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JOANNEUM RESEARCH Forschungsgesellschaft mbH

Electric vehicles as an element of a sustainable mobility

Gerfried Jungmeier

Interdisciplinary Summer School 2011 on "The Future of Energy Systems in Austria and the Czech Republic", Graz/Austria, June 15, 2011

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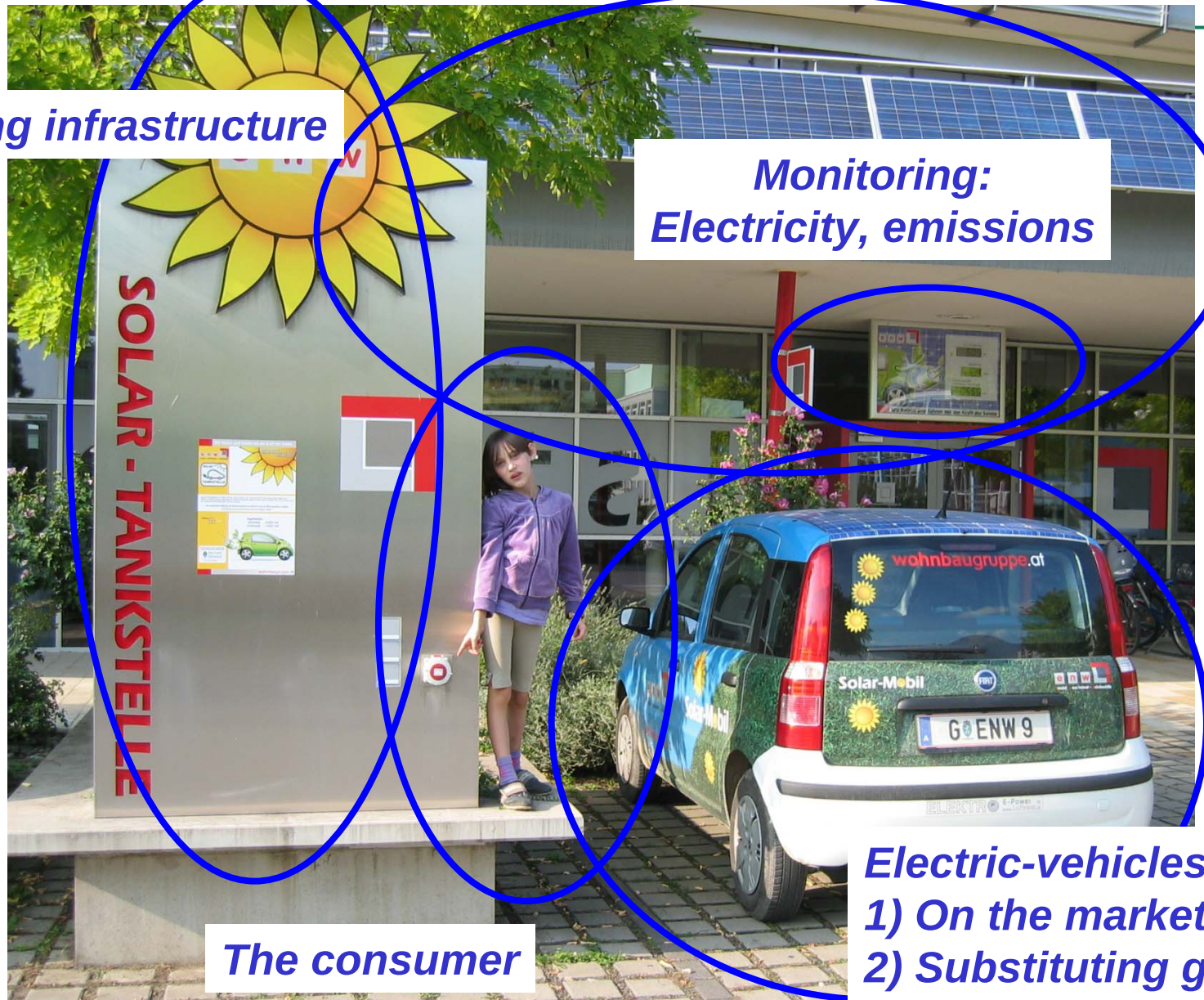
Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

Monitoring: Electricity, emissions

Additional renewable electricity

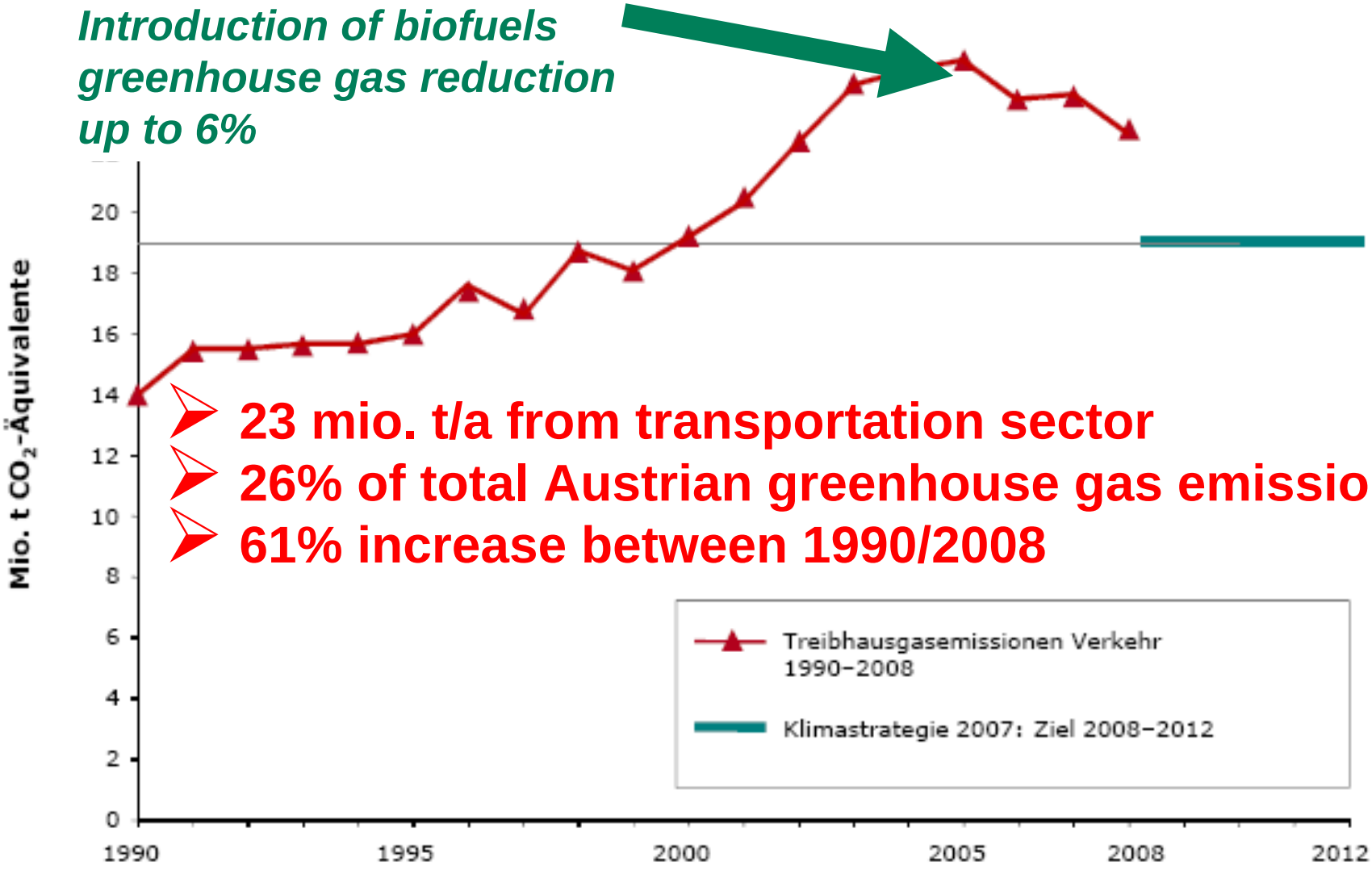
Electric-vehicles
1) On the market available
2) Substituting gasoline&diesel

The consumer

www.joanneum.at

Key Figures I of Austria Transportation Sector

Introduction of biofuels greenhouse gas reduction up to 6%



- **23 mio. t/a from transportation sector**
- **26% of total Austrian greenhouse gas emissions**
- **61% increase between 1990/2008**

Quellen: Umweltbundesamt (2010), Lebensministerium (2007)

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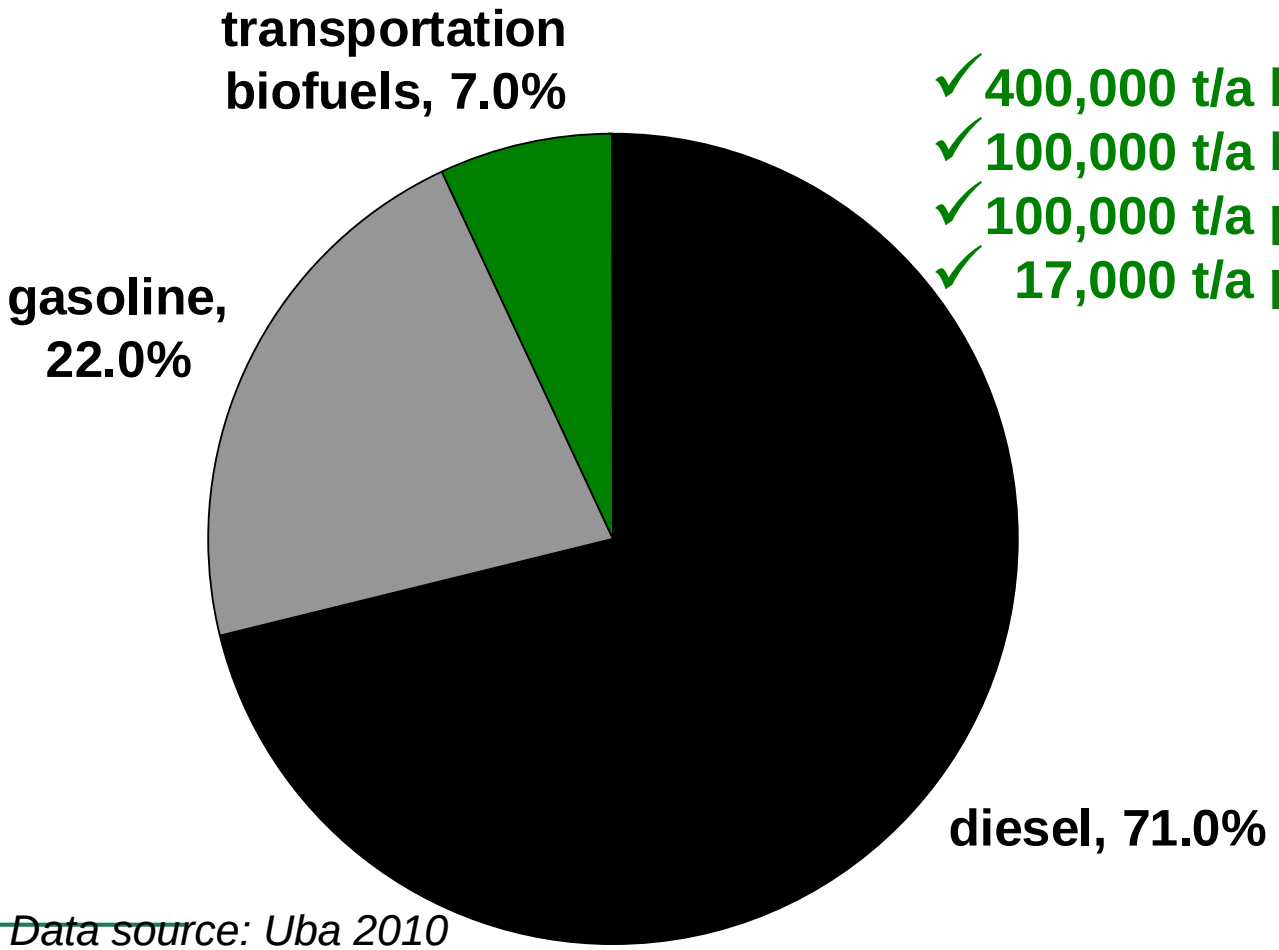
The Austrain Transportation Sector in 2009

Transportation fuel demand: 331 PJ/a
(domestic passenger cars 128 PJ/a)



Transportation biofuels:

- ✓ **400,000 t/a biodiesel blending to diesel**
- ✓ **100,000 t/a bioethanol blending to gasoline**
- ✓ **100,000 t/a pure biodiesel**
- ✓ **17,000 t/a pure vegetable oil**

Data source: Uba 2010

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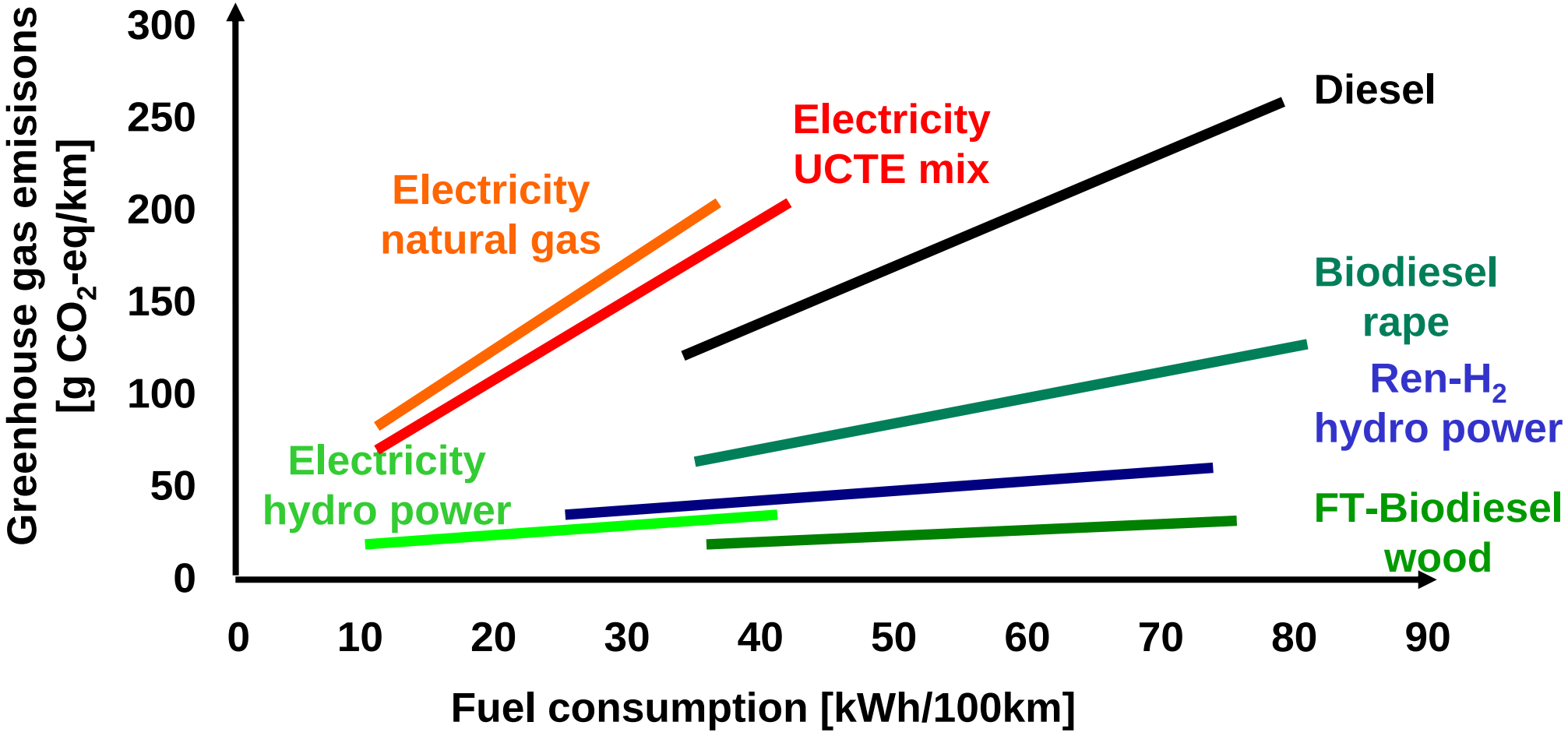
The Energy Efficiency Issue

Internal combustion engine and battery electric passenger cars



Source: passenger cars based on LCA, Joanneum Research

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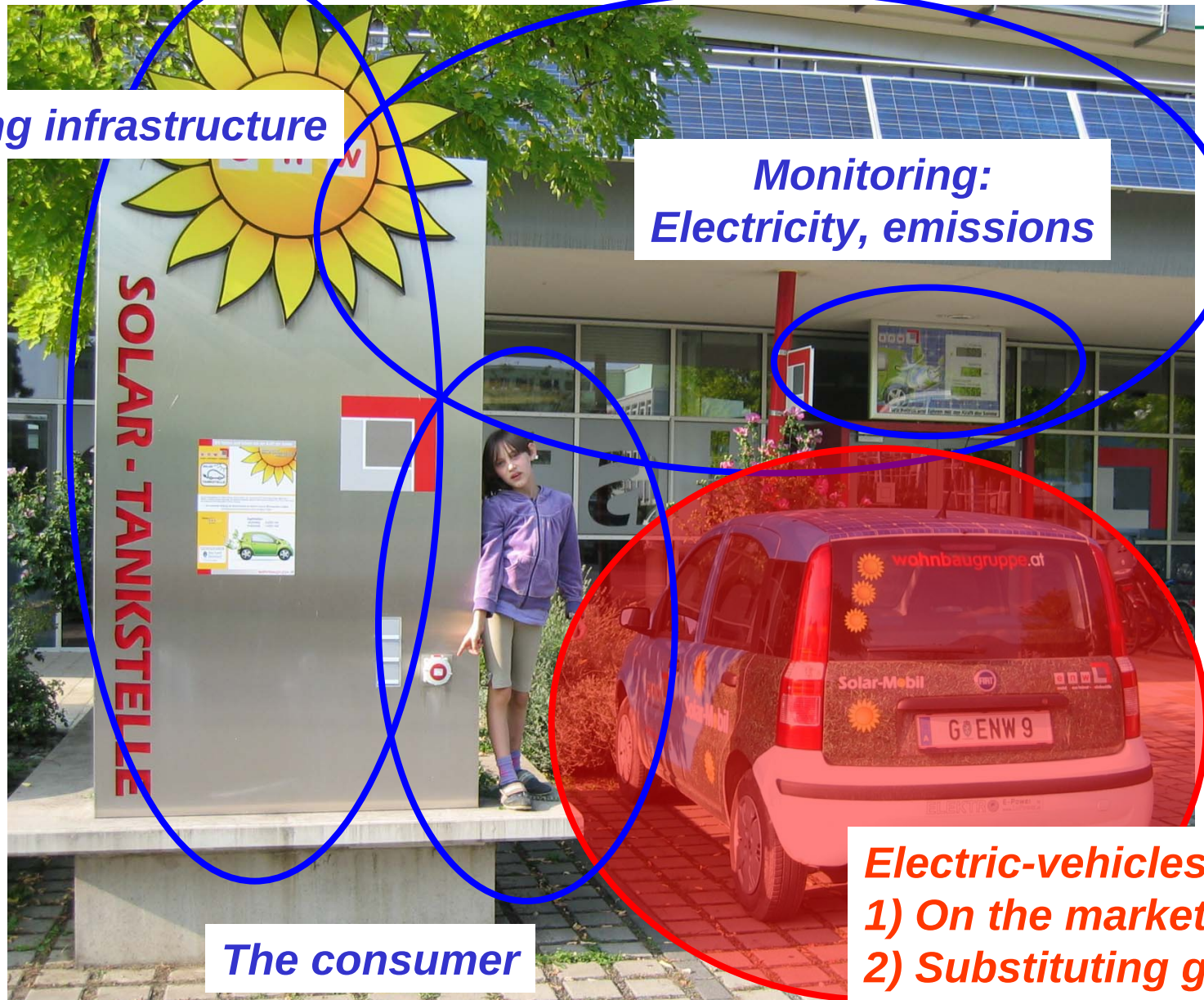

