



***„Zukunftsmobilität made in Graz“
Leistung, Reichweite und Umwelt - Erfahrungen aus der Praxis***

**Gerald Teuschl
29.02.2012**

Global Megatrends

Economy

1. Shortage of raw material
2. Limited fossil fuels
3. Environmental impacts
4. Globalization



Society

5. Virtual Digital Lifestyle
6. Demographic change
7. Individualization



Mobility

8. Urbanization / Megacities
9. New forms of mobility

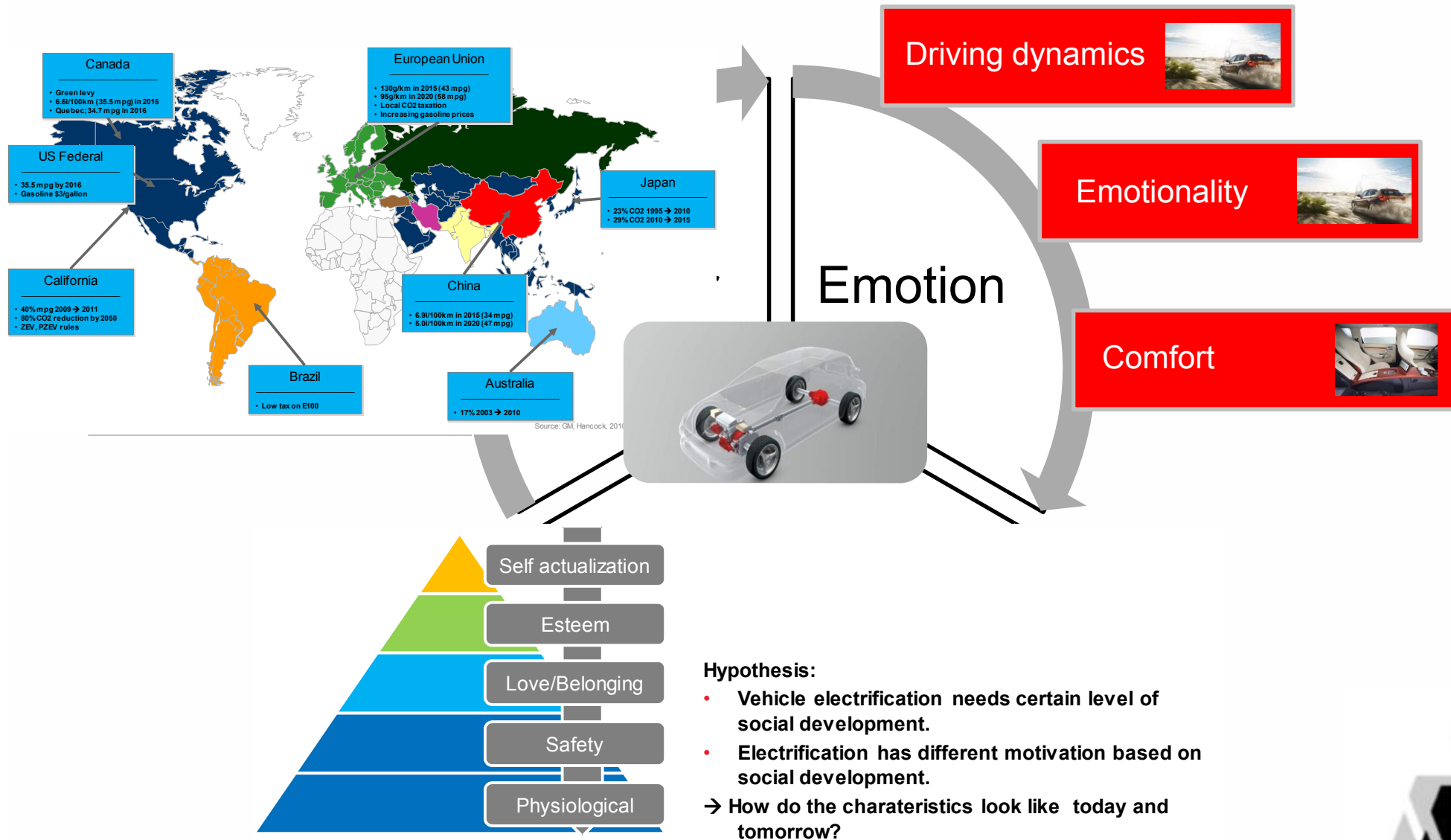


**New demands
for politics
and society**

Mobility is a basic need of mankind.
This need has been and is still satisfied in many different ways.
The way of satisfaction is based on the level of social development and individualization.

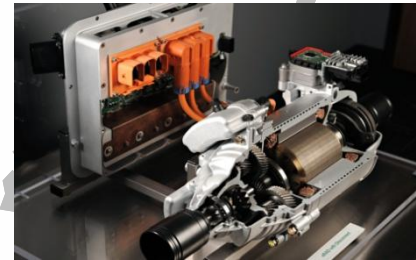


Area of Tension



Global hybrid & electric vehicles sales 2020

2020 Global Vehicle Market – 117,000,000



Micro Hybrid

24,270,000 - Global

6,420,000 – Asia
485,000 – NA
17,300,000 - EUR

21%

- Stop / Start
- BAS – Belt Alternator Starter
- Combustion restart

Mild Hybrid

911,000 - Global

743,000 – Asia
30,000 – NA
139,000 - EUR

0.8%

- ISAD – Integrated Starter/Generator Device
- BAS+

Full Hybrid

4,786,000 - Global

2,022,000 – Asia
1,490,000 – NA
1,275,000 - EUR

4%

- Power-split transmission
- 2Mode
- Thru the Road – eRAD
- Serial Range Extended

