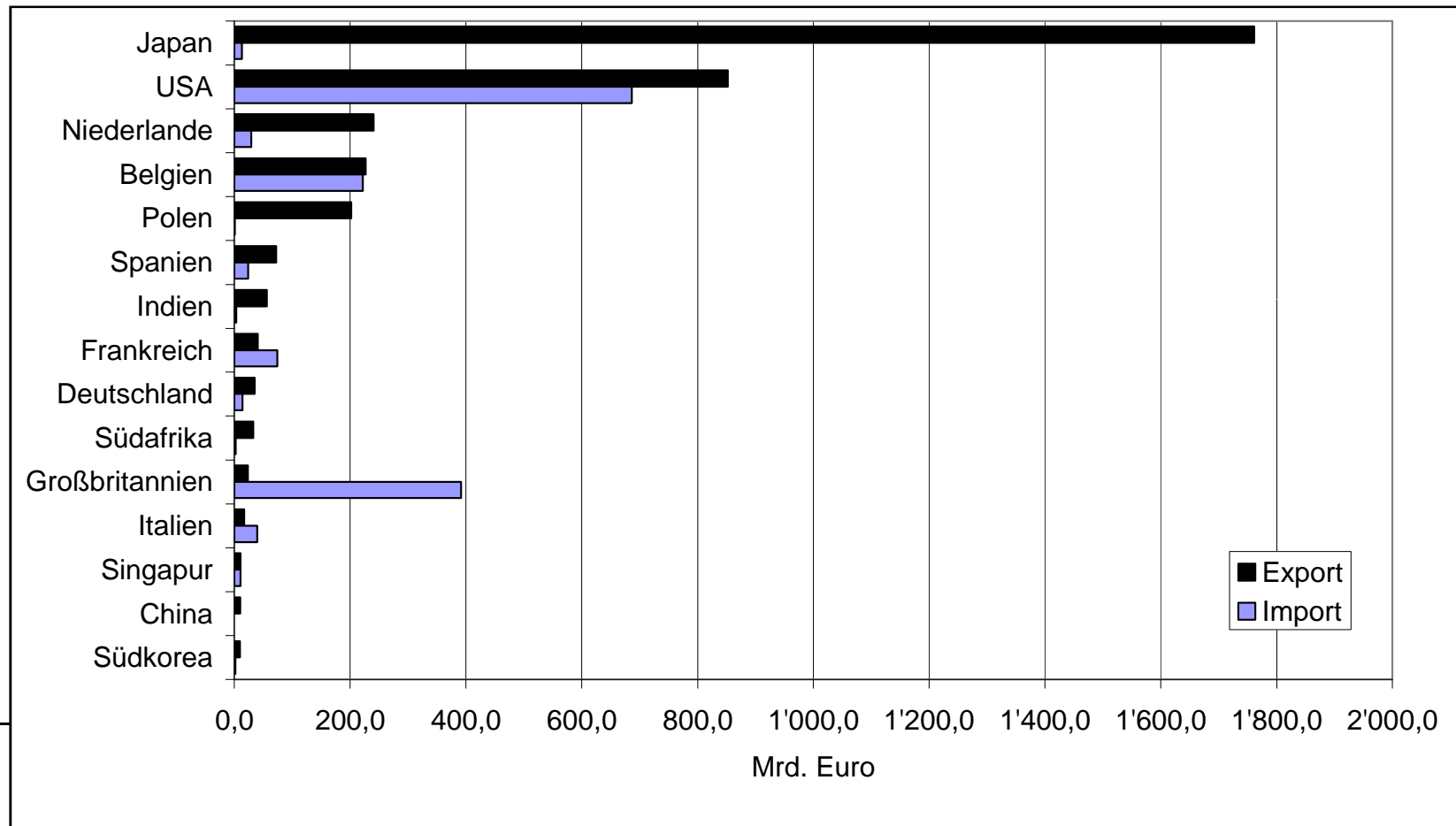
Innovation potentials – patent counts

Relative patent shares of hybrid propulsion systems for selected world regions over time



Potential markets – current exports and imports

Exports and Imports of vehicles with electric propulsion of the 15 most export-intensive nations in 2004