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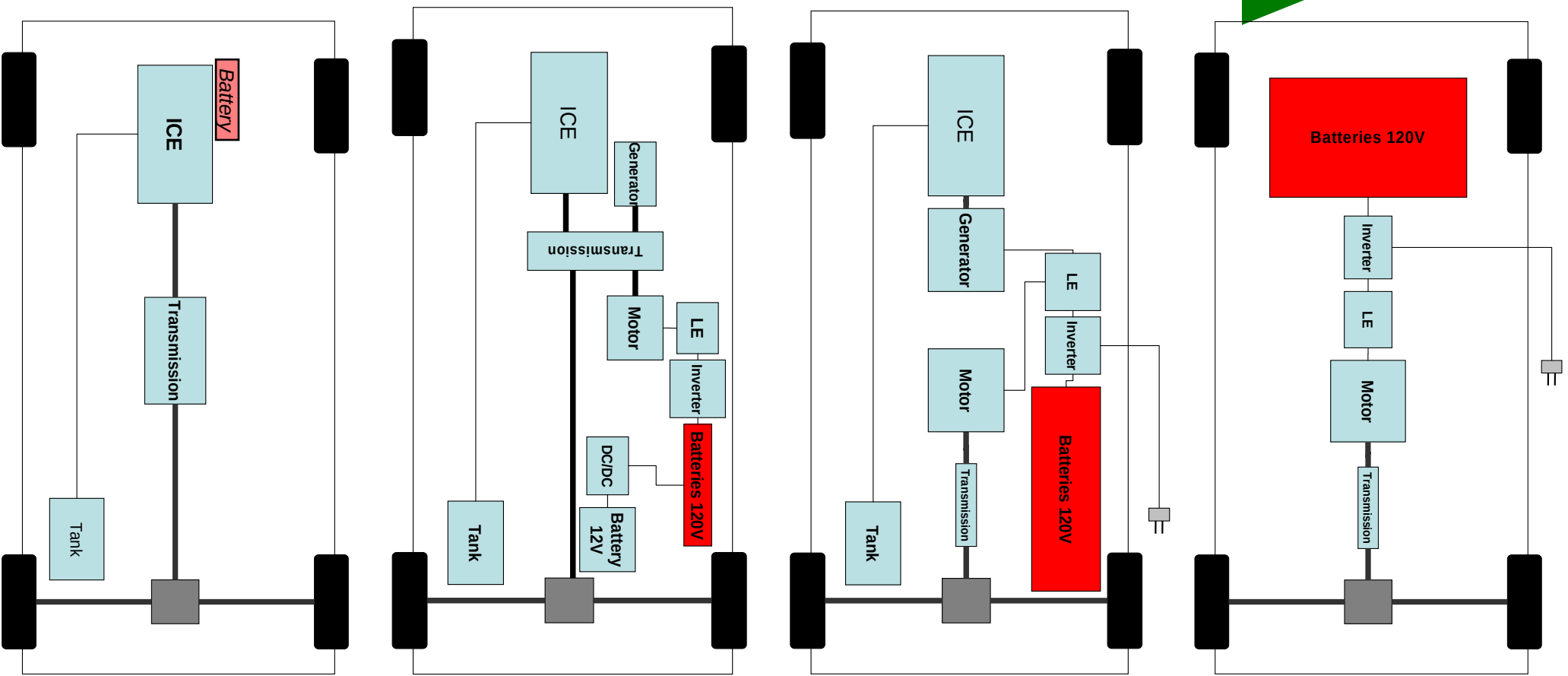
Types of Electric-Vehicles

Internal combustion engine (ICE)

Hybrid-Electric vehicles (HEV) (electric&internal combustion engine)

Battery electric vehicle (BEV)



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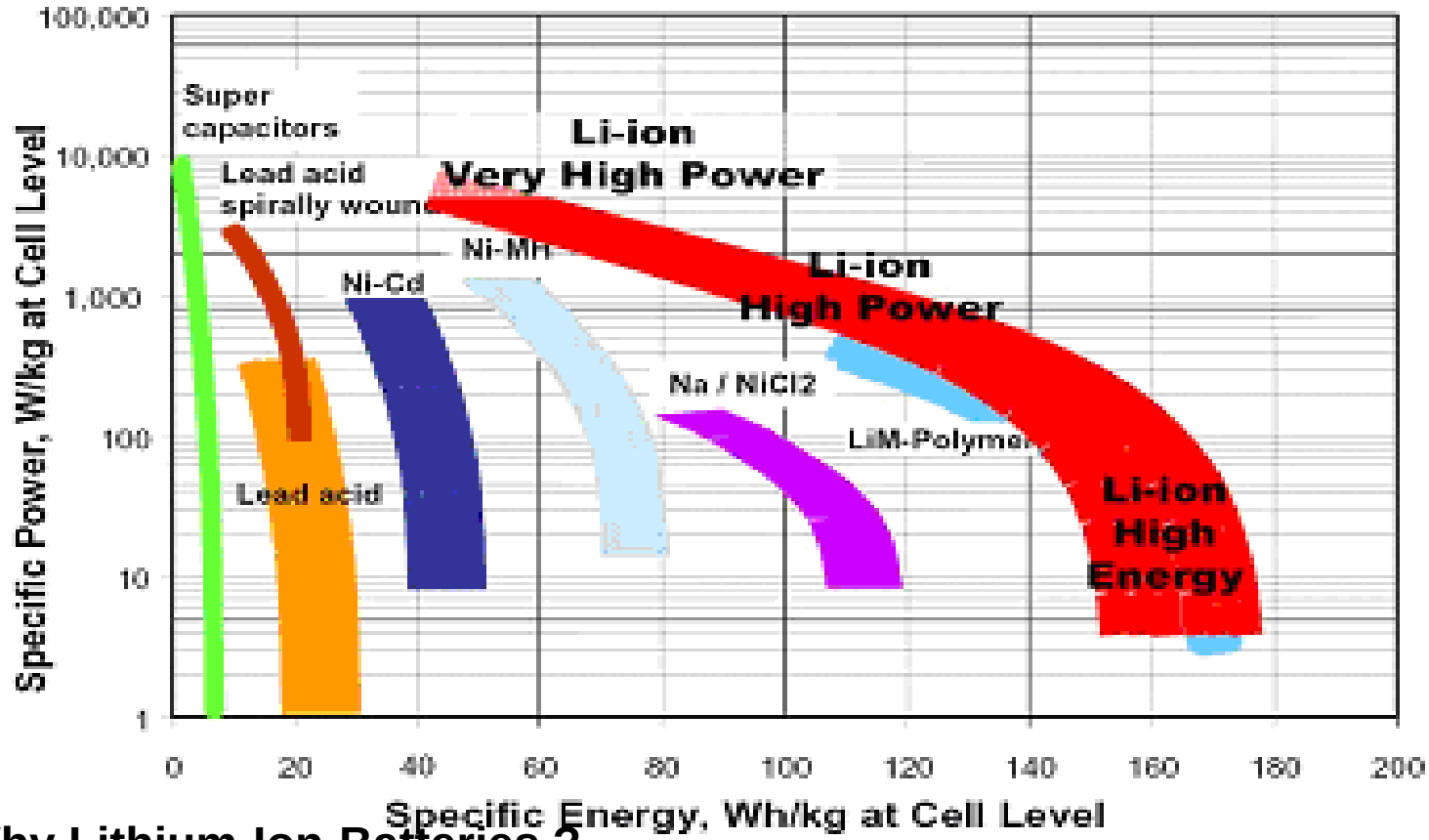
Characteristics of Battery Systems



Source: saftbatteries

Why Lithium-Ion-Batteries ?

⇒ higher specific energy and/or power compared to other systems

BUT

1) High investment costs, currently 8,000 – 20,000 €/passenger car
Mass prodcution enproduktion necessary
2) Lifetime and 3) Operation below 0°C

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vehicles since 2010

KLEINE ZEITUNG
FREITAG, 5. NOVEMBER 2010

AUTO & MOBIL | 47

MITSUBISHI I-MIEV

Verkaufsstart: Dezember 2010.
Elektro-Auto mit 67 PS, 180 Nm, Lithium-Ionen-Akku (fünf Jahre Garantie), Reichweite bis 150 km, Spitze 130 km/h, Ladezeit 6 Stunden bei 230 V/16 Ampere.
Preis: 35.900 Euro, Firmenleasing ab 499 Euro.

a B0
: 210km
i Ion 30kWh,

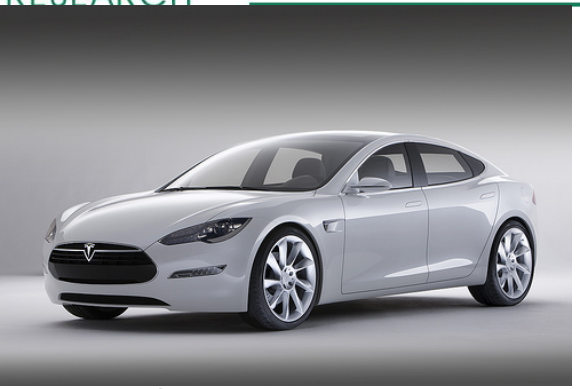
Batterie: Li Ion 1

e: Joanneum Research, recherche Oktober 2009

Reva NXR
Reichweite: 160 oder 80 km
Batterie: Li Ion oder Blei
ab € 15.000.- + monatl. Gebühr

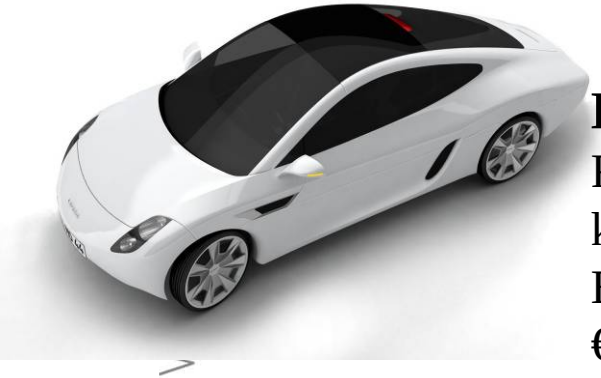
anneum.at

Elelectric vehicles since 2011



Tesla Model S
Reichweite: 250 bis 480 km
Batterie: Li Ion
$ 49.000.-

Nissan Leaf
Reichweite: 160 km
Batterie: Li Ion



Loremo EV
Reichweite: 150 bis 200 km
Batterie: Li Ion
€ 30.000.-

Mini Elektro
Reichweite: 168 km
Batterie: Li Ion, 35kWh

Quelle: Joanneum Research, Marktrecherche Oktober 2009

Hybrid-electric vehicles since 2011/2012

Fisker Karma
Plug in / Rangeextender

el. Reichweite: 80 km
Batterie: Li Ion
$ 87.900.-

Opel Ampera Plug in / Rangeextender

el. Reichweite: 60 km
Batterie: Li Ion

Quelle: Joanneum Research, Marktrecherche Oktober 2009

Audi A1 Sportback
Plug in / paralleler Hybrid

el. Reichweite: 100 km
Batterie: Li Ion

Toyota Prius Plug-in
paralleler Hybrid

el. Reichweite:20 km
Batterie: Li Ion

BYD Auto F3DM (Build Your Dreams)

paralleler + serieller Hybrid

el. Reichweite: 100 km
Batterie: Li FePO

ON aus TRADITION

Two-wheelers and others (I)

Bauer BIFS26

Vmax: 25 km/h
Reichweite: bis 60 km
Batterie: Li Ion
0,2 kWh
€ 1.398.-

Alko XOne

Vmax: 45km/h
Reichweite: bis 40 km
Batterie: Blei Gel,
2,8 kWh
€ 5.399.-

IO Florenz

Vmax: 45 km/h
Reichweite: bis 80
Batterie: Silizium,
2,2 kWh
€ 2.370.-

Quantaya Track

Vmax: 80 km/h
Reichweite: bis 120min
Crossfahrzeit
Batterie: LiPo, 48V
€ 9.198.-

E-max 90s

Vmax: 45 km/h
Reichweite: bis 60 km
Batterie: Silicon Silizium
1,9 kWh
€ 2.990.-

Vectrix VX-1

Vmax: 100 km/h
Reichweite: bis 110 km
Batterie: NiMH,
3,7 kWh
€ 8.990.-

ION aus TRADITION

Two-wheelers and others (II)

Segway X2

Vmax: 20 km/h
Reichweite: bis 38 km
Batterie: Li Ion
€ 6.590.- exkl.

Frauscher 750 St. tropez
Batterie: Li Mn

Bikeboard S500

Vmax: 25 km/h
Reichweite: 60 km
Batterie: Li Po
€ 2.990.- exkl.

eRockit
Mensch-Maschine Hybrid
Faktor 1:50

Vmax: 80 km/h
Reichweite: 60-80 km
Batterie: Li Ion
Nanophosphat 2,9kWh
€ 28.900.- exkl.

Quelle: Joanneum Research, Marktrecherche Oktober 2009

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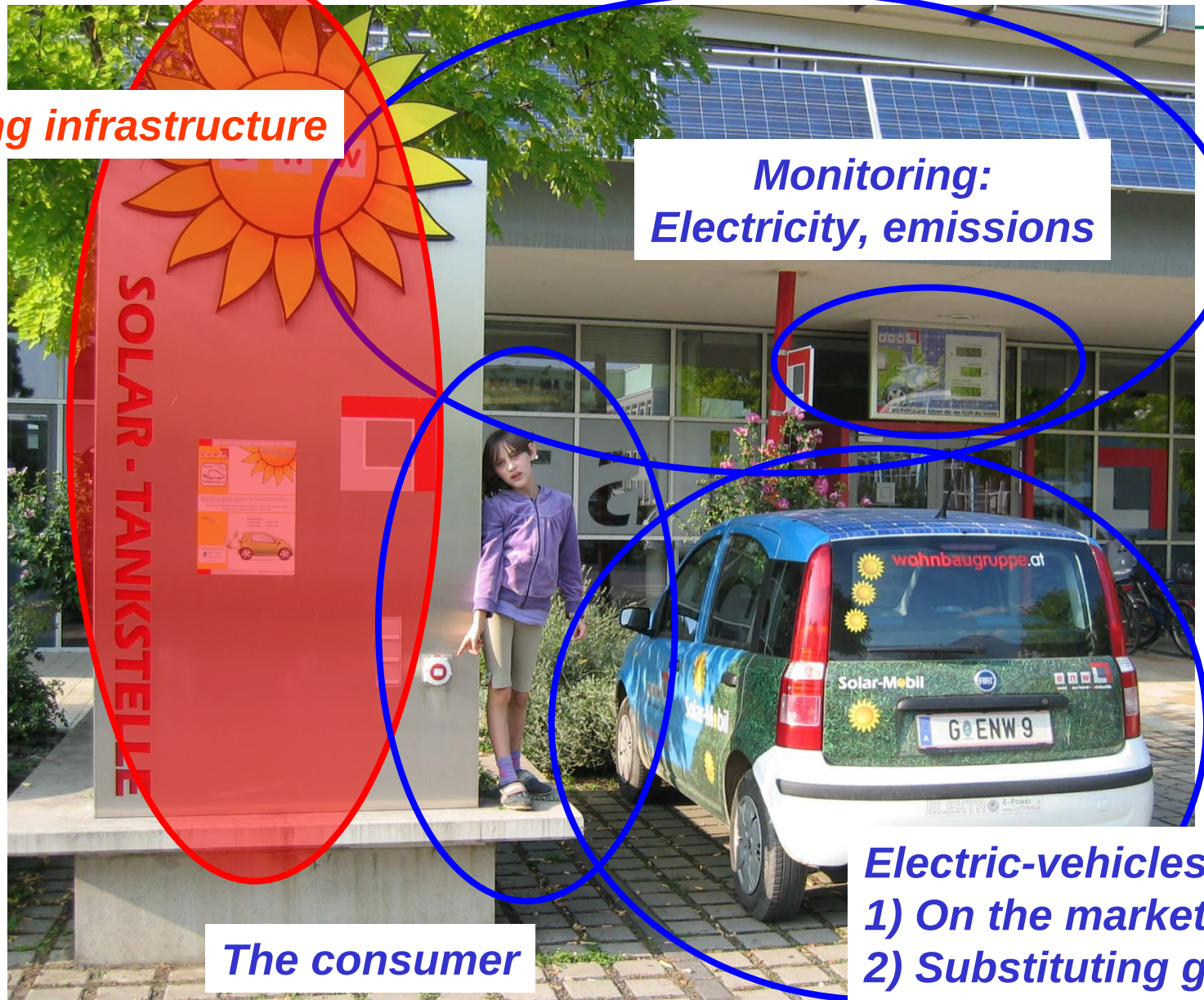
Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

Monitoring: Electricity, emissions

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The consumer

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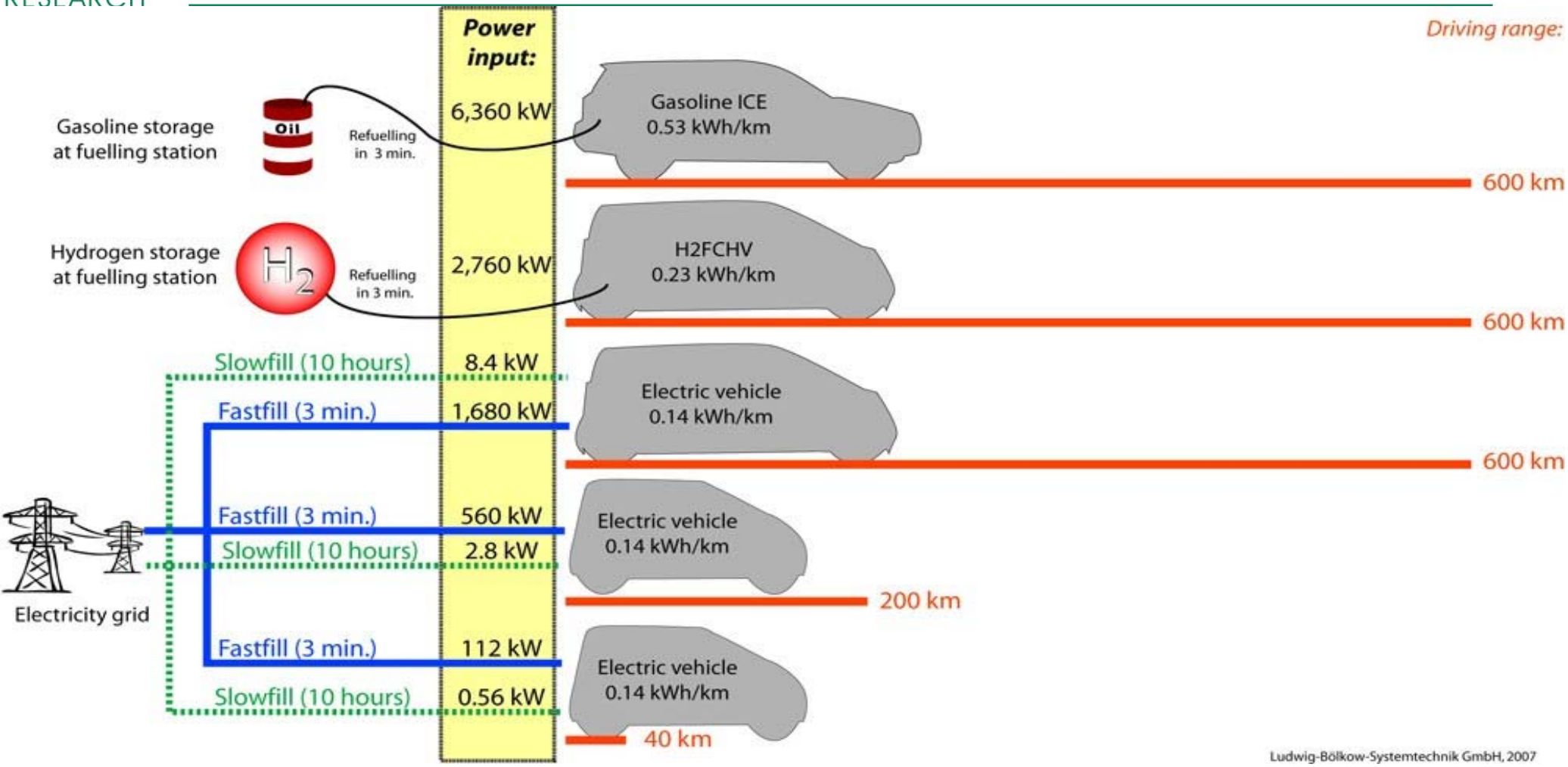
Technical Challenges – Power Capacity for Charging



- For comparison: standard houshold plug: 4 kW_{el} (250 V, 16 A)!