BEV / FCV

969,000 - Global

511,000 – Asia
106,000 – NA
350,000 – EUR

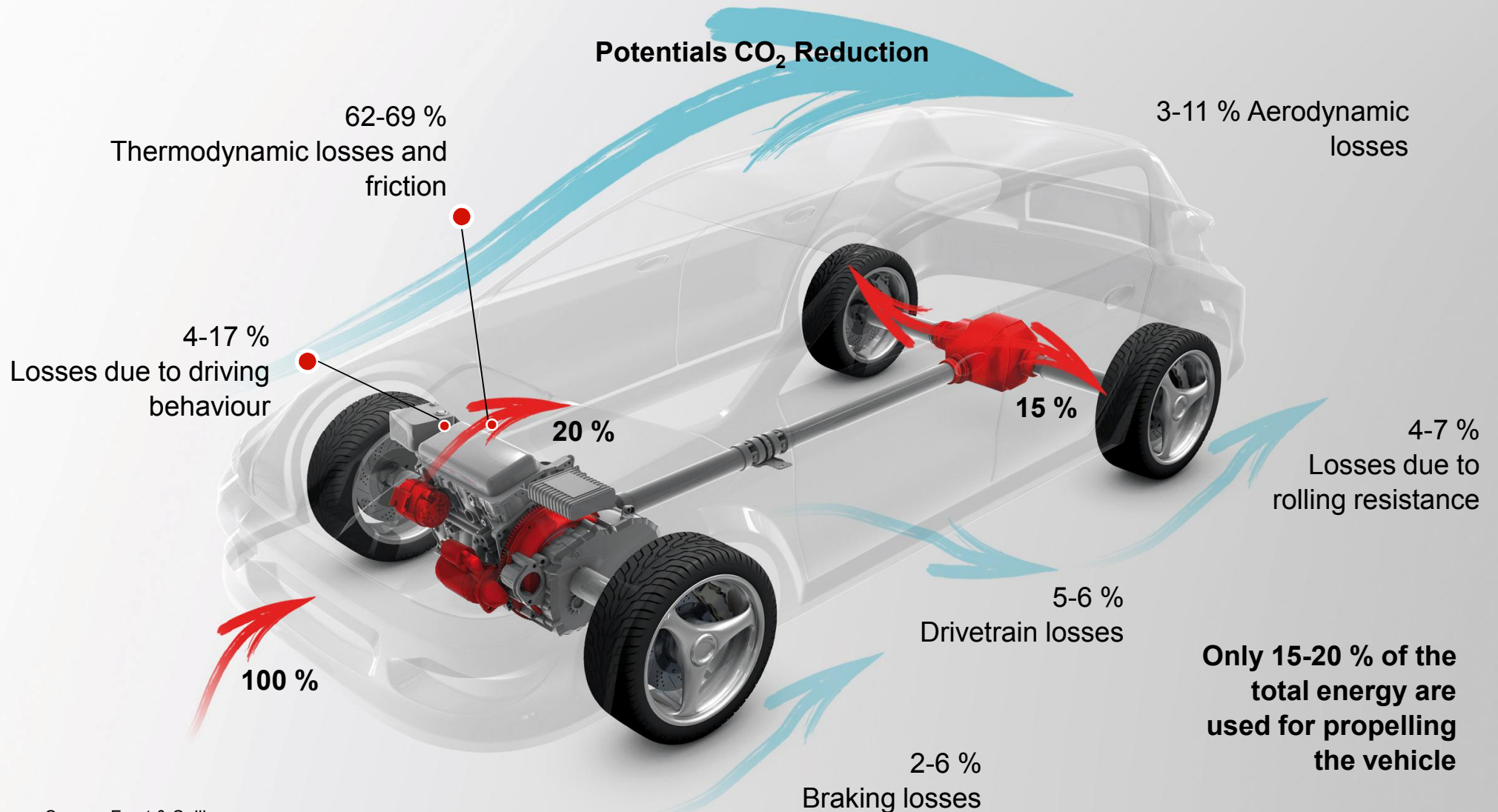
0.9%

- eDrive
- Fuelcell
- Wheel motors

Regional Mkt

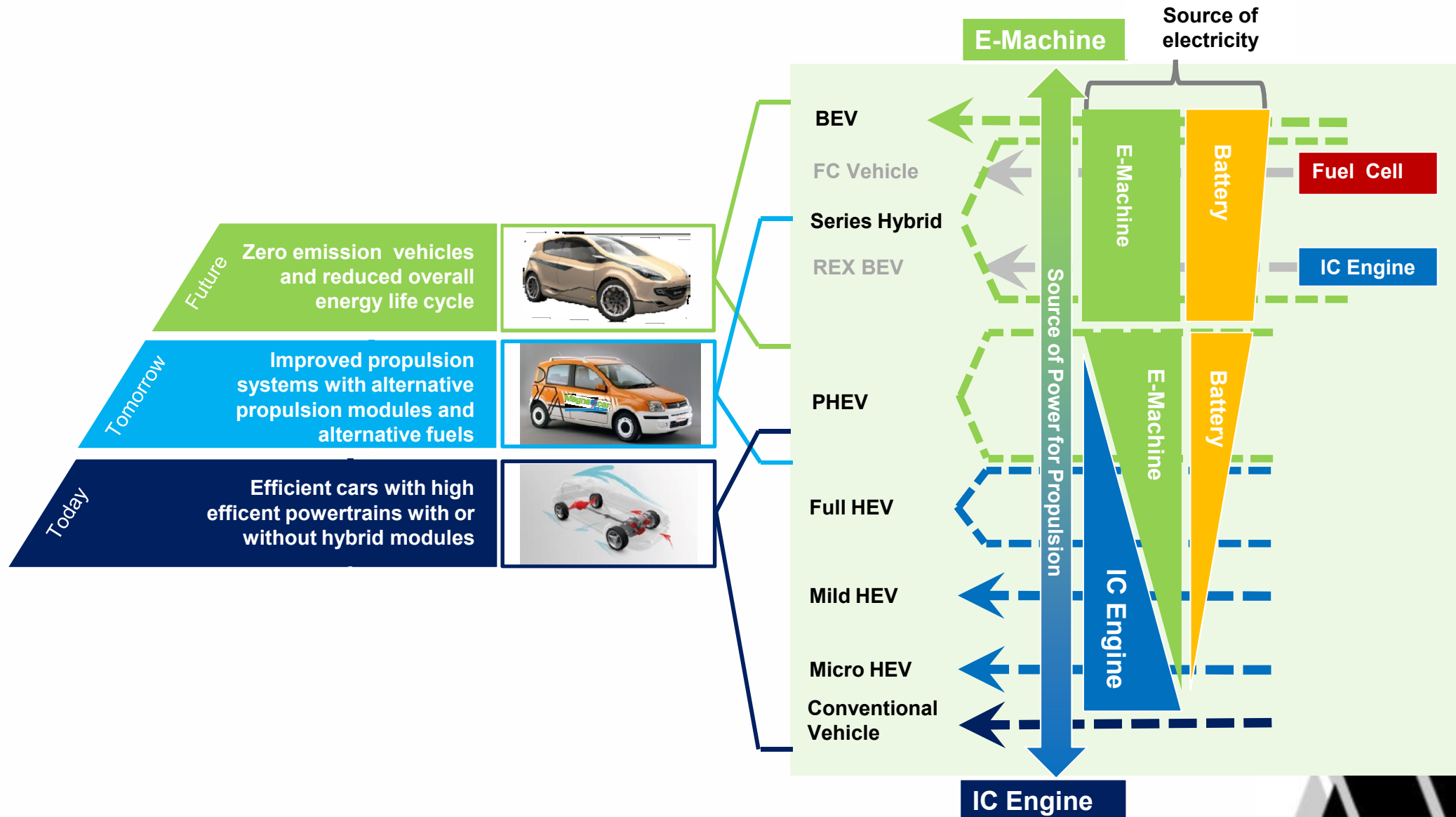
% of total in 2020

Approaches for CO₂ reduction






Source: Frost & Sullivan

Pathway towards electrification



Characteristica

		ICE	(P)HEV	BEV
				
Components	Propulsion	Conventional Vehicle Combustion Engine Gearbox (6 Gears)	Gearbox ,1 to 3 Converters, EM, DCDC Converter	Electric Motor, Gearbox (1 Gear) Converter DCDC Converter
	Energy Storage System	Tank ~ 60l	Tank ~ 50l, Battery Pack 15-250l, Onboard Charger	Battery Pack ~ 350l Onboard Charger
	Range	400 -1.000km	800 -1.200km	~150km (NEDC)
Functions	Max. V	>180	>180 (50;120;180)	<140 (1 gear)
	Tank – Charge Time	3min	3min to 3 hours	Several hours
	Energy Regeneration	<2%	10-20%	25-40%
	CO2 Emissions (Driving)	~140g/km	0 – 200g/km	0g/km
	Energy Efficiency	<30%	<40%	~70%