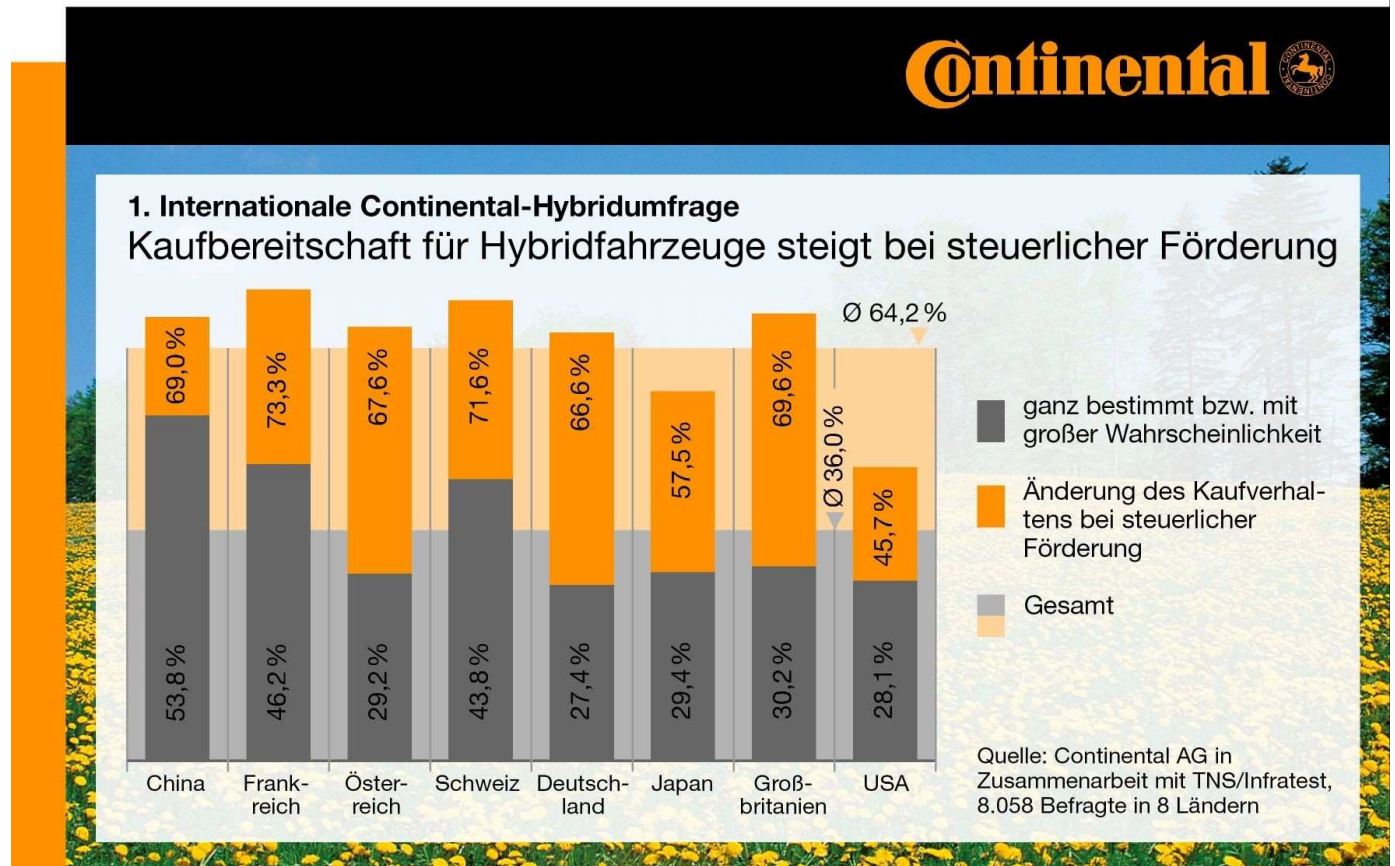
Motives for buying hybrid vehicles by world regions

Results of a poll by Continental among 800 customers in 8 countries

- grey: purchase with high conditions
- orange: purchase in case of tax reduction

Major impact of price and state subsidies

No consideration of regulatory environment, but conditional purchase in UK → London congestion charge



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Conclusions – SWAT analysis

Strengths	Opportunities
<ul style="list-style-type: none"> •Powerful car manufacturing industry •well skilled engineers •excellent starting position in some components, e.g. combustion engines and car electronics •Leading position in hybrid systems for special and heavy goods vehicles 	<ul style="list-style-type: none"> •ambiguous environmental policy of the European Union •growing cities worldwide plus growing concern of citizens for environmental problems and well-off consumers •rapidly growing energy prices
Weaknesses	Threats
<ul style="list-style-type: none"> •general back-log in developing hybrid vehicle propulsion systems •no competence in the field of rechargeable batteries •different environmental and transport policies in EU member states. 	<ul style="list-style-type: none"> •strong competition by catching-up countries •shortage of specialised employees •declining demand due to demographic change •further preference of consumers towards diesel technologies in cars



Conclusions and recommendations

1. Strengths:

- High potential for most technical components of HEVs in Europe.
- Sensitivity of European policy and citizens towards environmental issues

2. Technological challenge:

- Development of competence in battery development

3. Implementation challenges:

- Environment supporting low carbon propulsion technologies
- Clean propulsion does not suffice => embedding in larger living and mobility concepts





Toyota Prius



Peugeot Diesel



Hondy Civic Hybrid

MAN Citybus hybrid
3rd Generation



Think! City Car
hydrogen and
electric version

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