Quelle: LBST 2009

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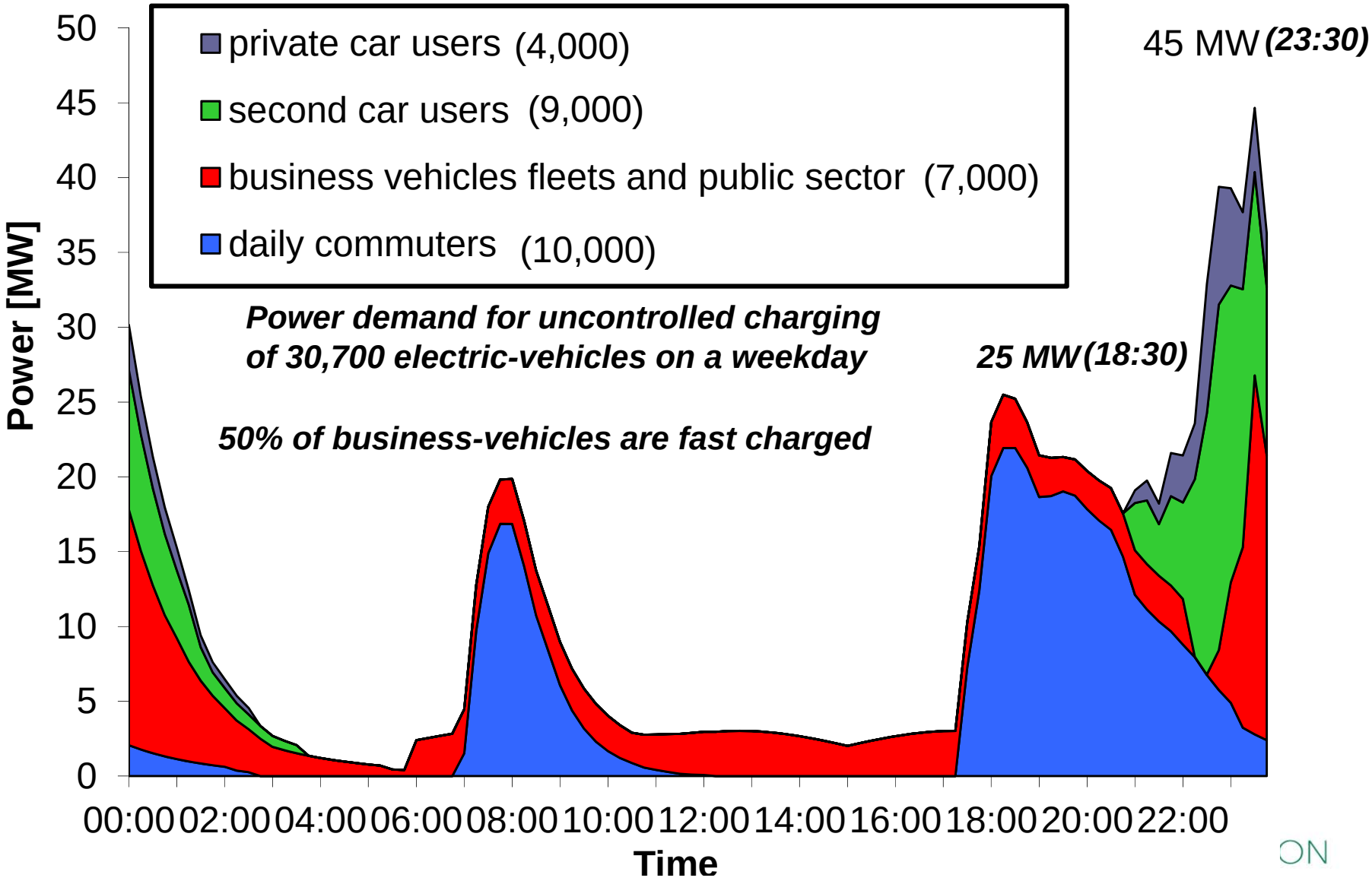
Power Demand for Charging 30,000 Electric-Vehicles



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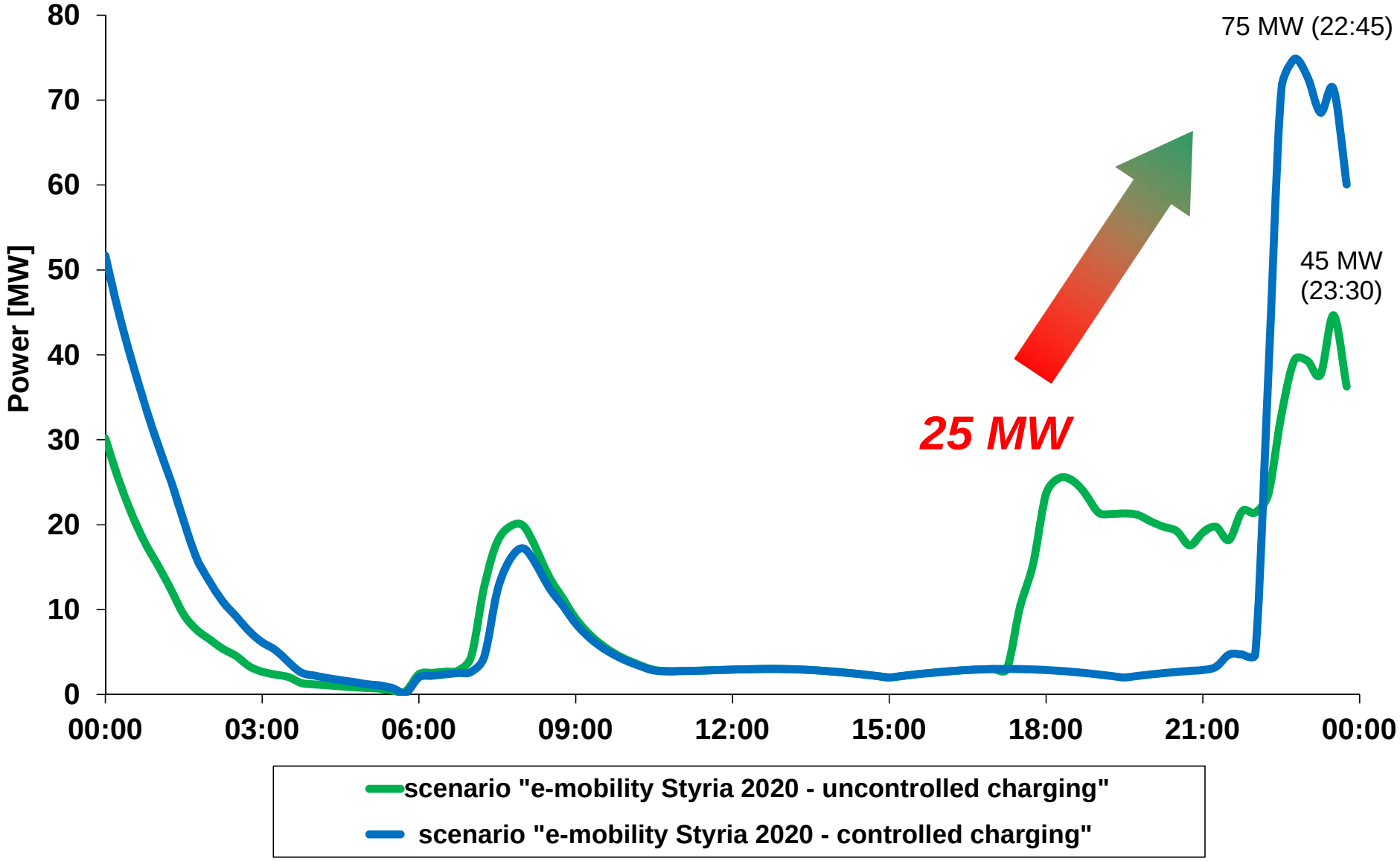
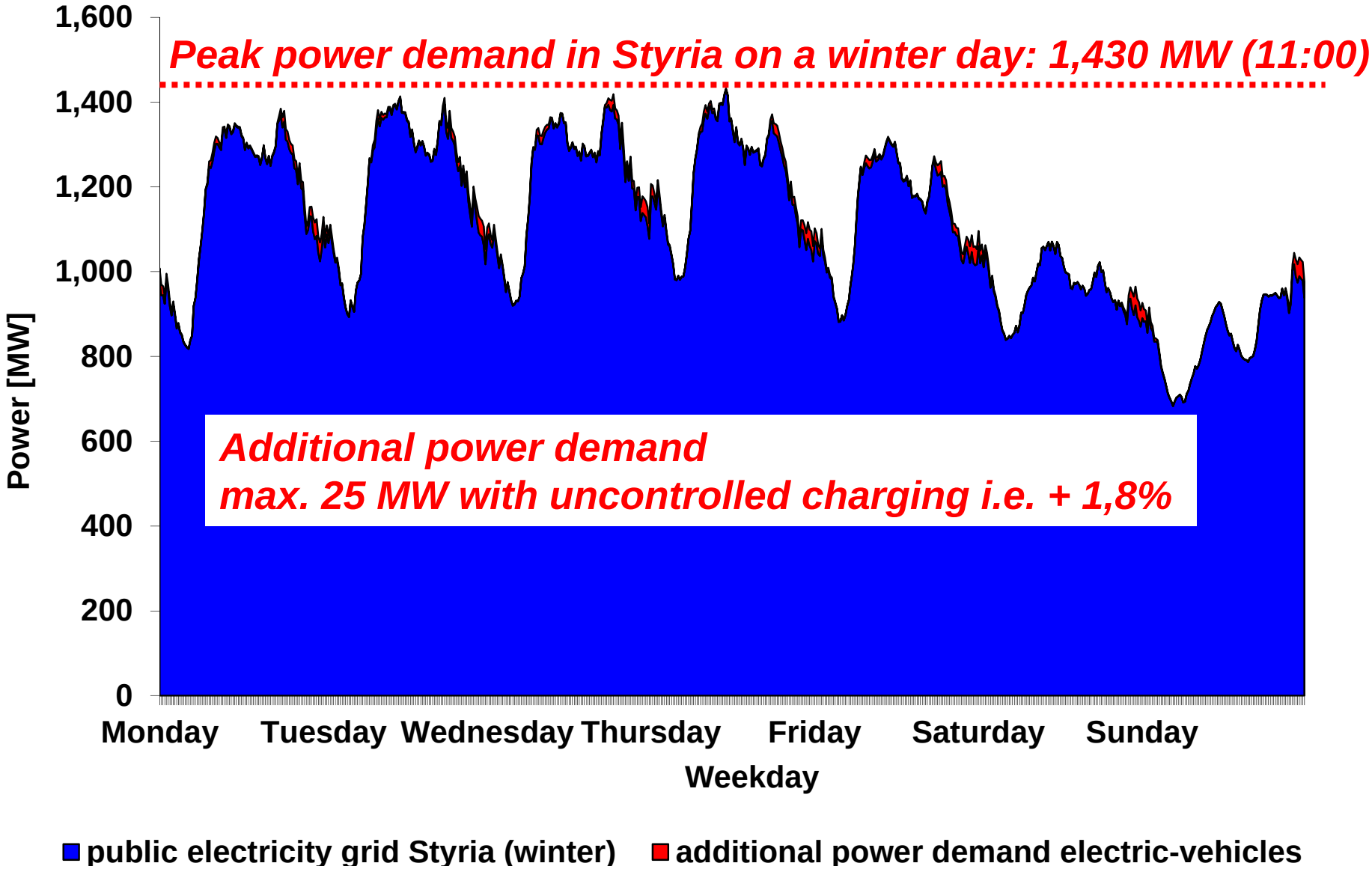
Power Demand for Charging 30,000 Electric-Vehicles



Power Demand During a Winter Week with 30,700 Electric-Vehicles



Technical Challenges – Charging Infrastructure in Cities

- Charging infrastructure necessary
- Long stay at charging point
- Legal aspects in public areas

© Ludwig-Bölkow-Systemtechnik GmbH

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Electric-Vehicles as Energy Storage – „Vehicle-to-Grid“

Pumping hydro plant Limberg II:
2 x 80 Mio. m³ water
75,000 MWh
Capacity: 2 x 240 MW

Battery electric vehicles:
Battery capacity: 24 kWh
3.1 Mio. vehicle necessary for same amount of electricity

New Infrastructure for fast loading/unloading necessary

Source: Brauner, TU-Wien, 2009

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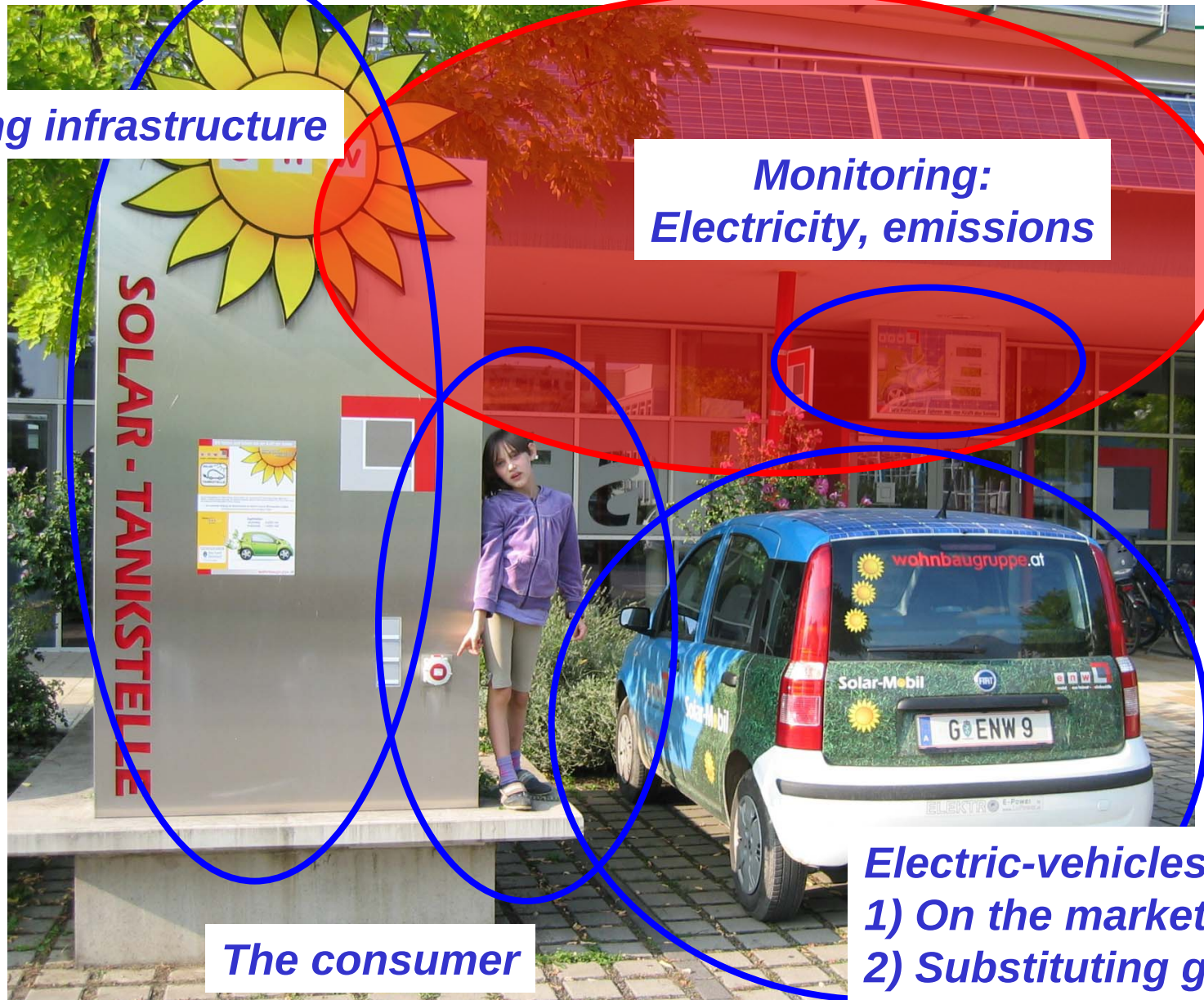
Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

Monitoring: Electricity, emissions

Additional renewable electricity

The consumer

Electric-vehicles
1) On the market available
2) Substituting gasoline&diesel

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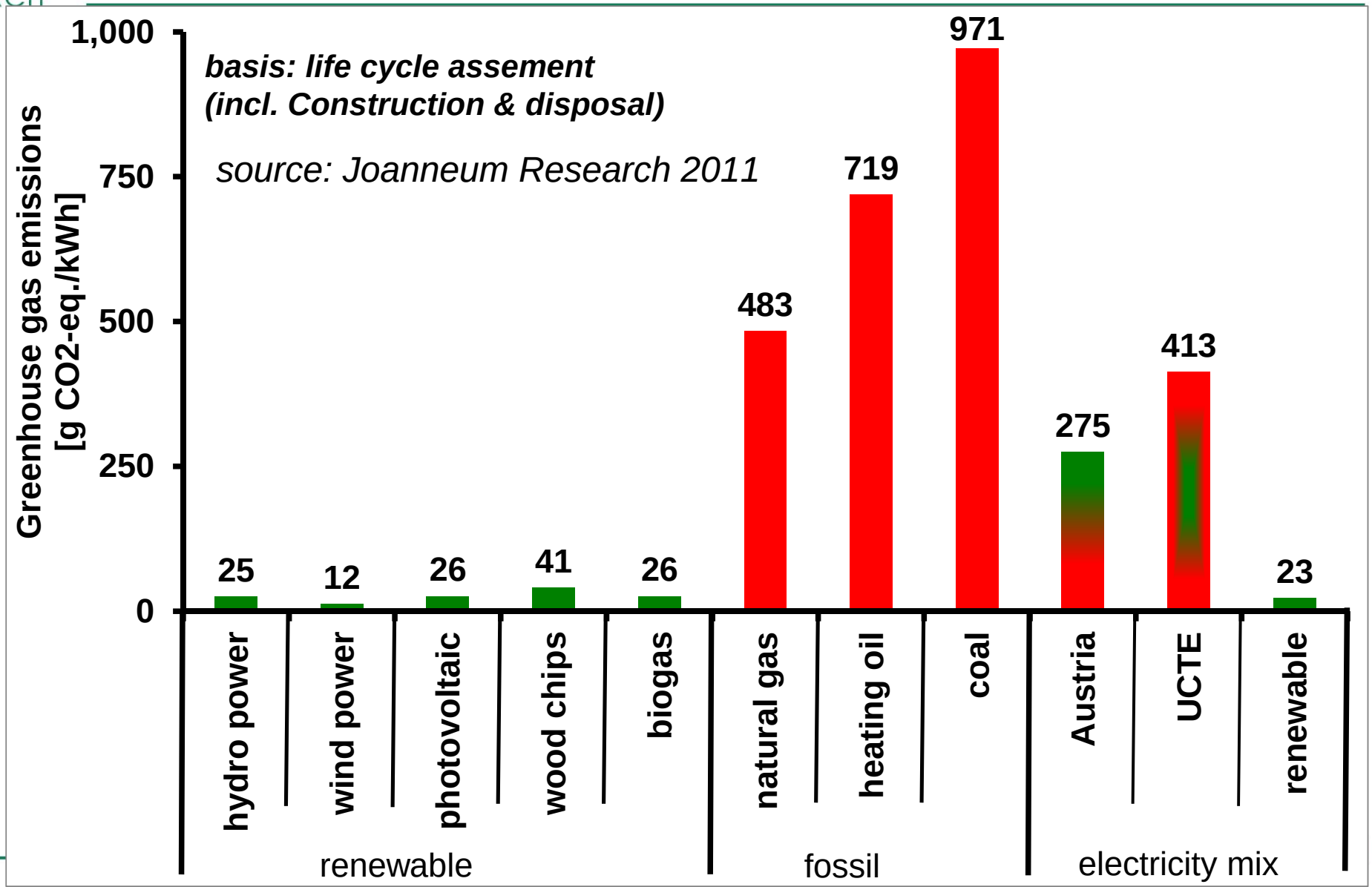
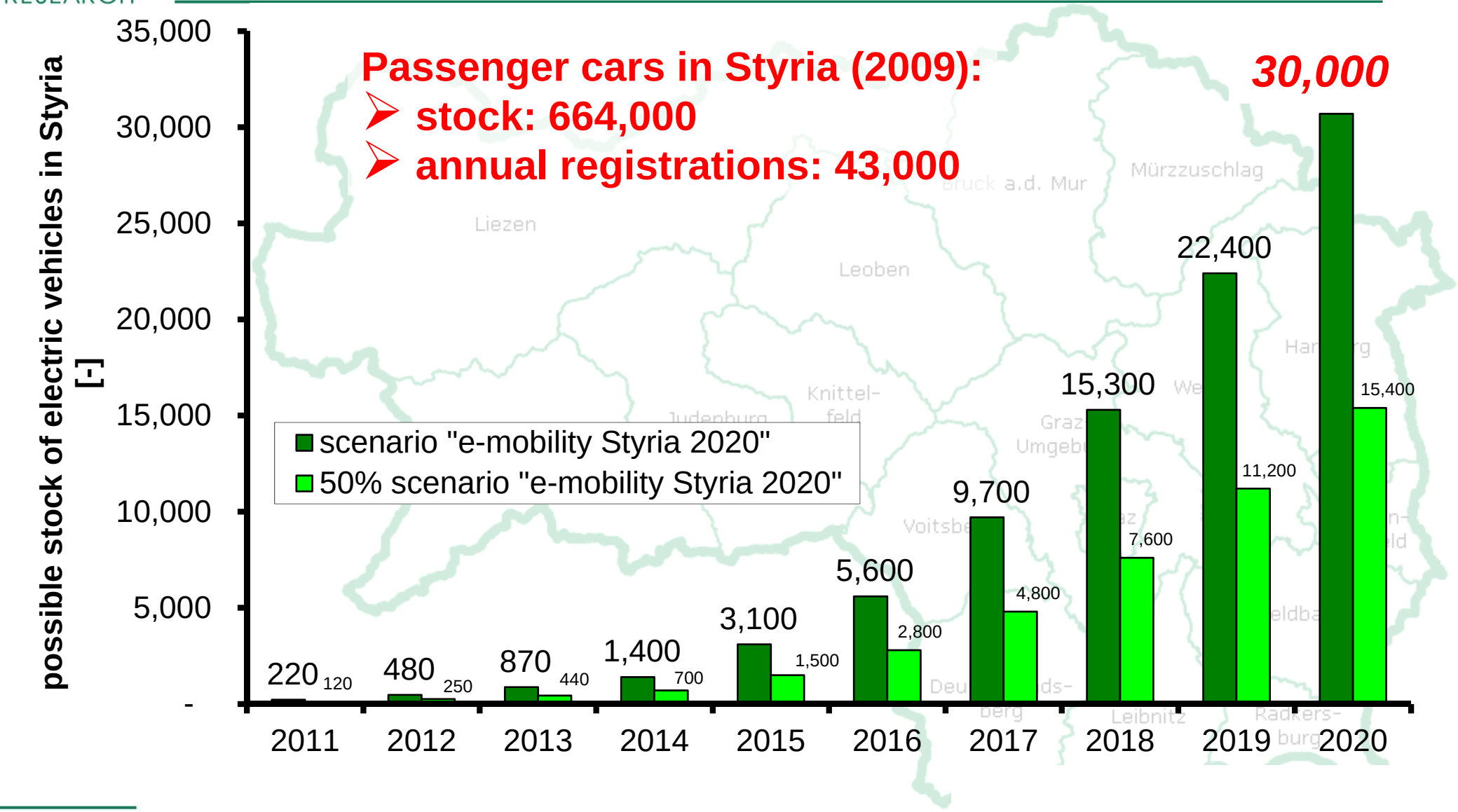
All Types of Electricity Generation have GHG-Emissions