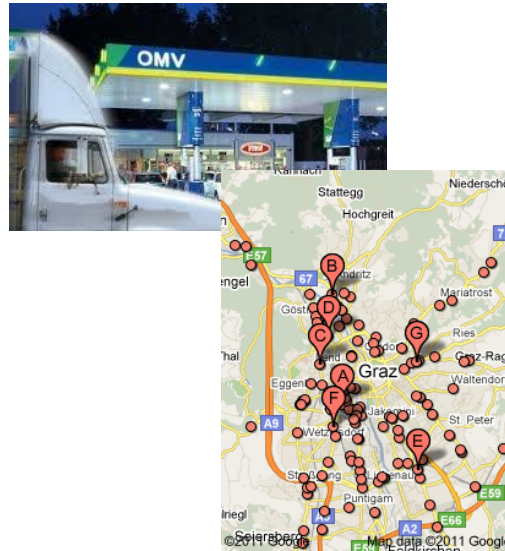
Source: Magna E-Car Systems

Reason for range anxiety of consumer



Yesterday

1935



Today

2011

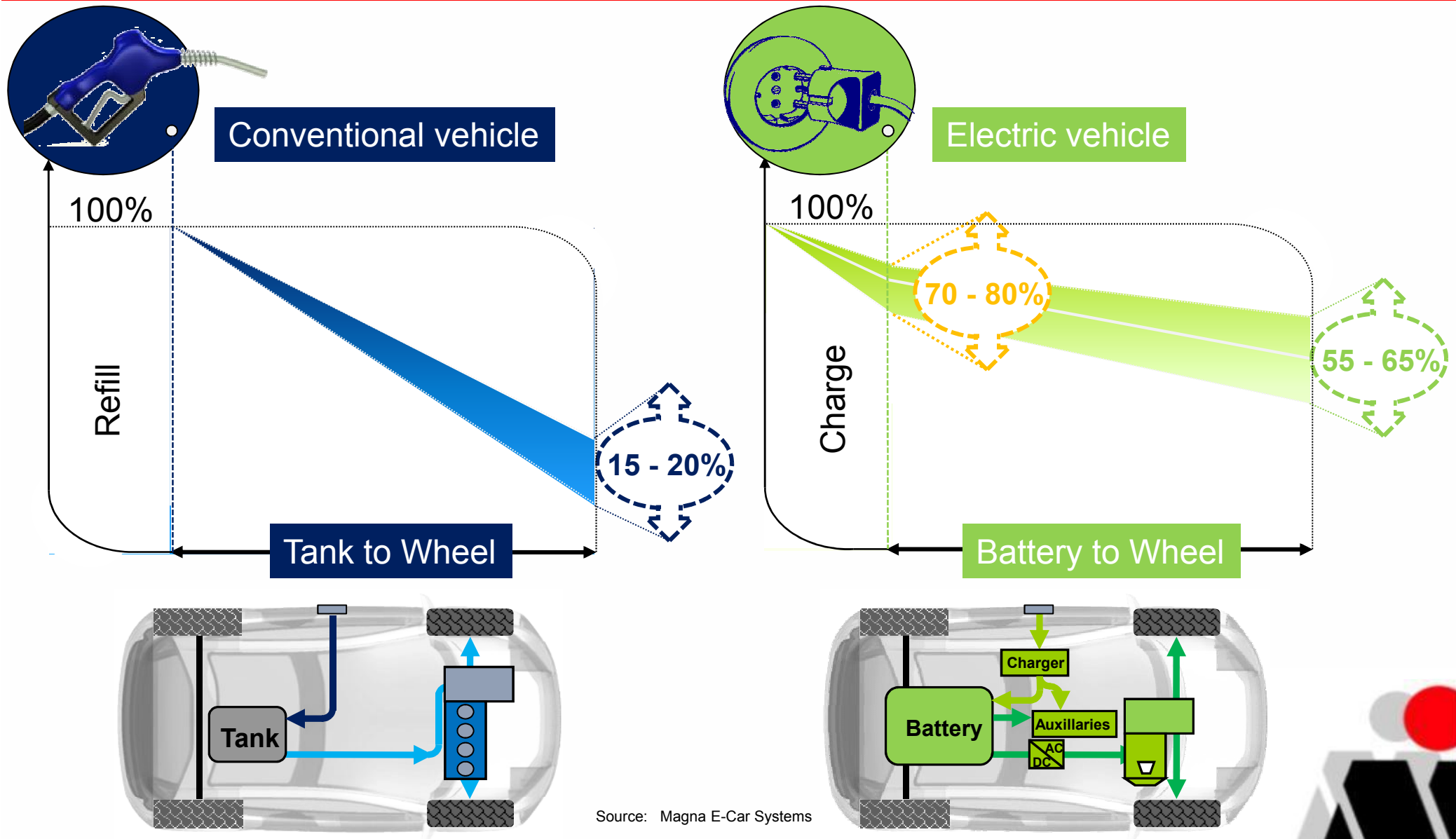


Today

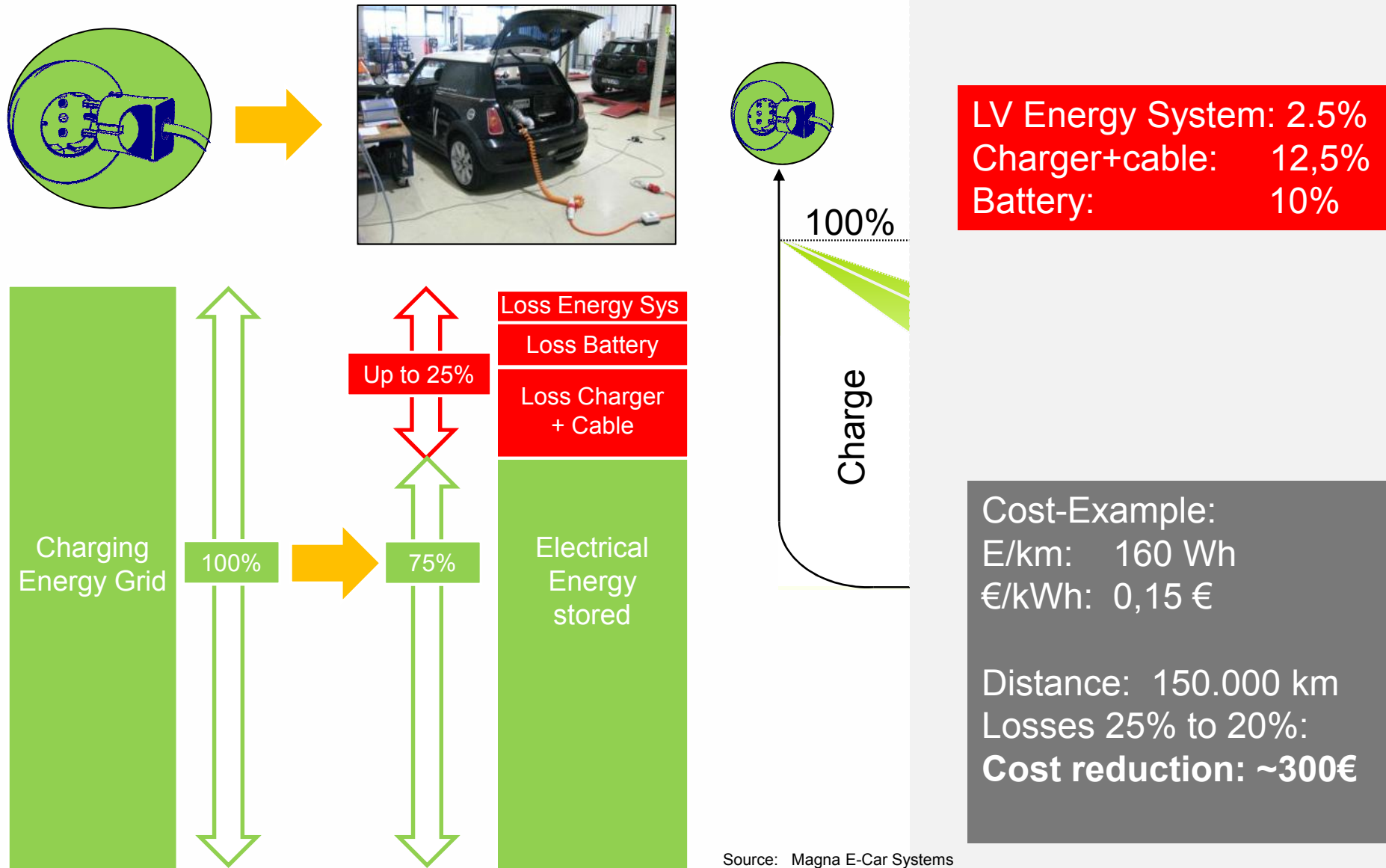
2012

→ So “range anxiety of consumer” only a rumor?