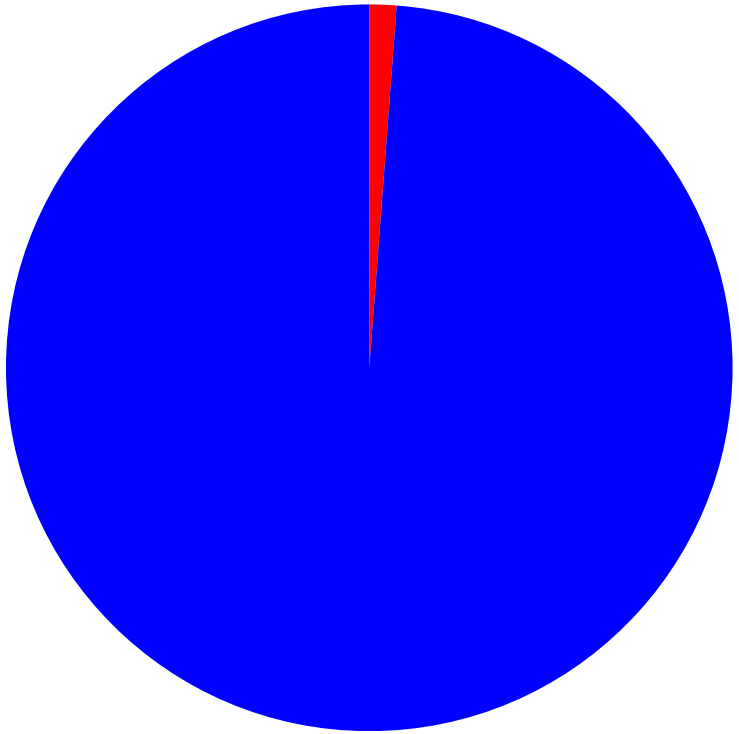


Number of Electric-Vehicles in Styria until 2020



Electricity Demand for Electric-Vehicles in 2020

Additional electricity demand for 30,000 electric-vehicles 1.2%



Electricity demand Styria (2009) 98.8%

- ✓ ***Styria: 8.300 GWh/a (30 PJ/a)***
- ✓ ***electric vehicles: 98 GWh/a***

- ✓ ***30.000 electric-vehicles are 5% of passenger car stock in Styria***

source: Joanneum Research 2011

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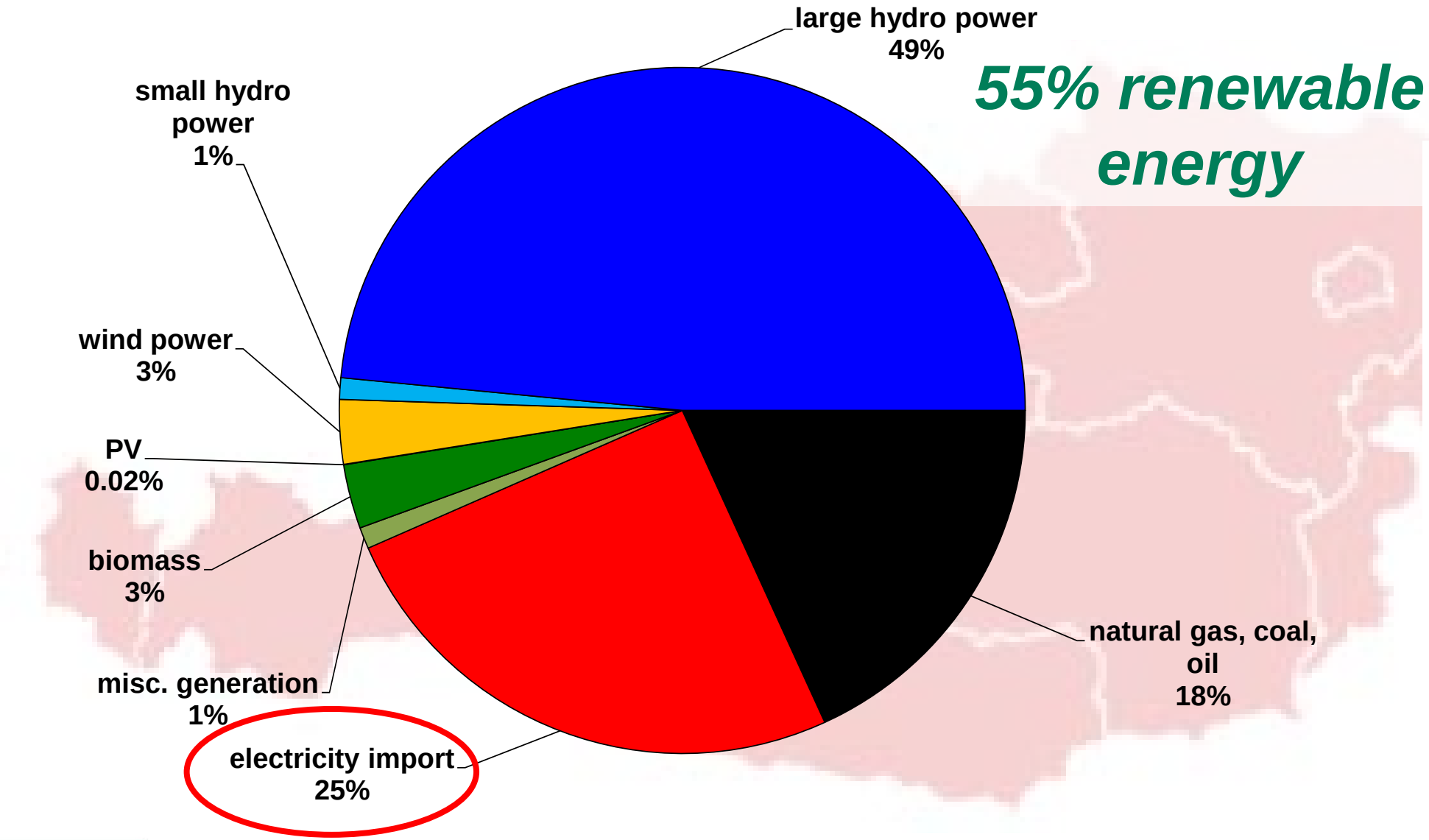
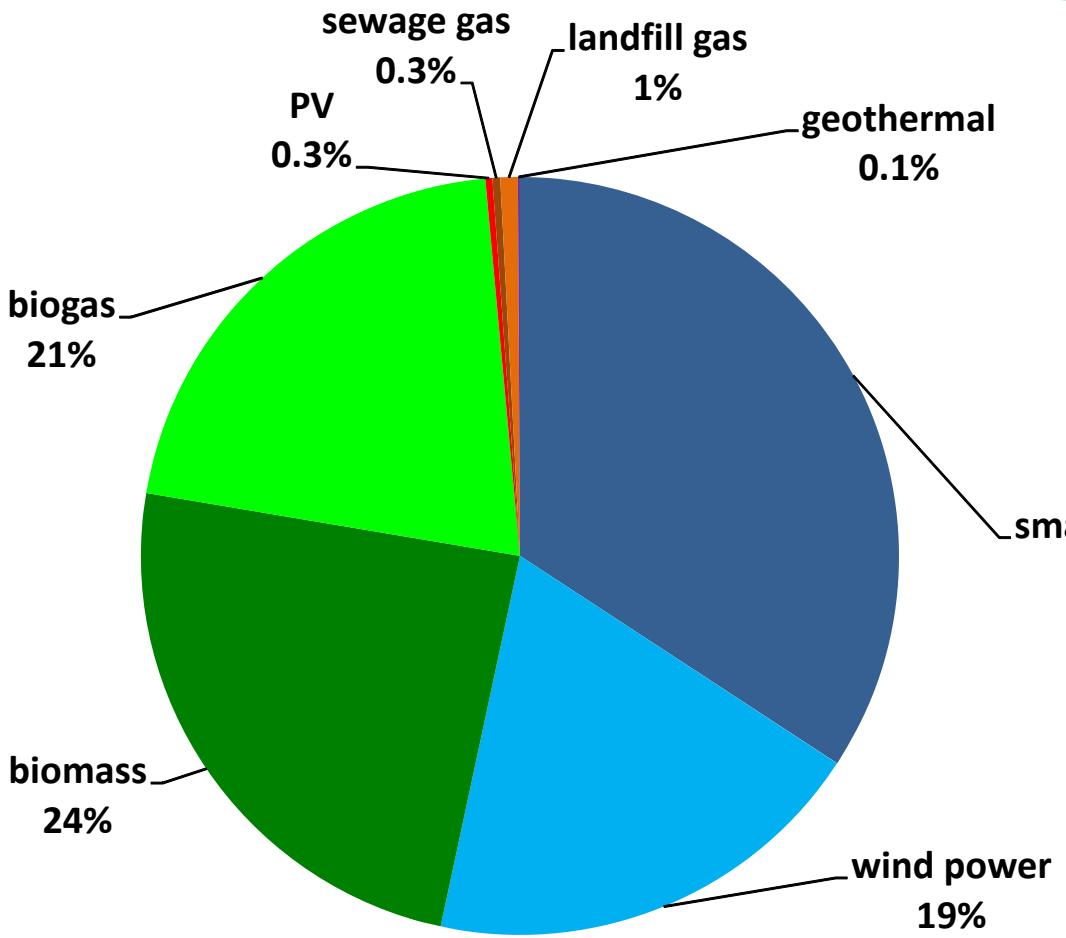
Electricity Mix in the Austrian Grid



55% renewable energy

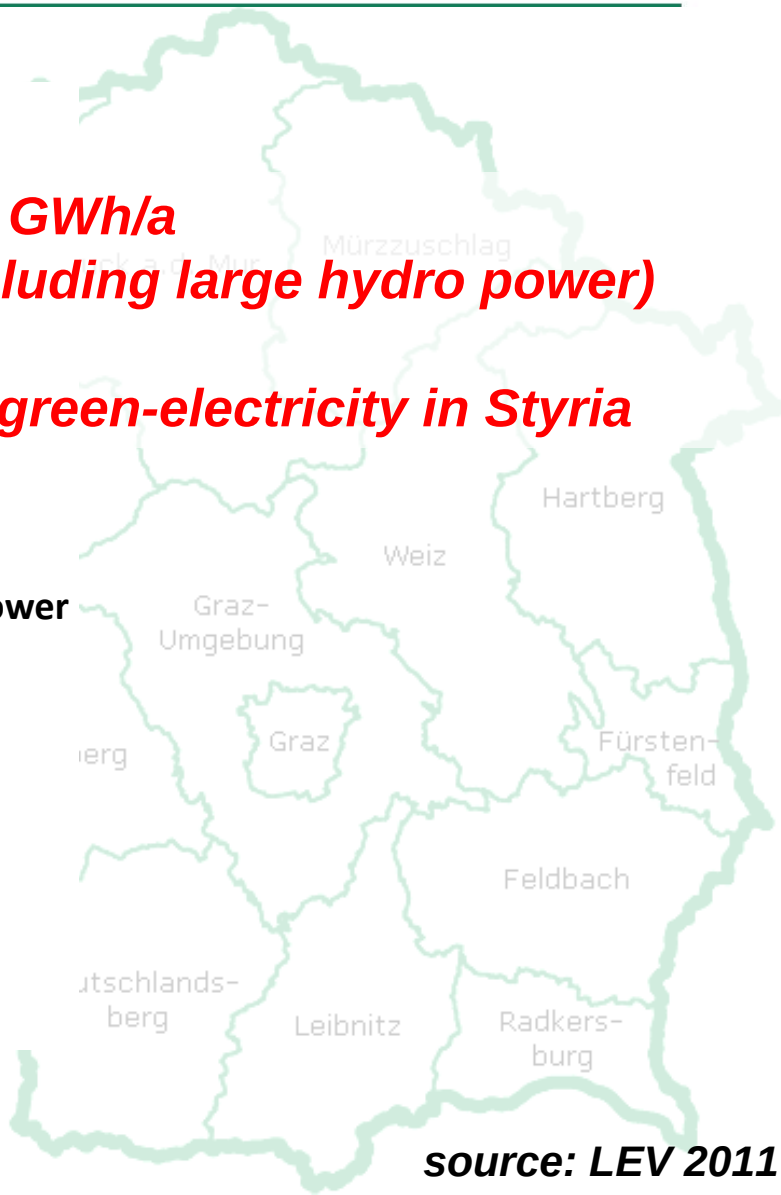
source: Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2009

Current Generation of Renewable Electricity in Styria



✓ *520 GWh/a*
(excluding large hydro power)

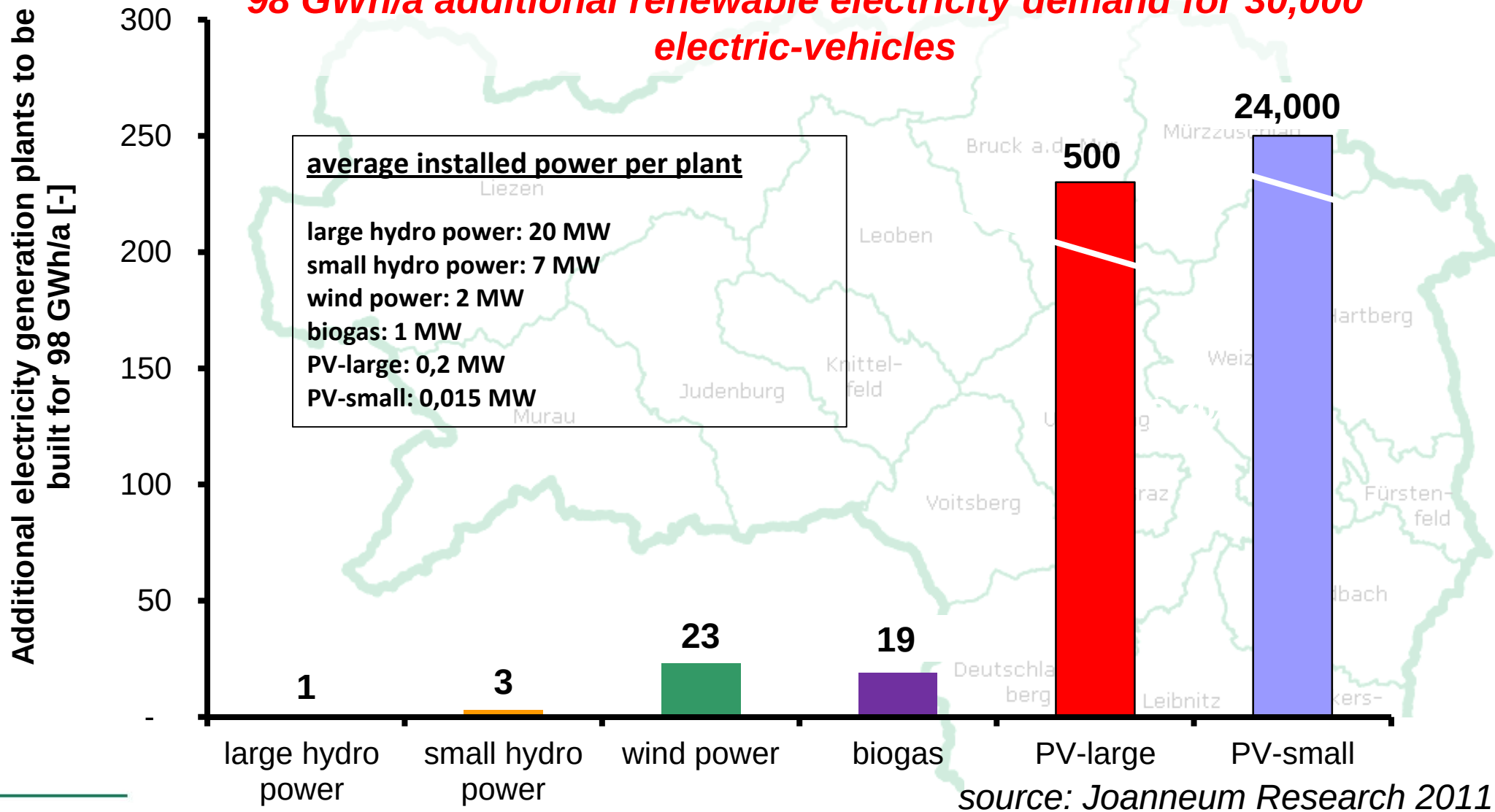
✓ *6% green-electricity in Styria*



source: LEV 2011

The Additional Electricity Generation should be....

98 GWh/a additional renewable electricity demand for 30,000 electric-vehicles



source: Joanneum Research 2011

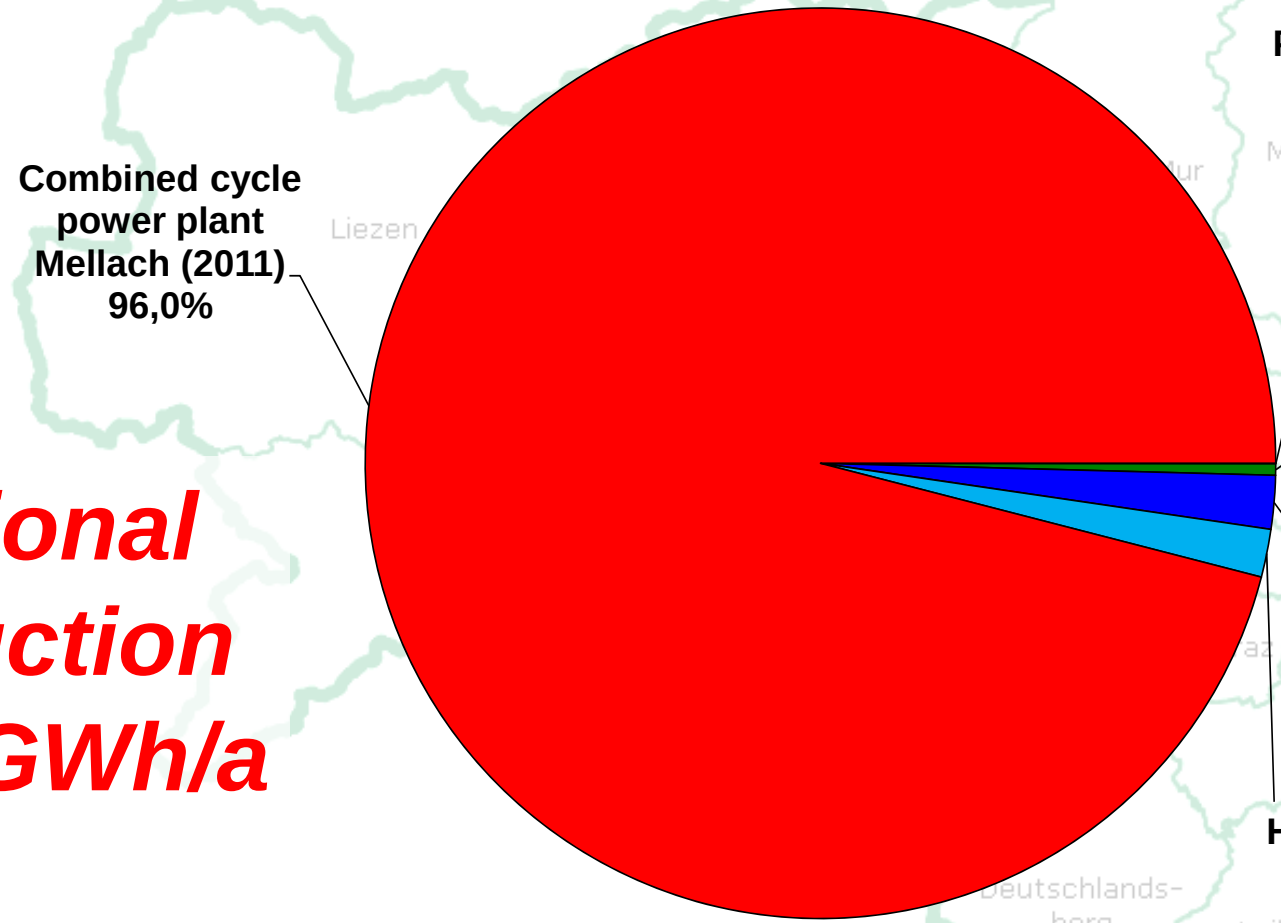
The Additional Electricity Generation will be…..