Efficiency Chain



Efficiency Chain – Charging Details PHEV



Cost-Example:

E/km: 160 Wh

€/kWh: 0,15 €

Distance: 150.000 km

Losses 25% to 20%:

Cost reduction: ~300€

Source: Magna E-Car Systems

Mila-EV Measurements Charge-Efficiency



P-meter
(FINDER)

Dewetron

Current
HVbat

Current
+12Vbat

Source: Magna E-Car Systems

29.02.2012

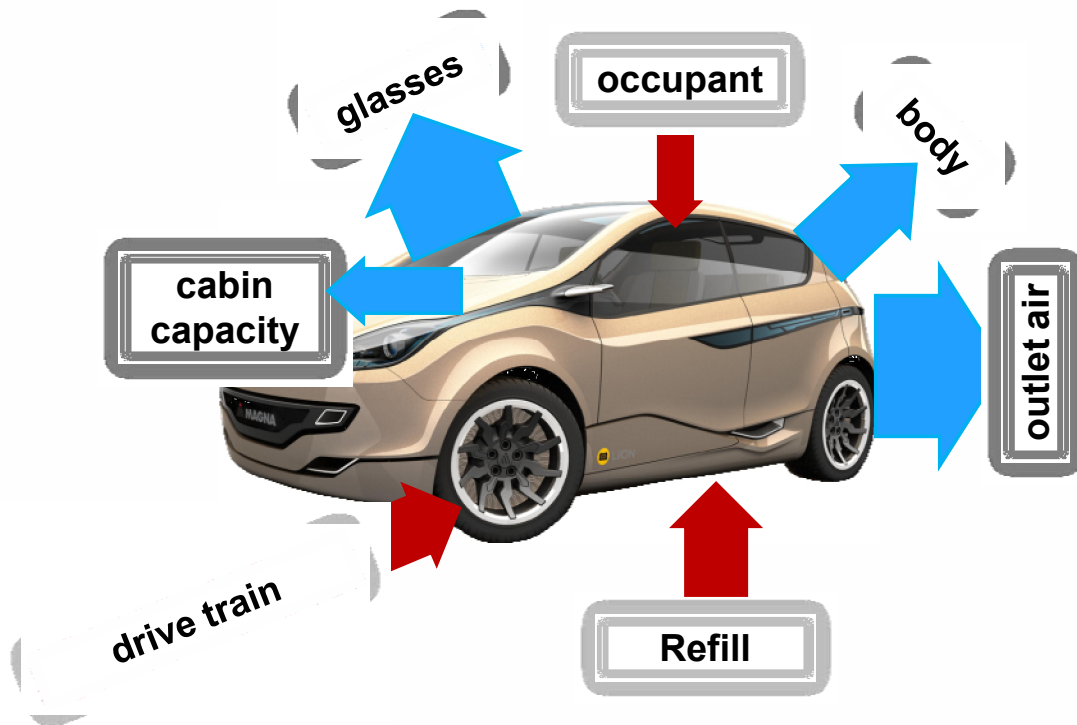
G. Teuschl

Disclosure or duplication without consent is prohibited

11



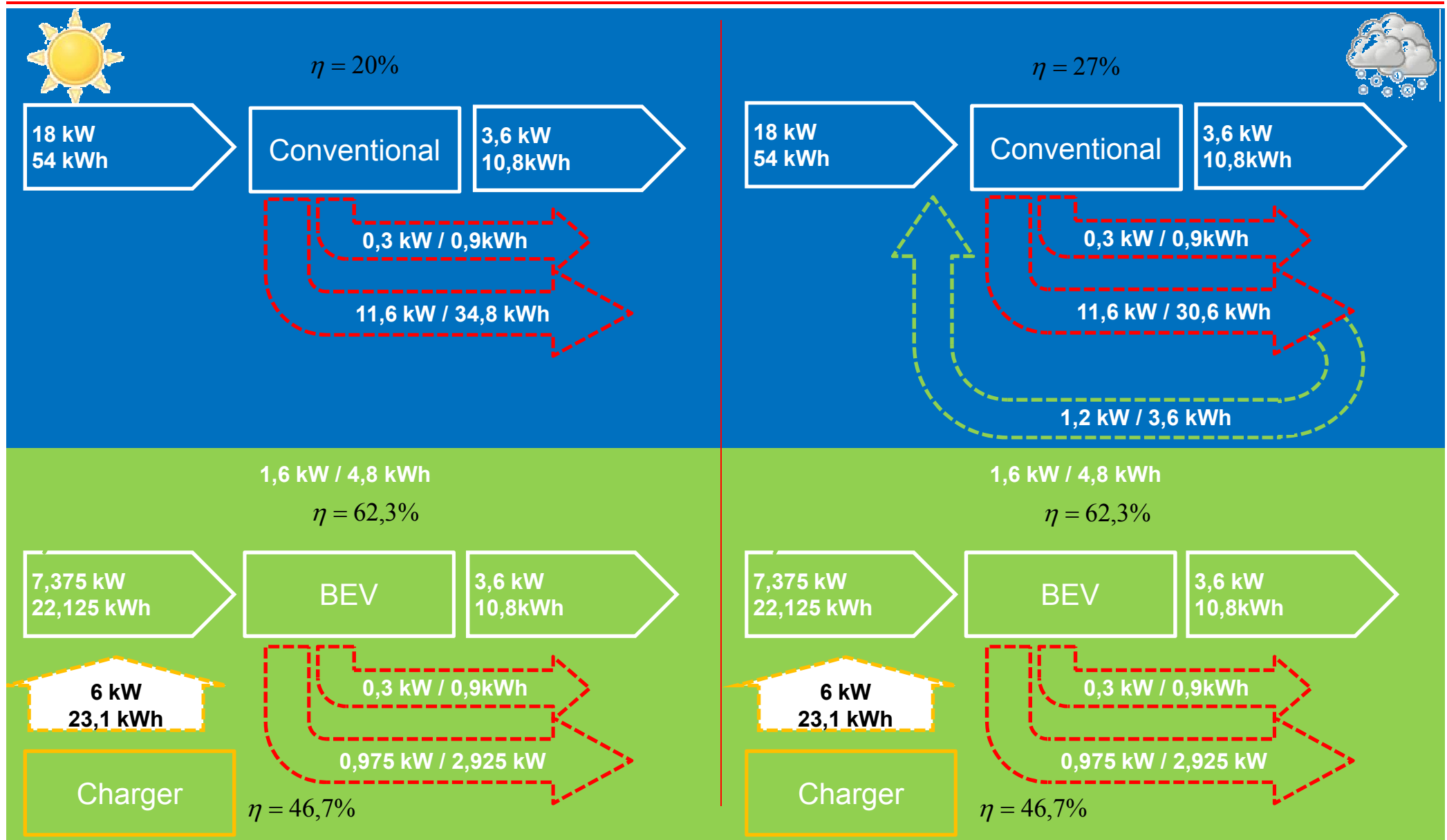
Where does the energy go to?