New power plants in Styria

Power plants under construction /planned	Power MW	Annual production GWh/a	Investement Mio. €
Hydro power plant Gössendorf (2012)	18,5	88,6	75 - 80
Hydro power plant Kalsdorf (2013)	18,8	81,2	75 - 80
Hydro power plant Graz (2015)	16,1	72,6	87
PV-plant Mureck (2011)	1	1	3,5 – 4,5
PV-stations subsidised by climate and energy fund (2011- 2015)	35	35	100 – 140
Combined cycle power plant - Mellach (2011)	832	4.500	550
Power plant Werndorf (2015)	580	3.000	

sources: Österreichs Energie (11/2010); PV assumptions

Additional Electricity Generation in Styria until 2013

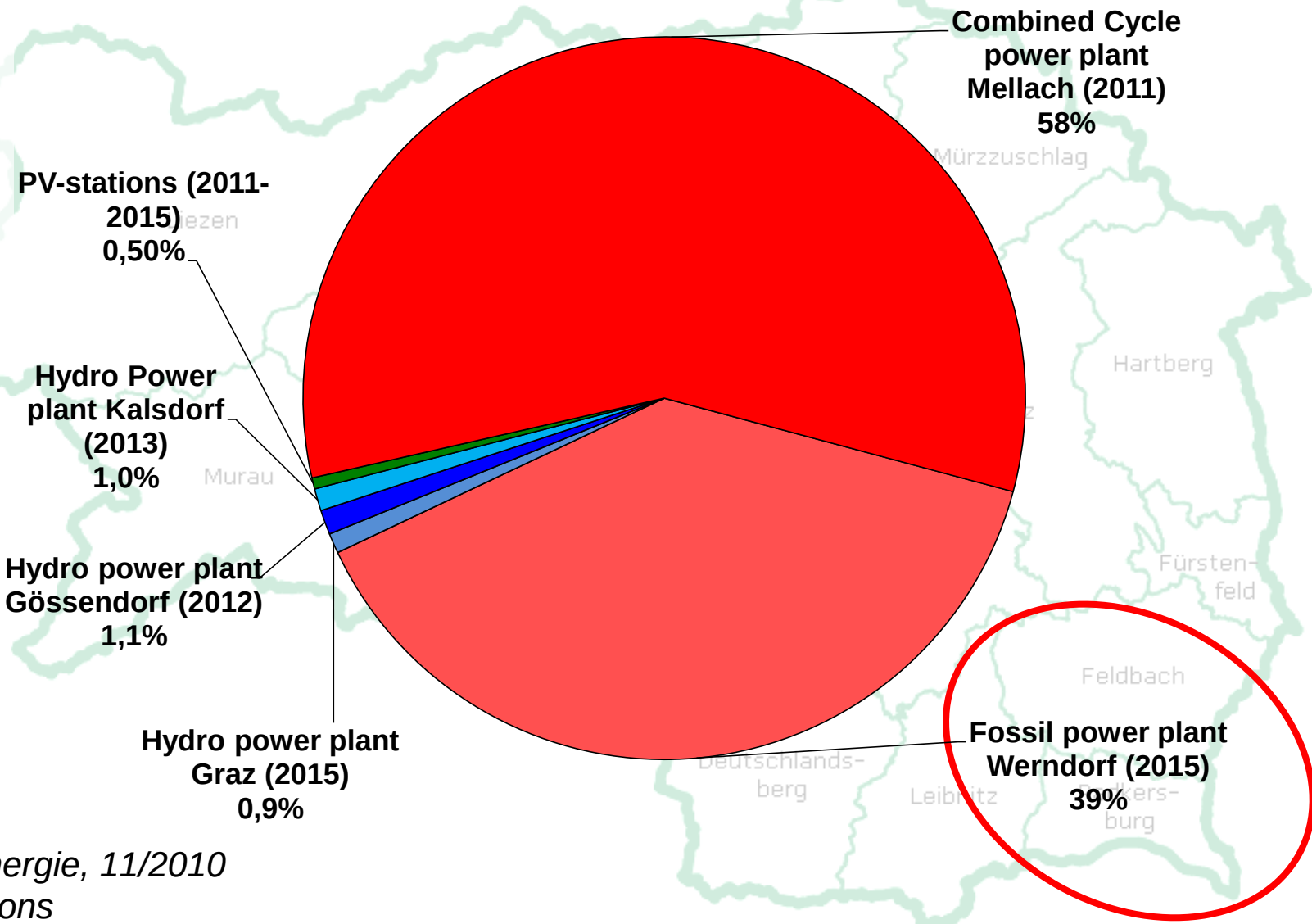


additional production 4,700 GWh/a

sources: Österreichs Energie, 11/2010
PV assumptions

Additional Electricity Generation in Styria until 2015

Additonal production 7,800 GWh/a, → 97% fossil



sources: Österreichs Energie, 11/2010
PV assumptions

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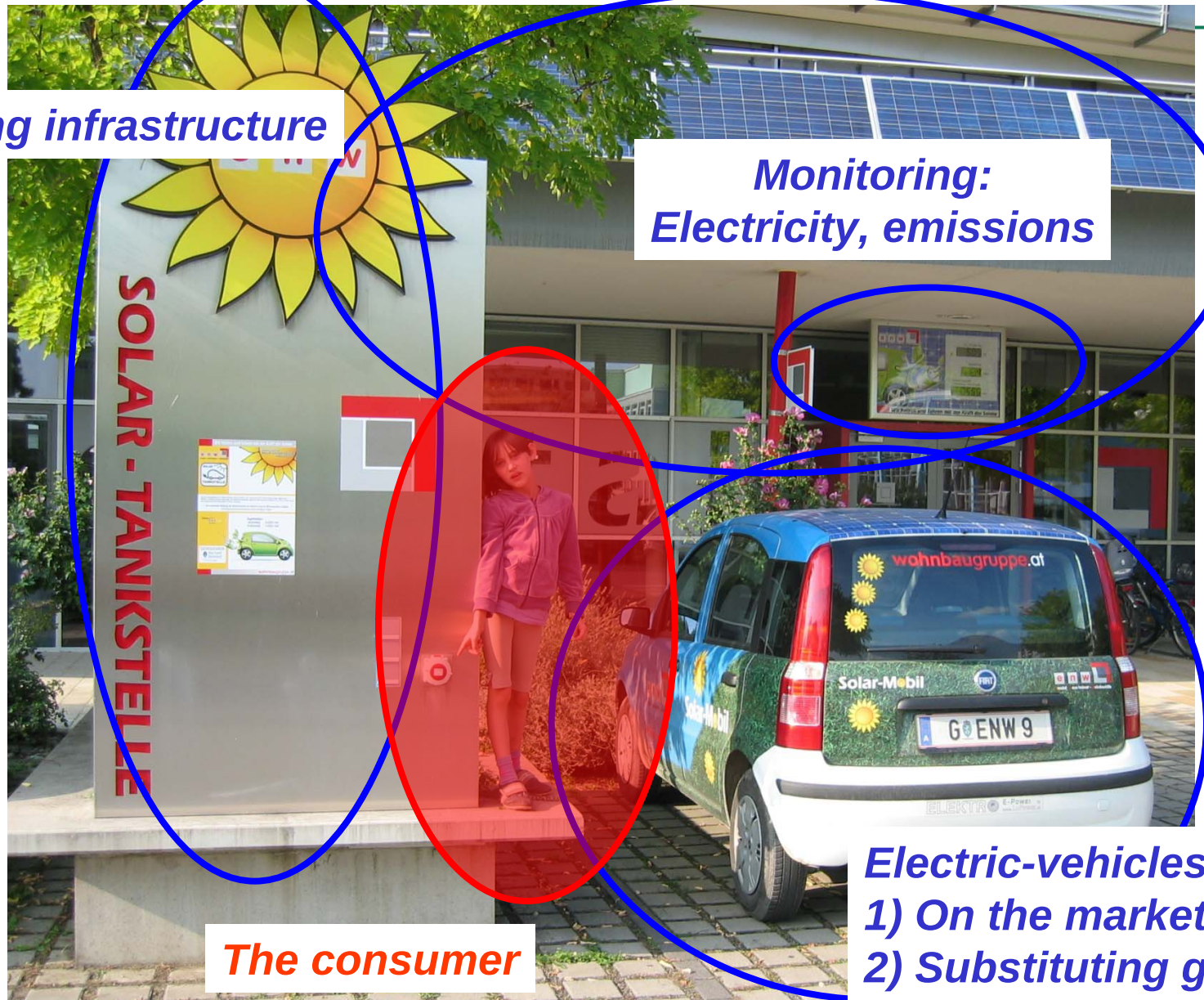
Challenges for the Successful Market Introduction of Electric-Vehicles



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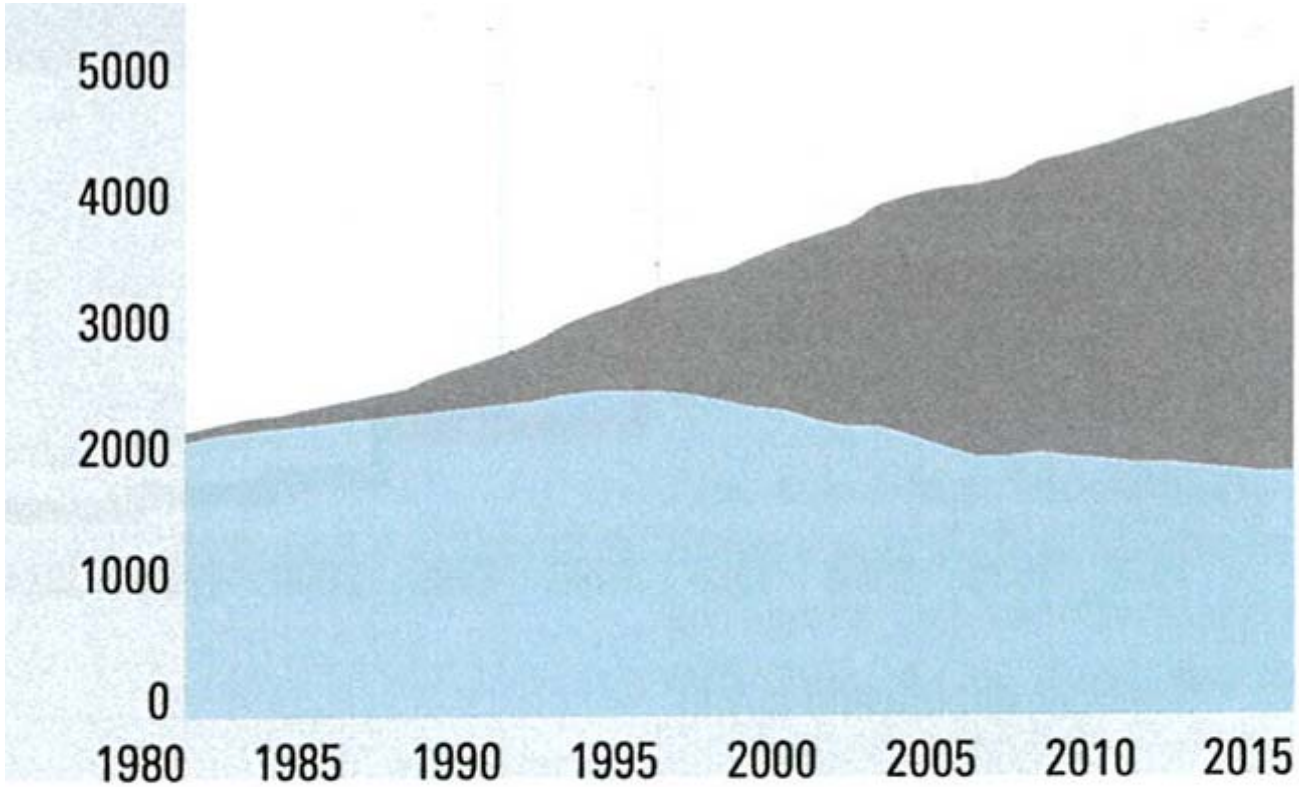
Development of Passenger Cars in Austria



	1980 [in 1000]	2005 [in 1000]	2015 [in 1000]
PKW-Diesel	78	2.540	2.999
PKW-Benzin	2.147	1.980	1.876
Summe	2.225	4.520	4.875

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IS TRADITION

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The Electric-Mobilty started already long time ago…..

..and is now going to be continued on 2 and 4 wheels……

www.joan

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…and initially on 2 wheels...

Elektrisch unterwegs zu neuen Erfolgen: Mag. Peter Engert (Sprecher der Geschäftsführung Raiffeisen Leasing GmbH), Mag. Dr. Eveline Steinberger-Kern (Geschäftsführerin green minds), DI Thomas Raffeiner MBA (Partner The Advisory House), Mag. Hans Lukits (Vorstandssprecher Bewag), Sigi Kämmerer (Pressesprecher Salzburg AG) und Kai Karring, MSBA (Geschäftsführer Mobility House) – v.l.n.r.

The Mobility House goes Europe

Königsdisziplin E-Mobilität

Quelle: VEÖ 01/2010

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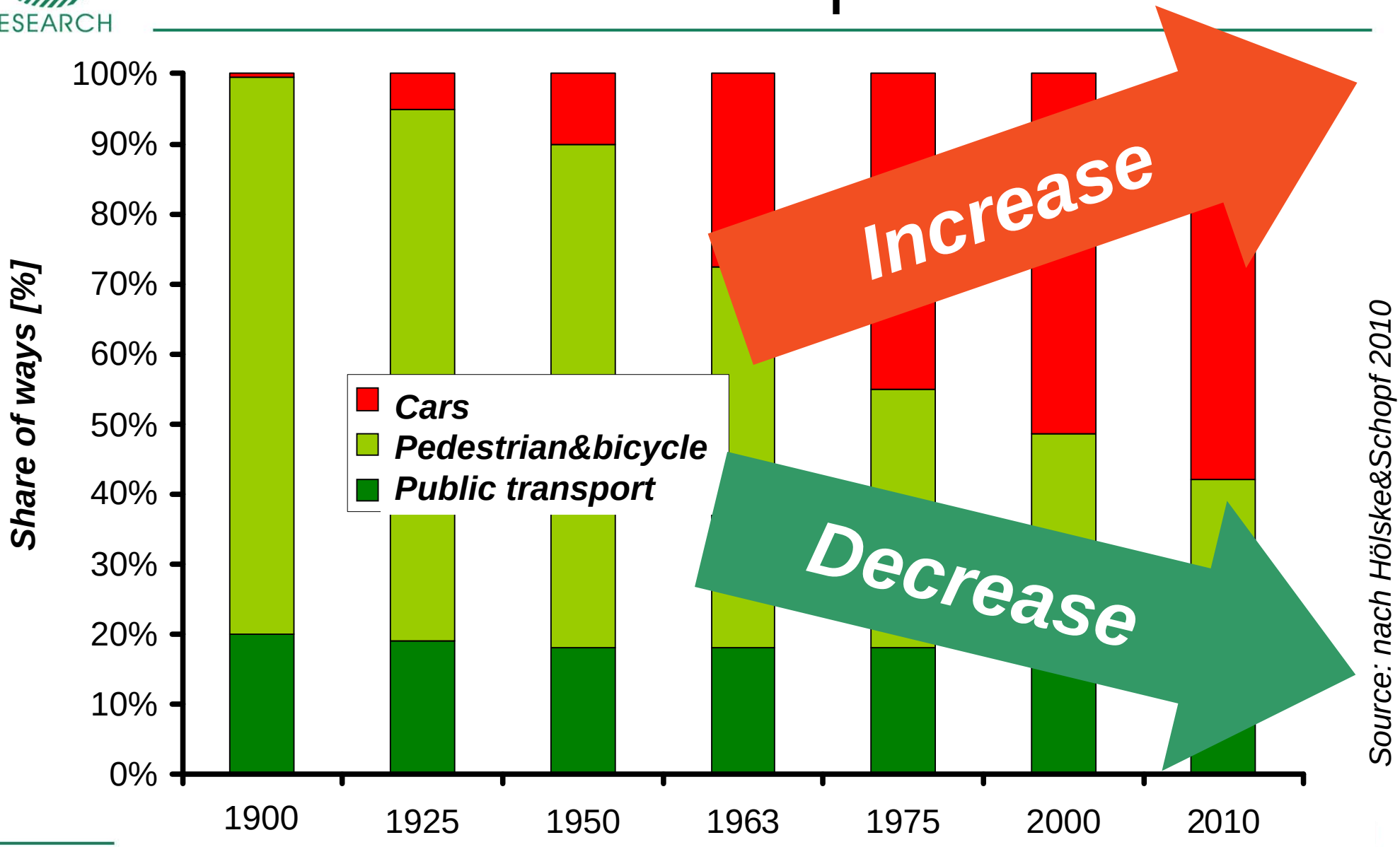
Development of Shares of Transportation Means



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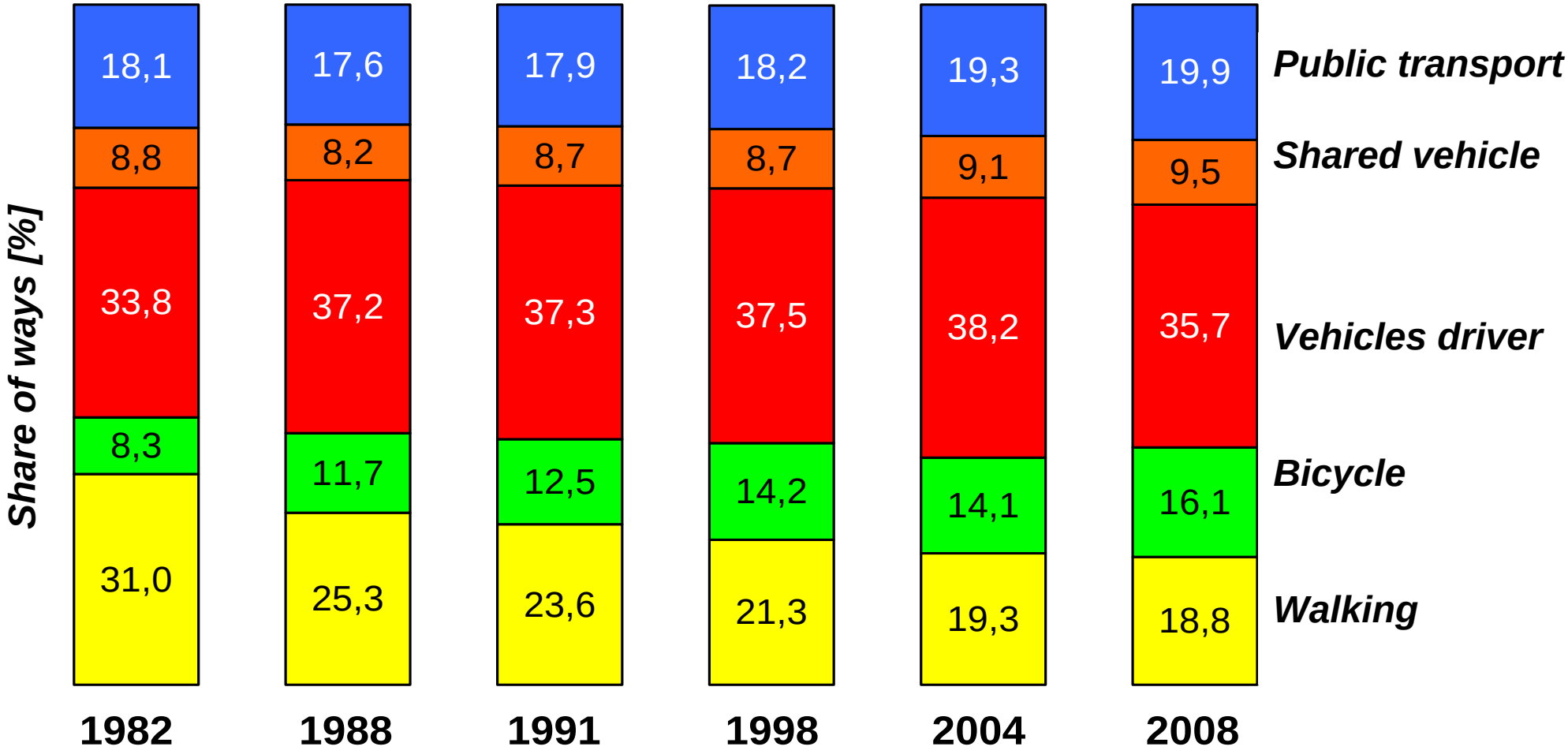
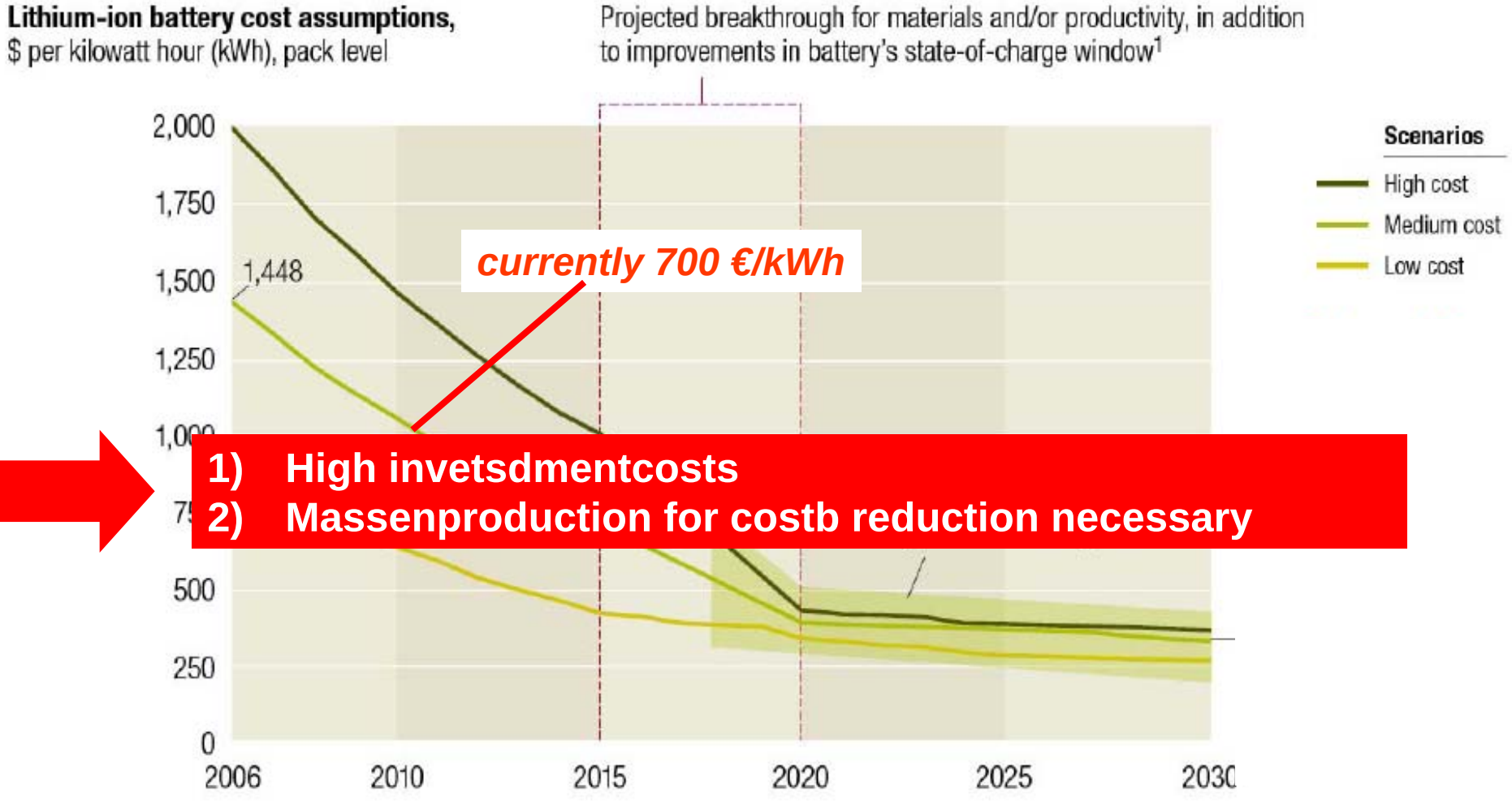
Graz: Analyses of Share of Ways 1982 - 2008



Stadt GRAZ Verkehrsplanung

Expected costs of battery development



Cost of „Small Passenger Car“: Example Mitsubishi

technical data	Mitsubishi Colt 1.1 - gasoline 	Mitsubishi MiEv - electric 
tare weight	935 kg	1.110 kg
power	55 kW	49 kW
consumption	5,4 l/100km	17 kWh/100km
range (max)	800 km	150 km
cost incl. Taxes	8,999 €	35,900 €
battery leasing	-	-
energy costs	1,35 €/l	0,20 €/kWh
mileage	10.000 km/Jahr	10.000 km/a
maintenance	400 €/a	220 €/a
insurance	600 €/a	250 €/a
rate of interest	5 %/a	5 %/a

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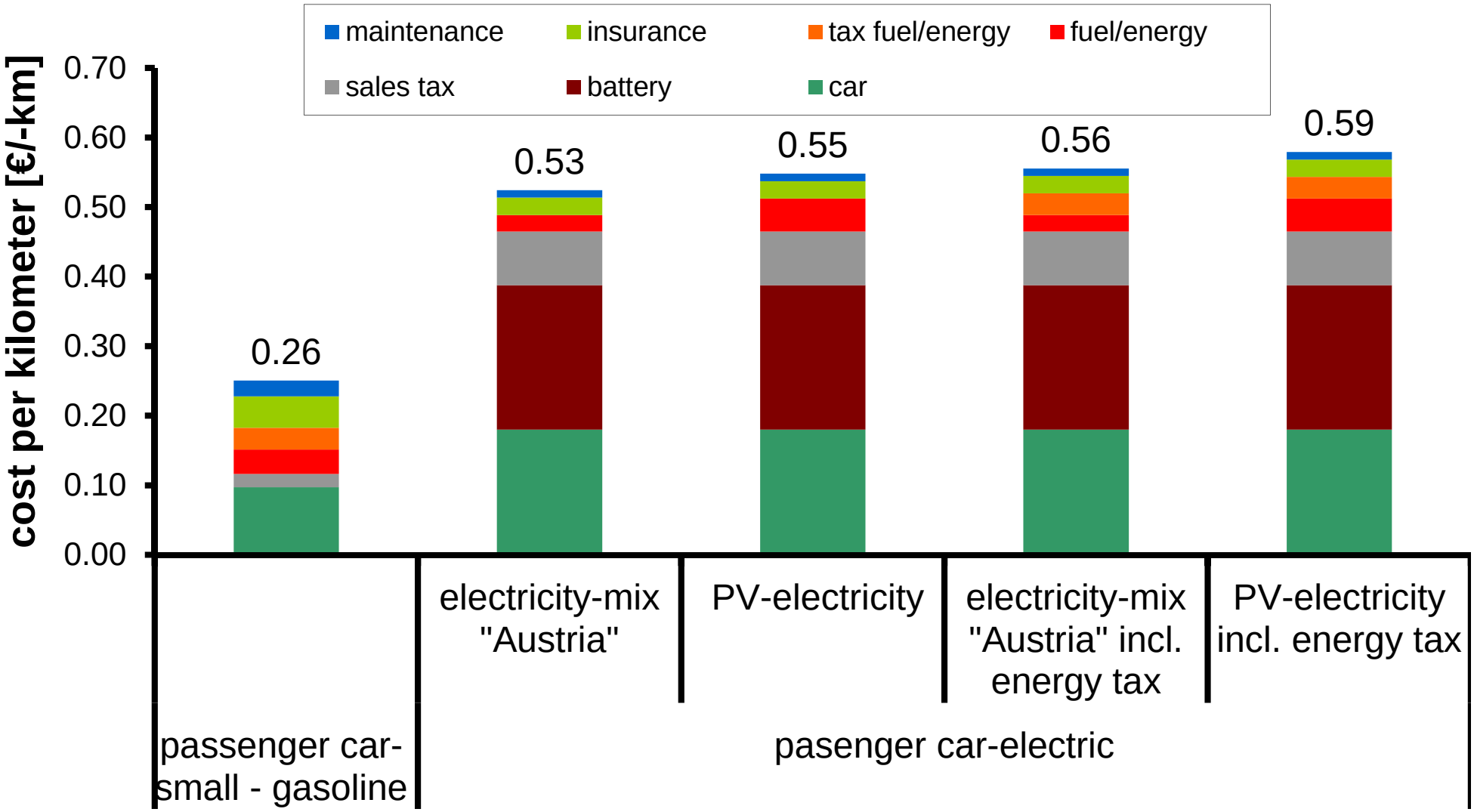
Possible Costs of Transportation Service of a Small Passenger Car



Cost of „Middle Class Passenger Car“: Example Renault

technical data	Renault Fluence 1.6 16V - gasoline 	Renault Fluence Z.E. - electric 
tare weight	1.265 kg	1.610 kg
power	81 kW	70 kW
consumption	6,7 l/100km	25 kWh/100km
range (max)	900 km	180 km
cost incl. Taxes	19,990 €	26,400 €
battery leasing	-	79 €/month
energy costs	1,35 €/l	0,20 €/kWh
mileage	10.000 km/a	10.000 km/a
maintenance	400 €/a	220 €/a
insurance	600 €/a	250 €/a
rate of interest	5 %/a	5 %/a

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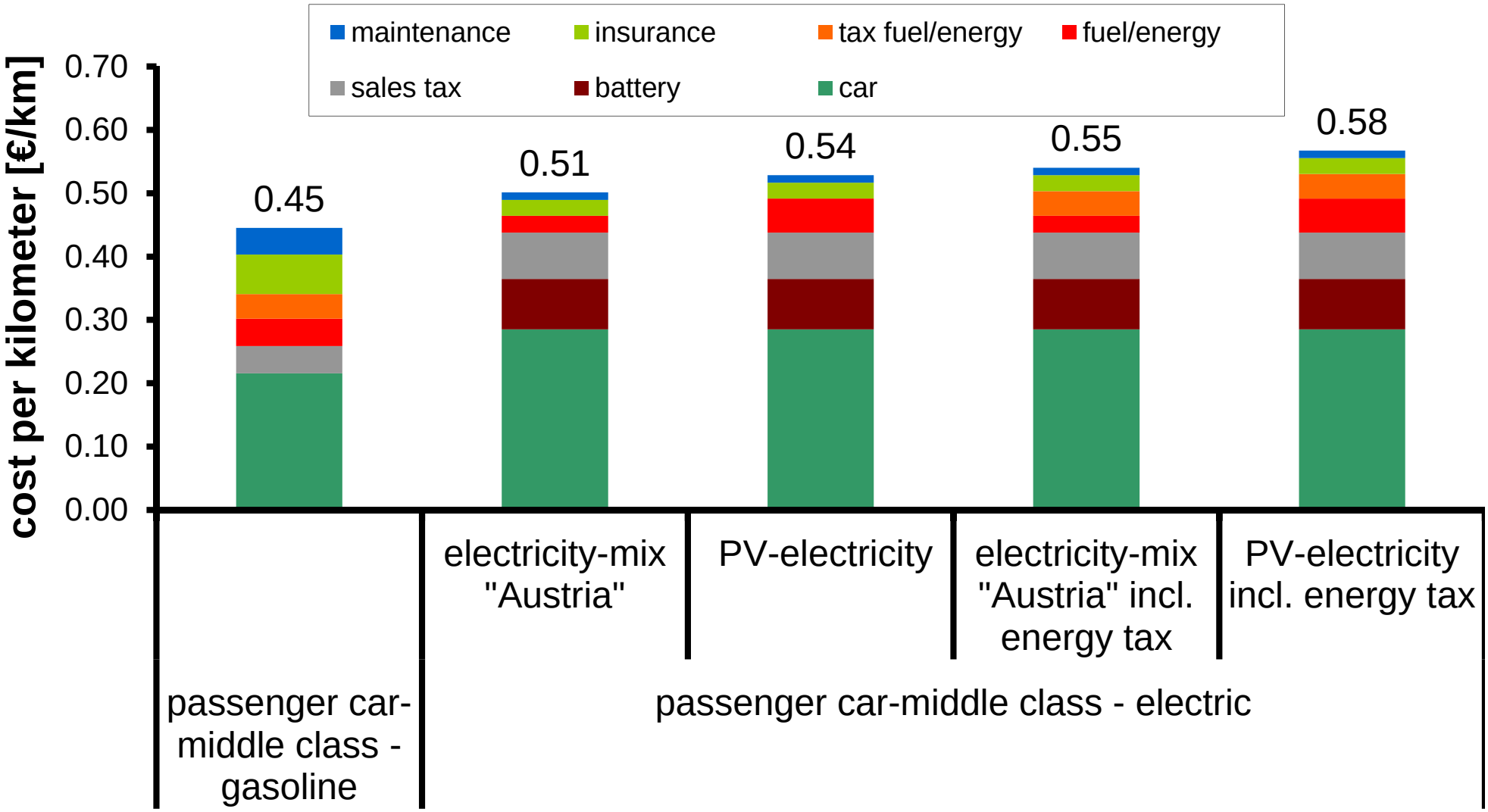
Possible Costs of Transportation Service of a Middle Class Passenger Car



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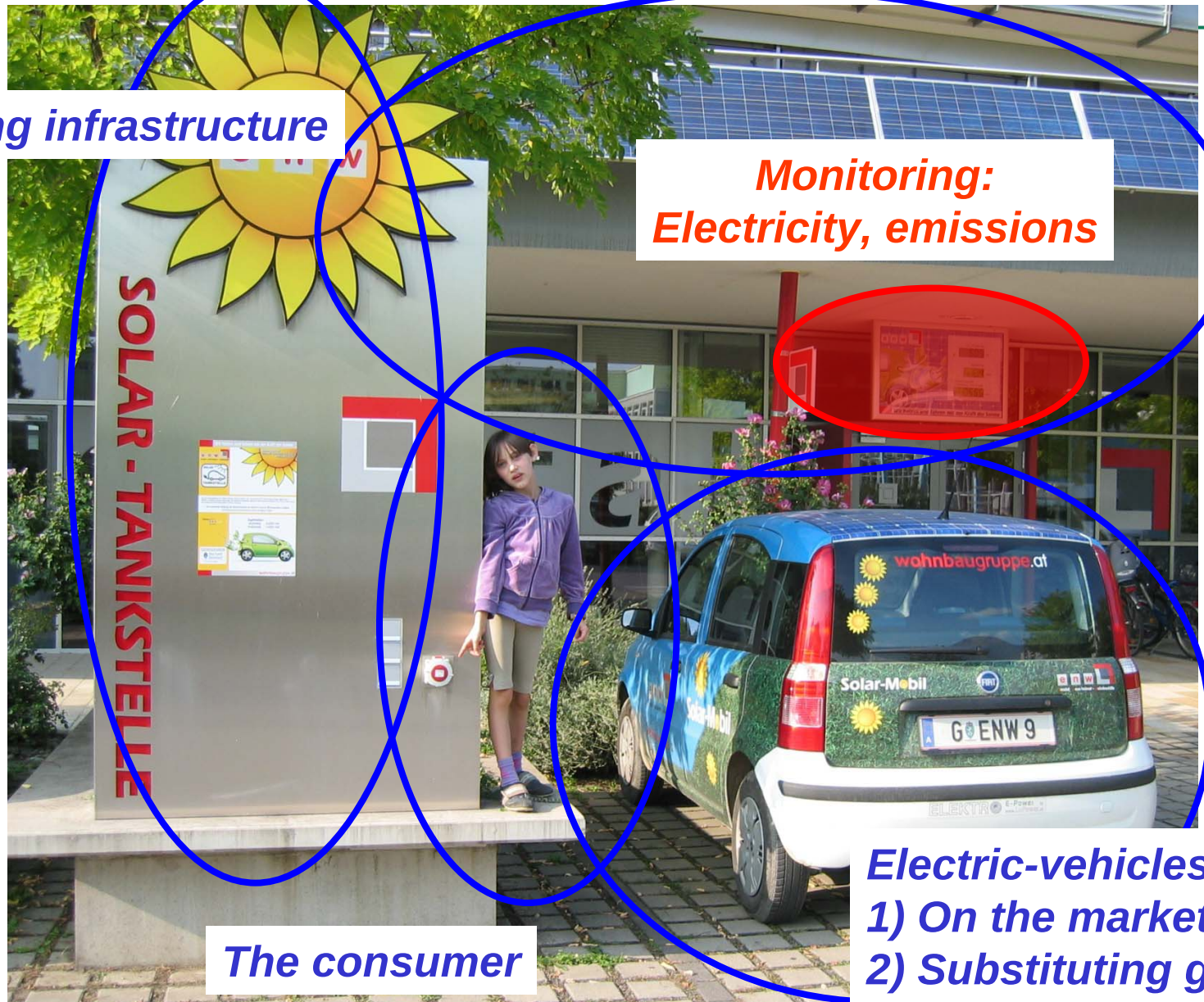
Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

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Life Cyle Assessment of Electric Vehicles