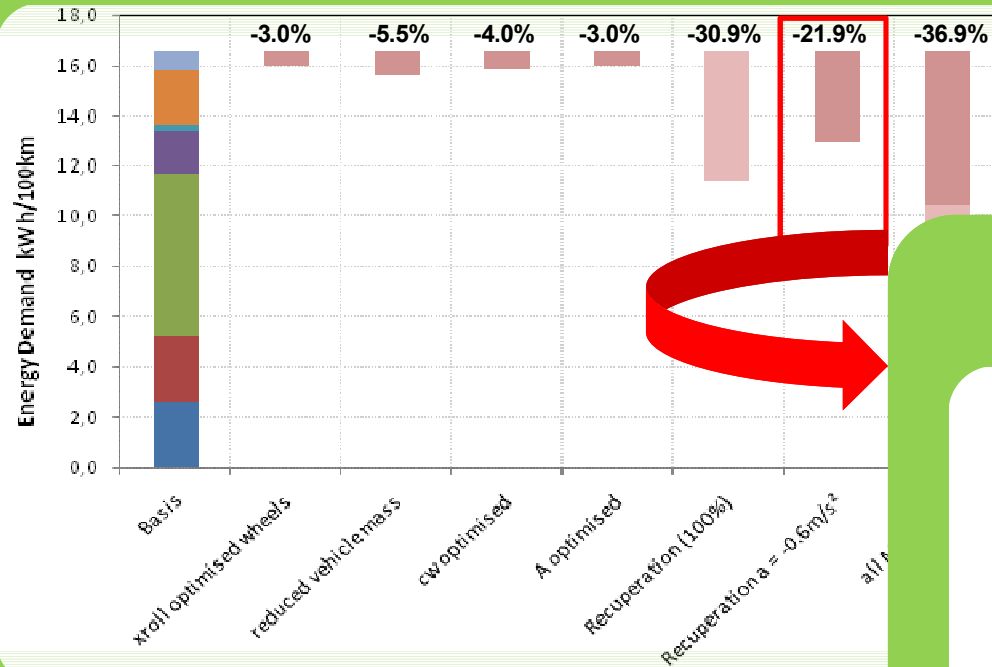
eCYCLE GRAZ

Duration	s	4808
Distance	km	41.61
Max Speed	km/h	105.24
Avg Speed	km/h	31.17
Max Accel	m/s ²	2.74
Max Decel	m/s ²	-2.89
Standstill	s	533.6
Max Standstill	s	55.2

Energy Flow – Summer/Winter



Parameter Study - NEDC



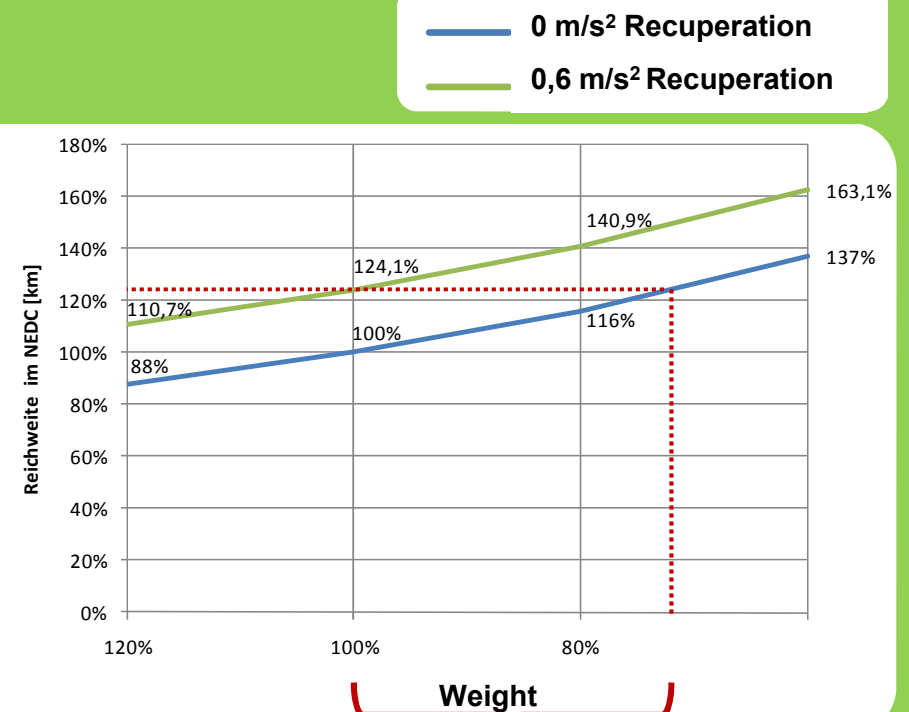
Cycle NEDC Auxillaries considered

- Battery - Discharge Losses
- Losses E- Machine & Inverter
- mech. Losses
- Slope Resistance
- Accel. Resistance
- Air Resistance
- Roll Resistance