Primary Energy

Electricity production

Electricity grid

Charging infrastructure

Production of vehicle

Production of battery

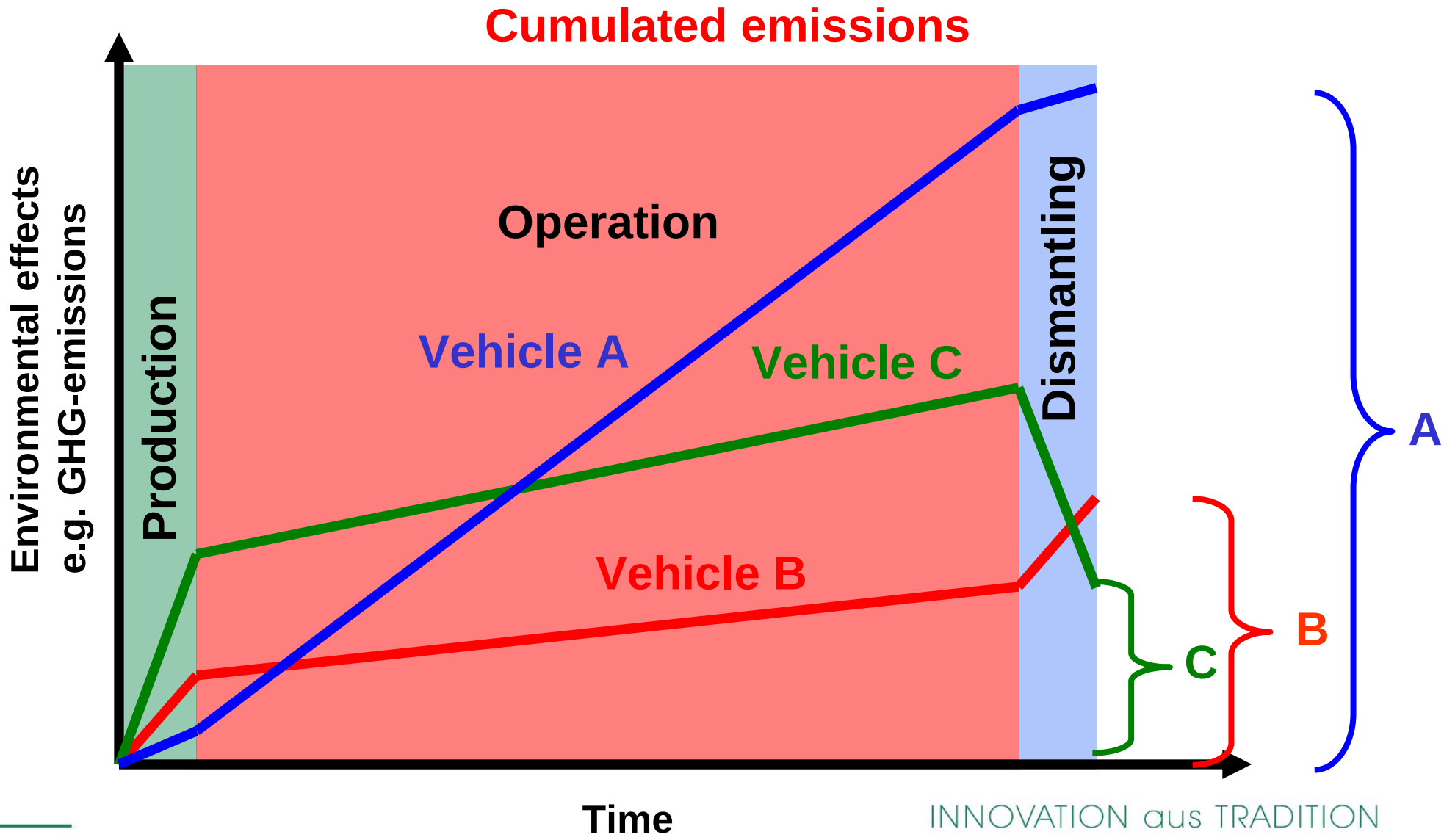
Electric vehicle

„End of life management“ Dismantling of vehicle

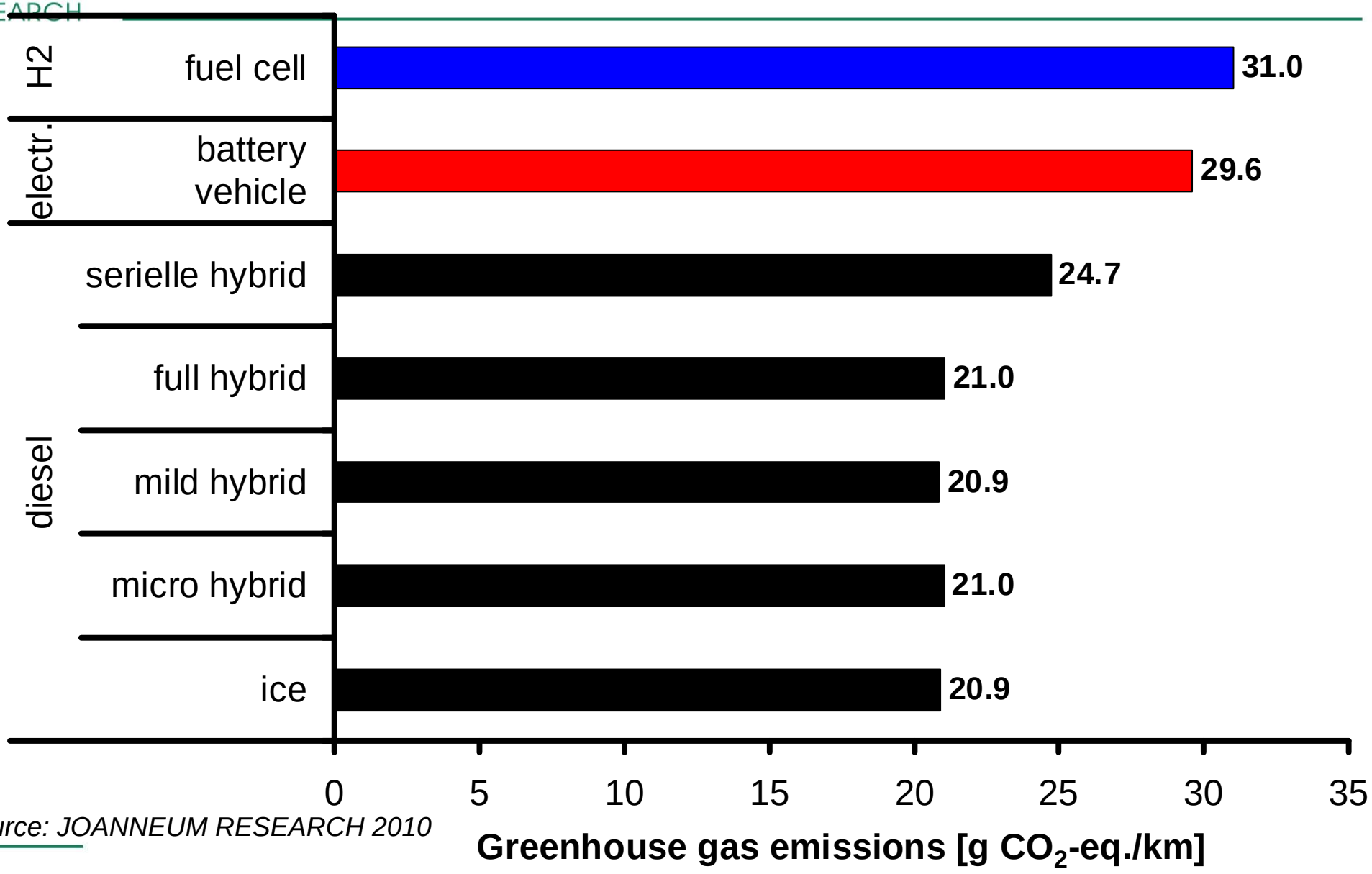
Transportation service

JOANNEUM RESEARCH

The Three Phases in the Life Cycle of A Vehicle

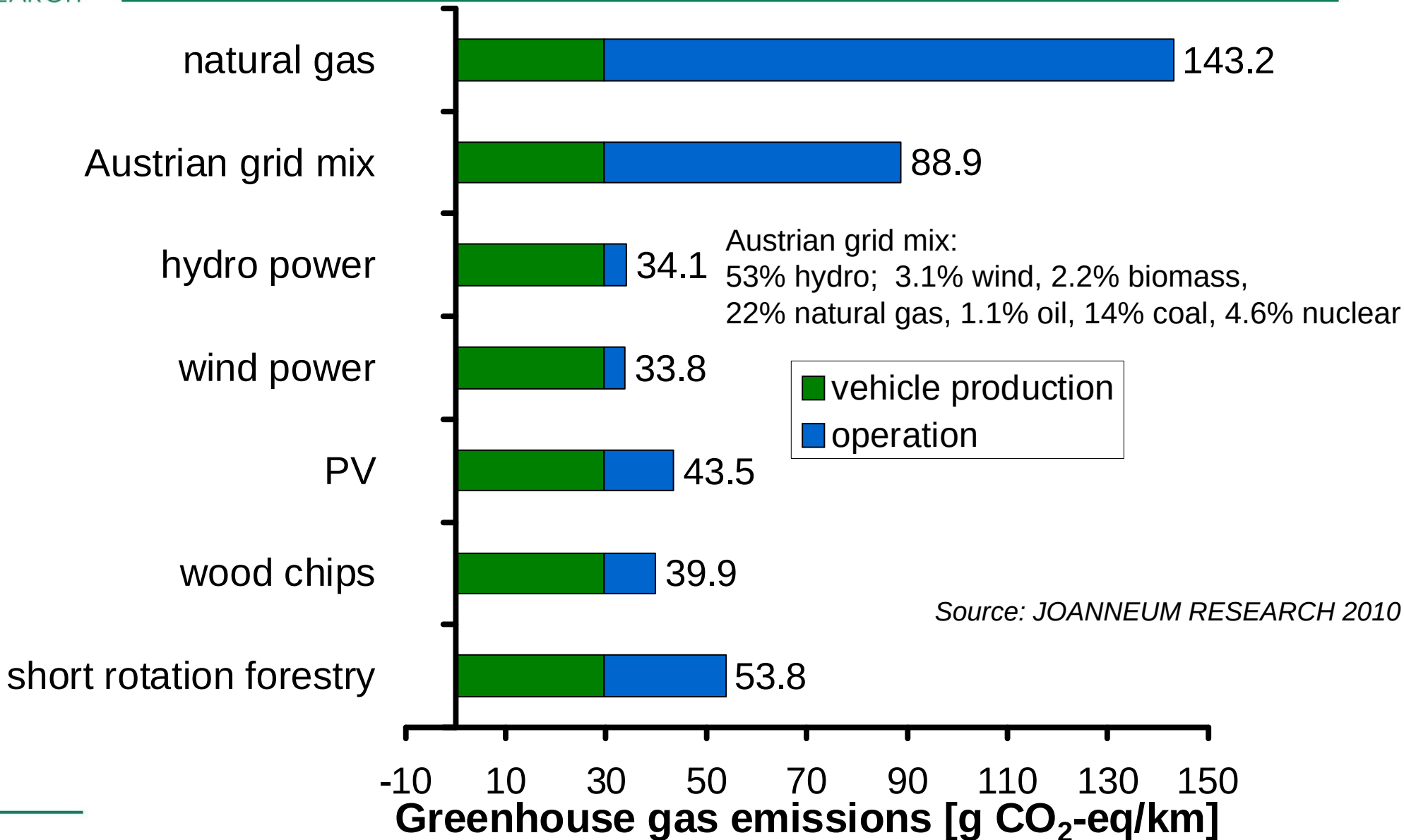


Greenhouse Gas Emissions of Vehicle Production

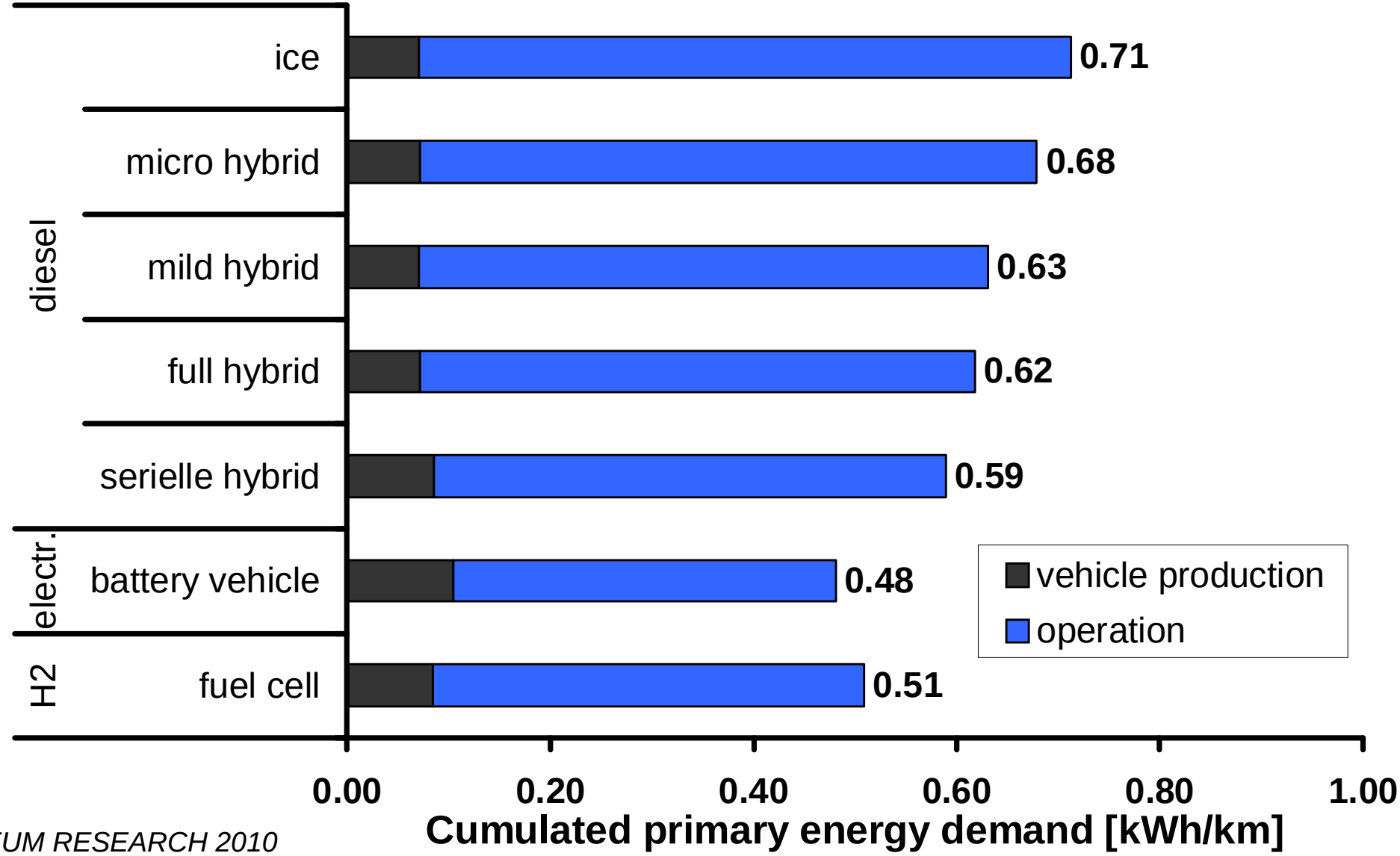


Source: JOANNEUM RESEARCH 2010

Greenhouse Gas Emissions of Electric Battery Vehicle

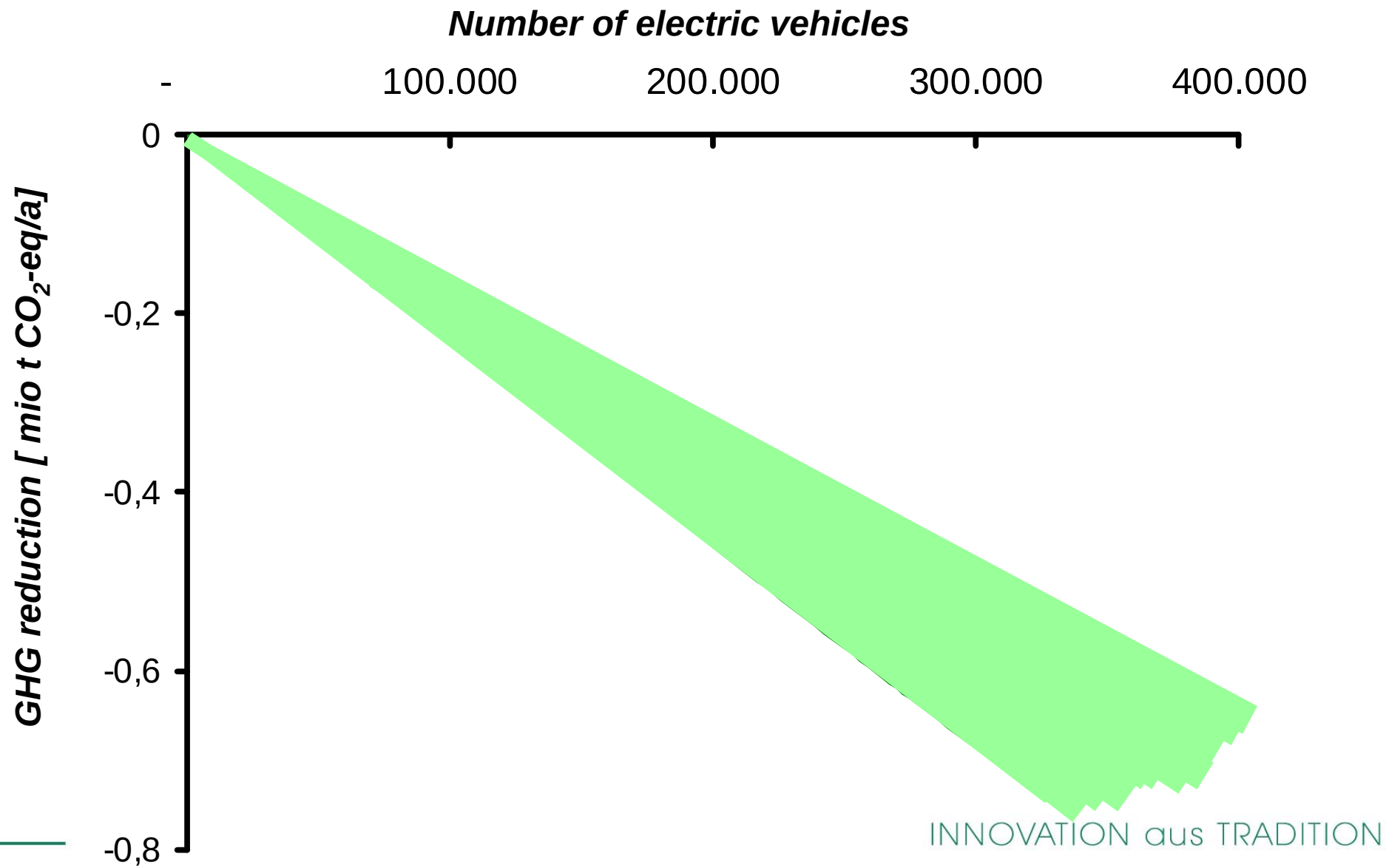


Cumulated Energy Demand of Vehicle Production



Source:
JOANNEUM RESEARCH 2010

The possible GHG reduction until 2020



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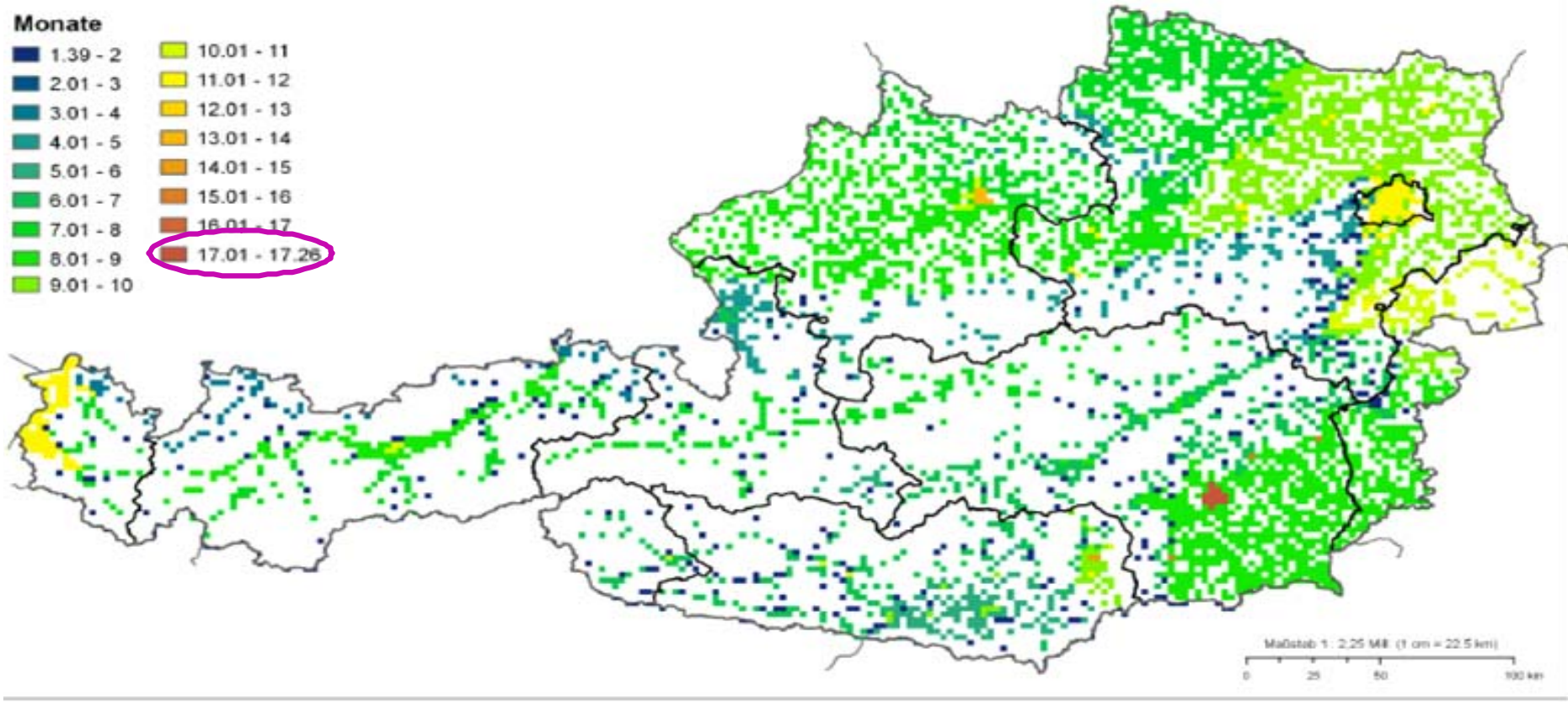
PM10 Immission in Austria – Reduction of life time expectation



Raumeinheiten: Bundesländer (Gebietsstand 1.1.2005)

Quelle: Bundesamt für Eich- und Vermessungswesen (BEV), Statistik Austria
Bearbeitung: Kompetenzzentrum Geografische Informationssysteme; Dez. 2006

umweltbundesamt®

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INNOVATION aus TRADITION

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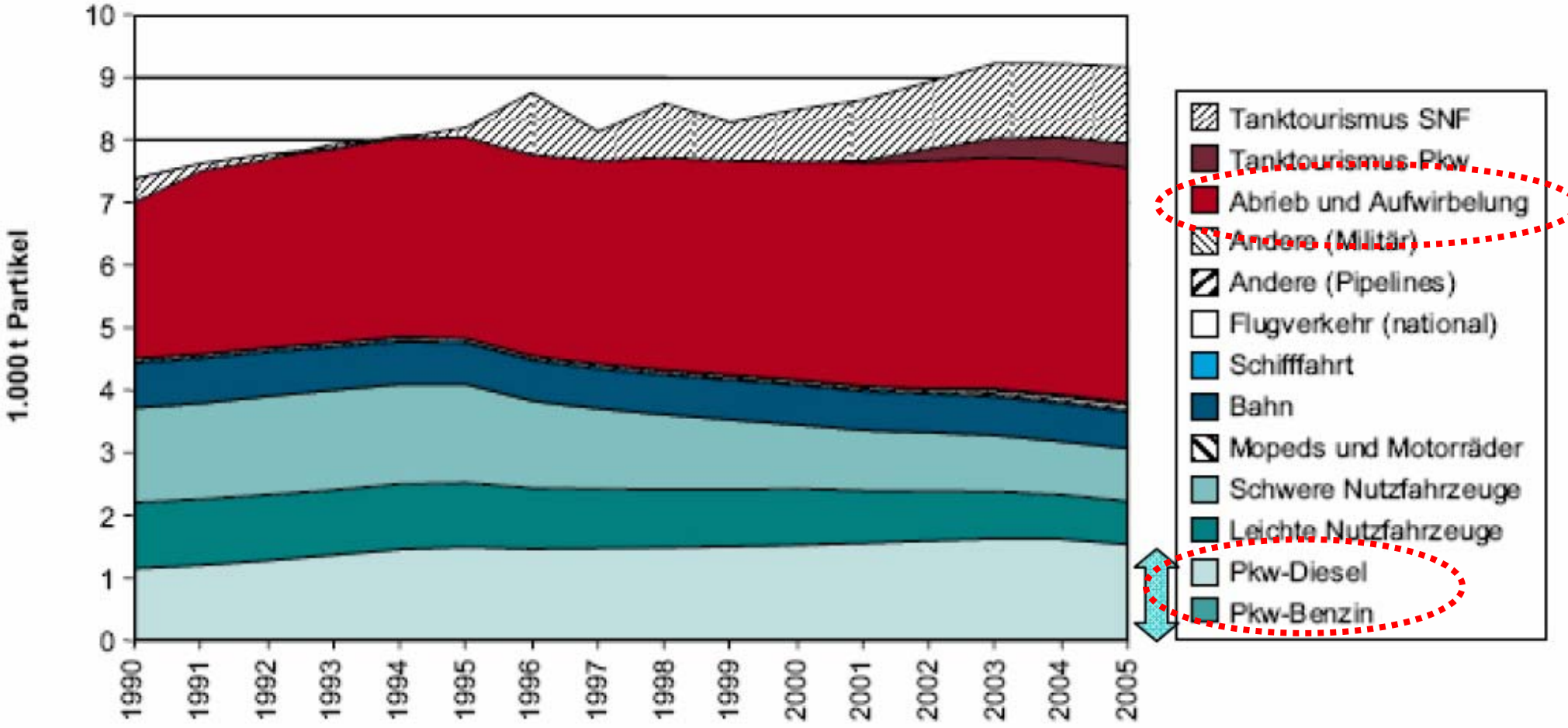
Particle-Emissions in Transport sector