Source: Magna E-Car Systems
29.02.2012

G. Teuschl

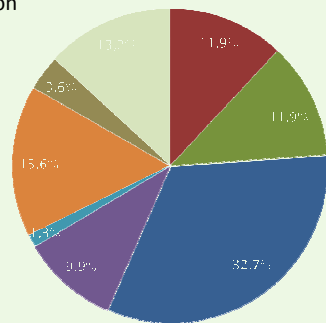
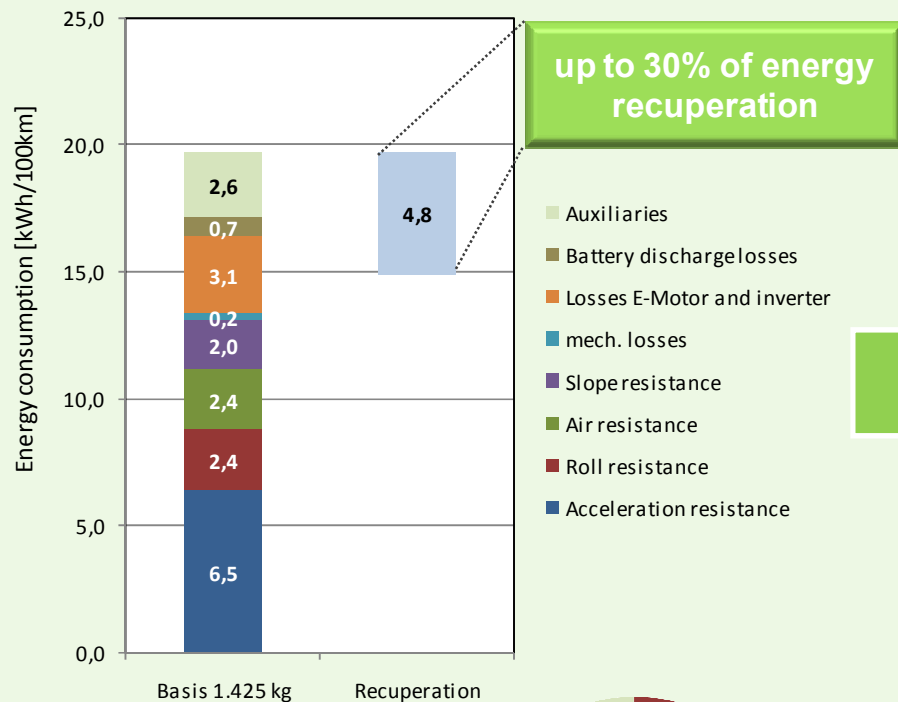
Disclosure or duplication without consent is prohibited



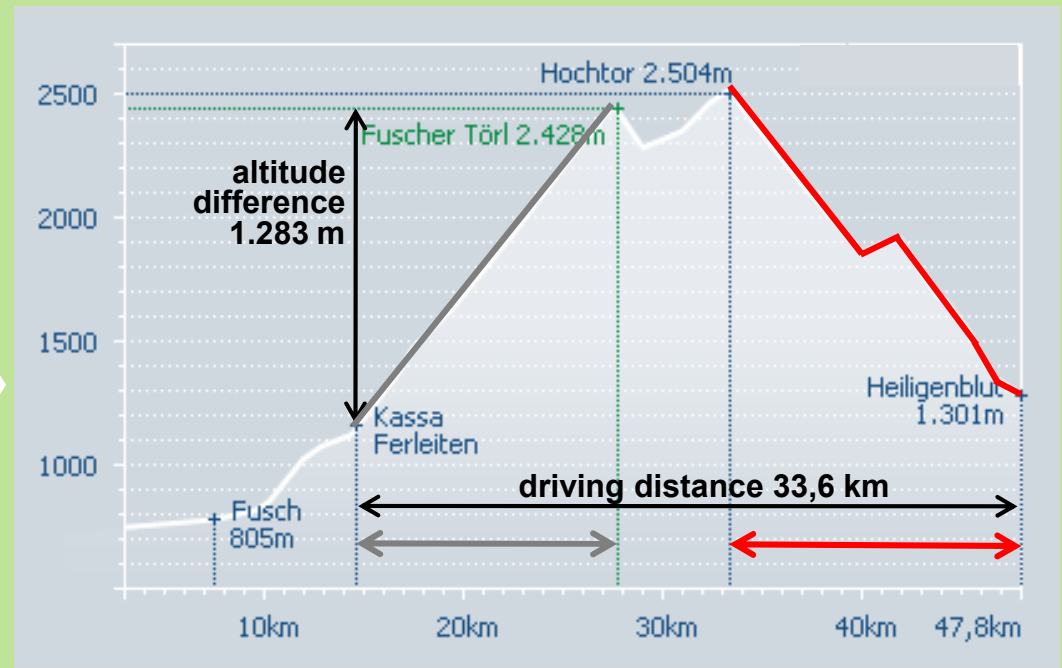
Without recuperation 28% vehicle weight reduction for the same range necessary