Quelle: Umweltbundesamt, Auswertung auf Basis OLI

Datenstand: Dezember 2006

umweltbundesamt

INNOVATION aus TRADITION

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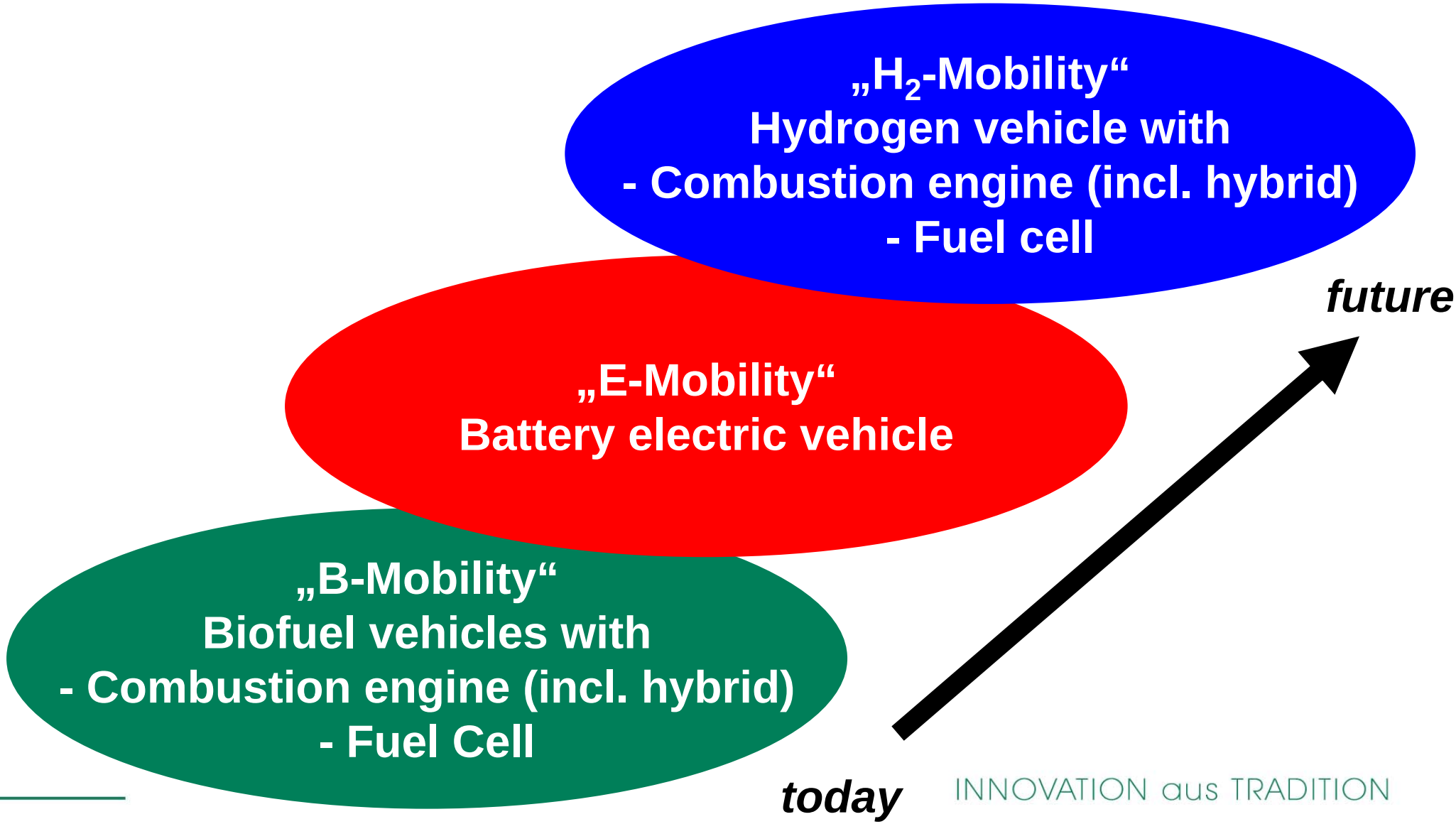
The Future Options for Renewable Transportation Fuels



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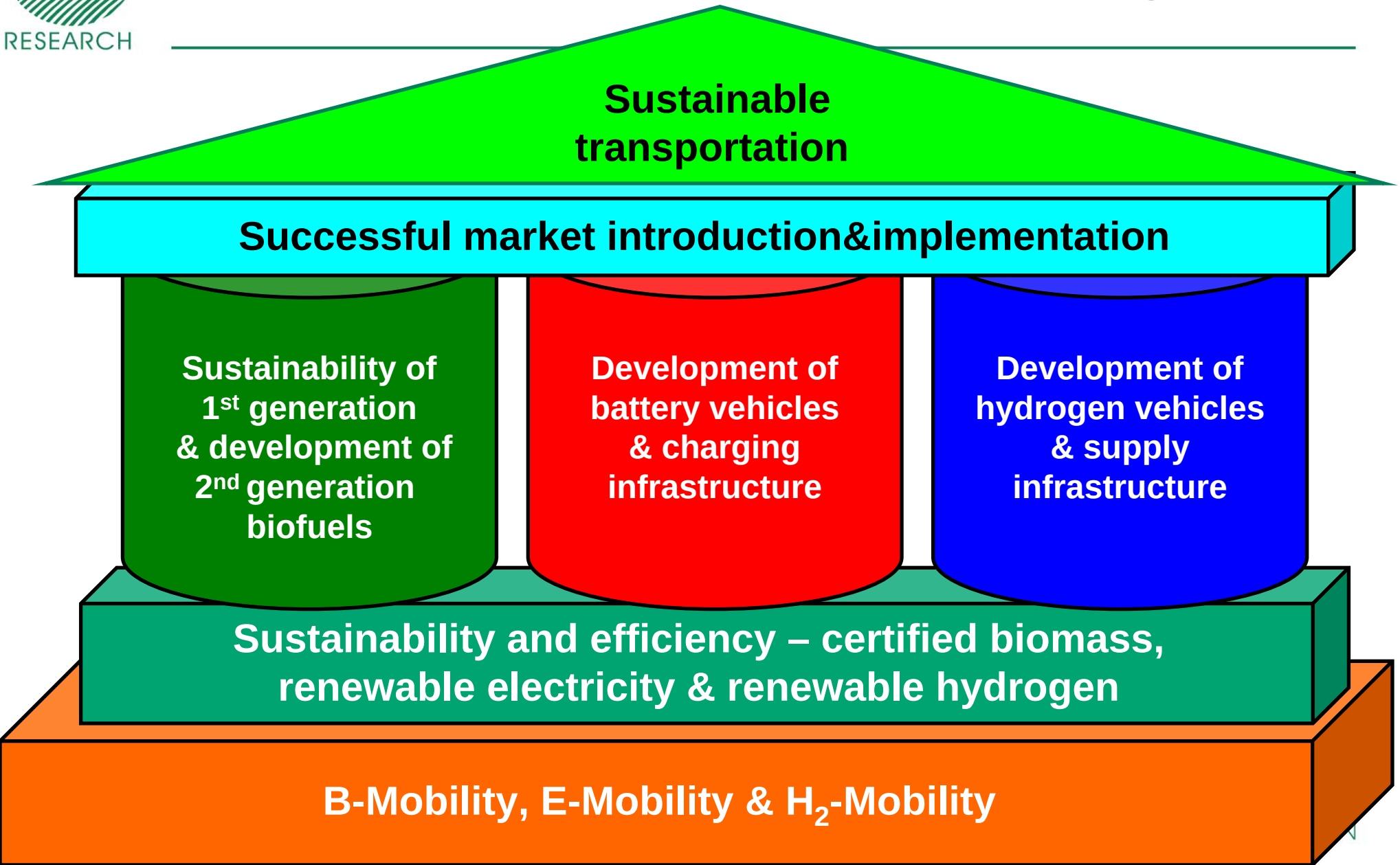
The Challenges



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Comparative Assessment for Renewable Transportation Fuels

	"B-Mobility"	"E-Mobility"	"H_2-Mobility"
Primary energy	many options	many options	many options
Fuel production technology	1st generation existing 2nd generation under development	existing	fossil existing renewable under development
Sustainability	food/feed/fibre/fuel	renewable	renewable
Local emission	yes	no	very low
Infrastructure	existing	partly existing	not existing
Vehicle technology	existing	under development	under development
Customer needs (Range/Refuel time)	common	uncommon	less common

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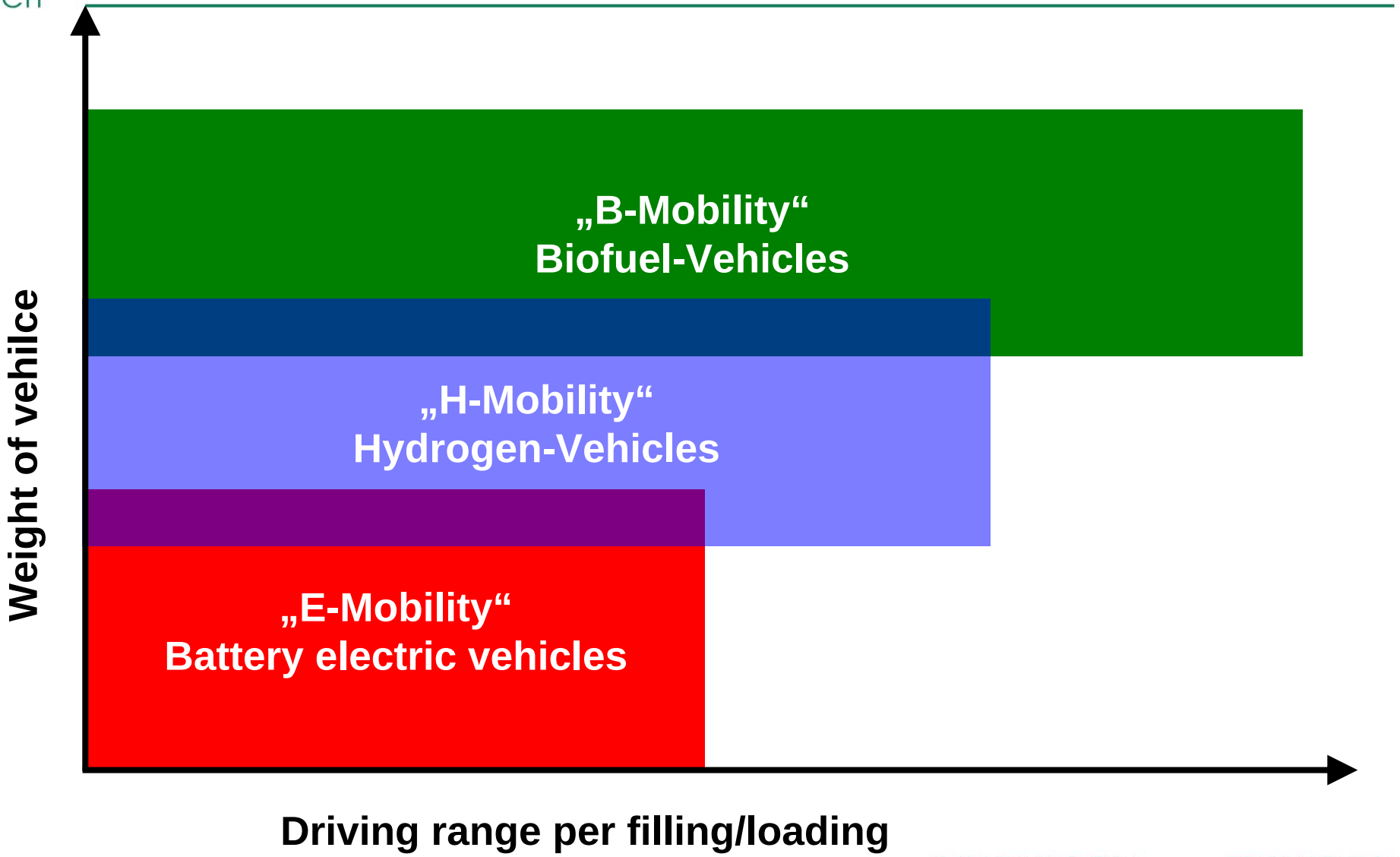
Optimum Application of Vehicles with Renewable Energy



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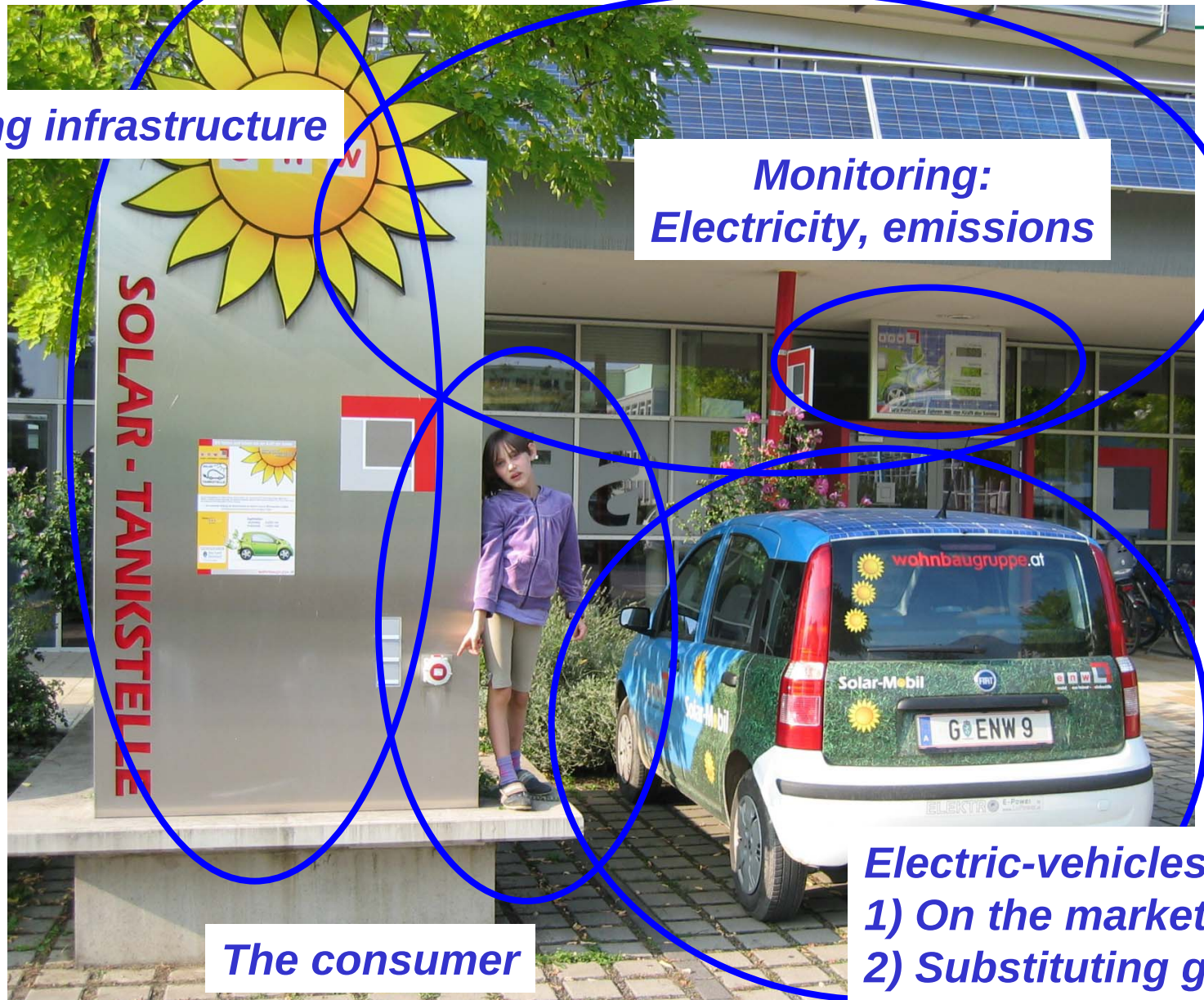
Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

Monitoring: Electricity, emissions

Additional renewable electricity

Electric-vehicles
1) On the market available
2) Substituting gasoline&diesel

The consumer

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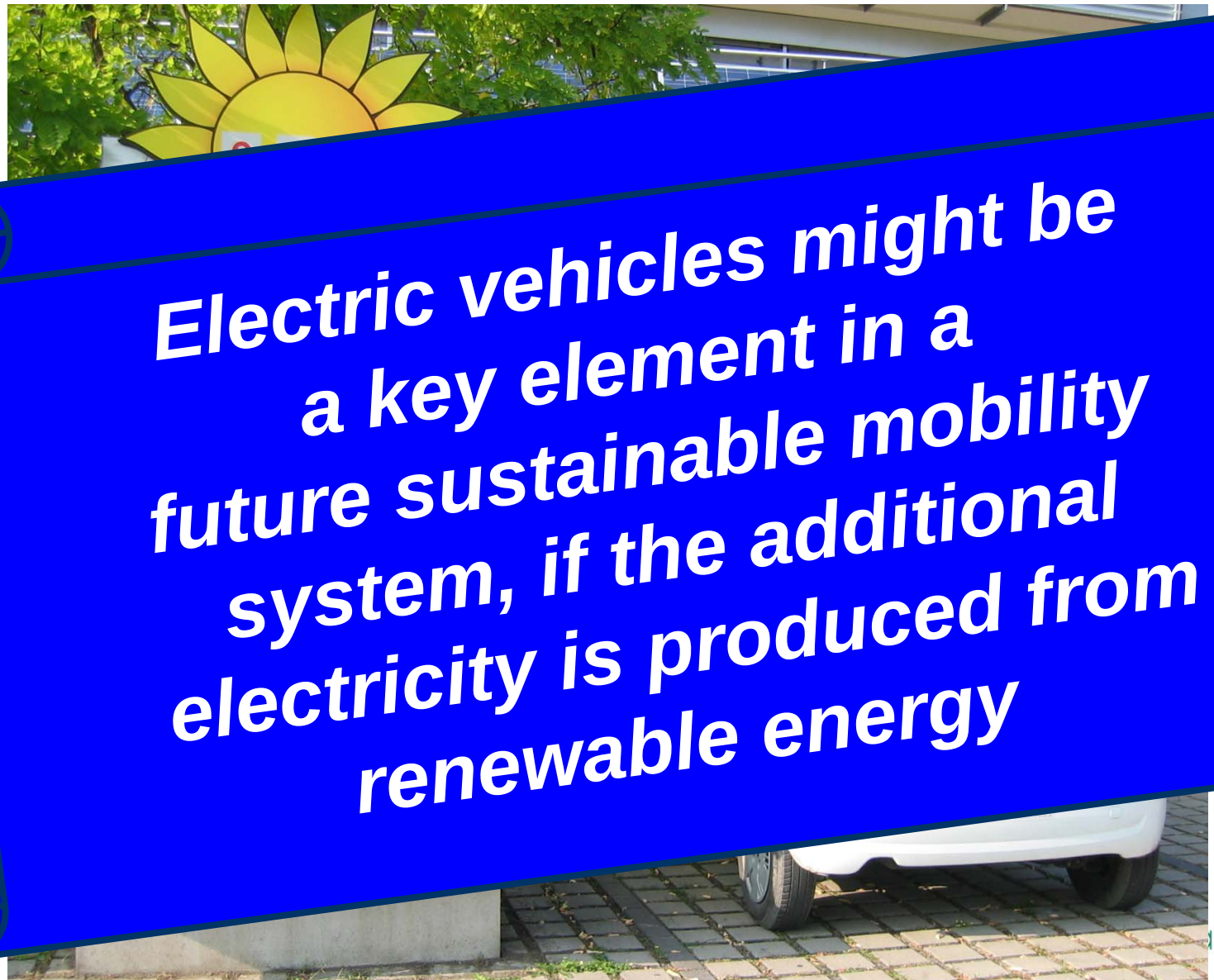
Challenges for the Successful Market Introduction of Electric-Vehicles



Electric vehicles might be a key element in a future sustainable mobility system, if the additional electricity is produced from renewable energy

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