Recuperation potentials

Simulation e-Cycle Graz



Großglockner High Alpine Road Profile



		Ferleiten – Fuschertörl		Hochtörl - Heiligenblut	
		Uphill	Downhill	Uphill	Downhill
Energy battery	kWh	8,9	-4,5	9,3	-3,7
Recuperation Ratio	%	50		40	

Source: Magna E-Car Systems

Challenges



Electric vehicle ~1.400kg

preconditioned at 22°C



Capacity Usable 26kWh → 16,2 kWh/100km @ NEDC

Battery
~96%

Inverter
~97%

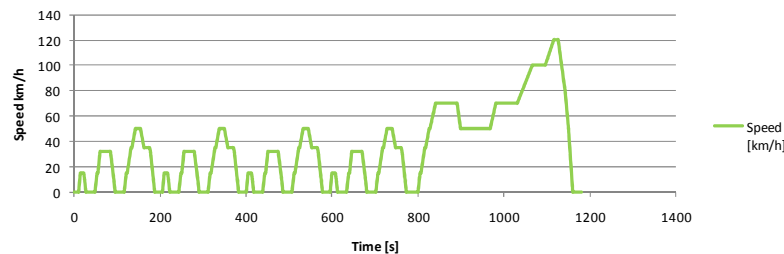
E-Motor
~91%

Transmission
Differential
~97%

Drive Shaft
Hub bearing
~97%

Wheel
20,8 kWh
Efficiency~80%

NEDC Cycle Speed Profile



NEDC
Wheel
20,8 kWh
Range = 160km

Charge
32,5 kWh

Driving
20,8 kWh

Comfort
4,9-10 kWh

4,9 kWh
3hours



Examples:
- Parking car ventilation
- Thermal glasses , ...

Range
129km →
135km

10 kWh
3hours



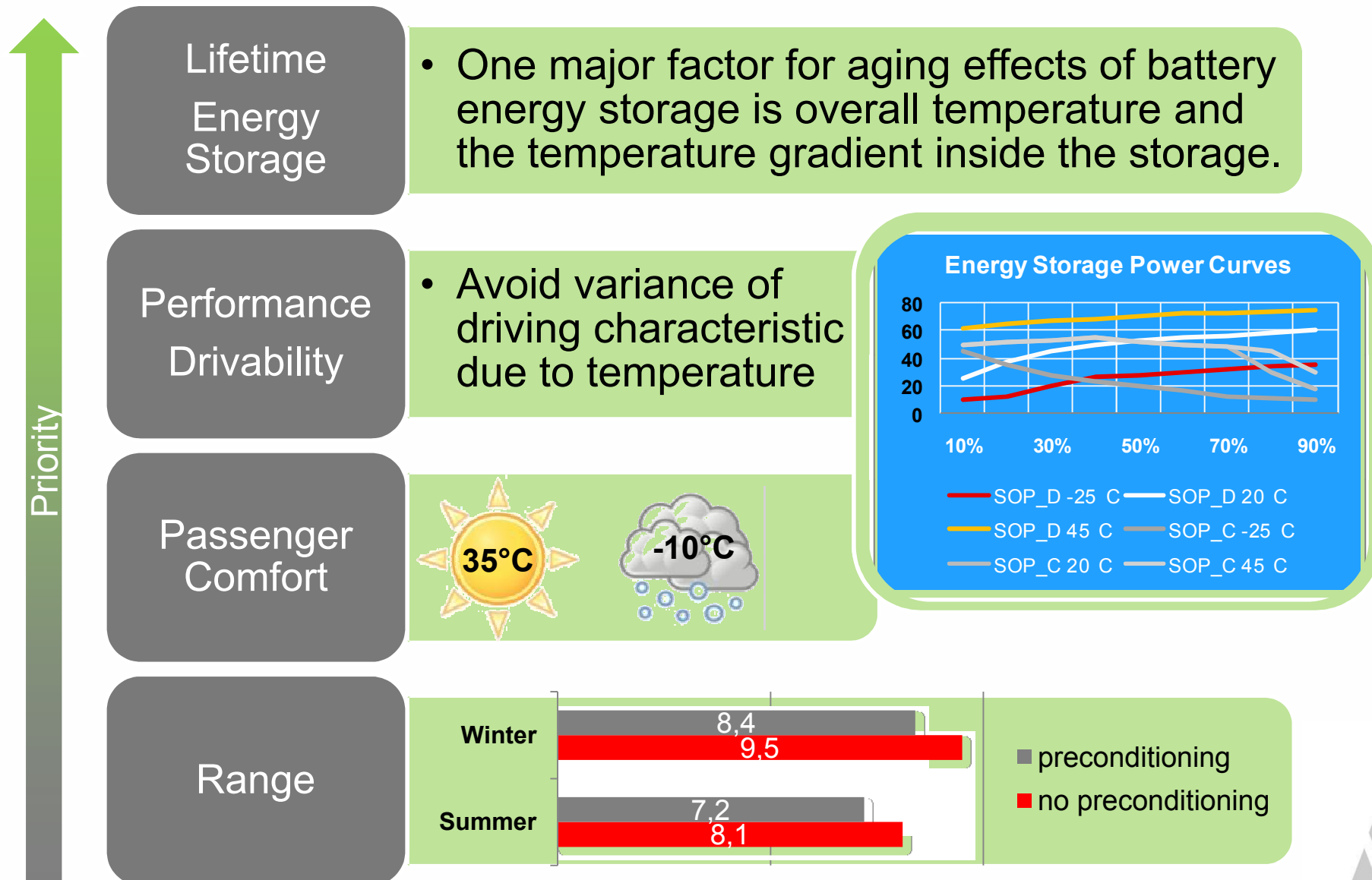
Insulation glasses
- Heat pump system
- Controlled air flap, ...

Range
96km →
110km

Battery to Wheel



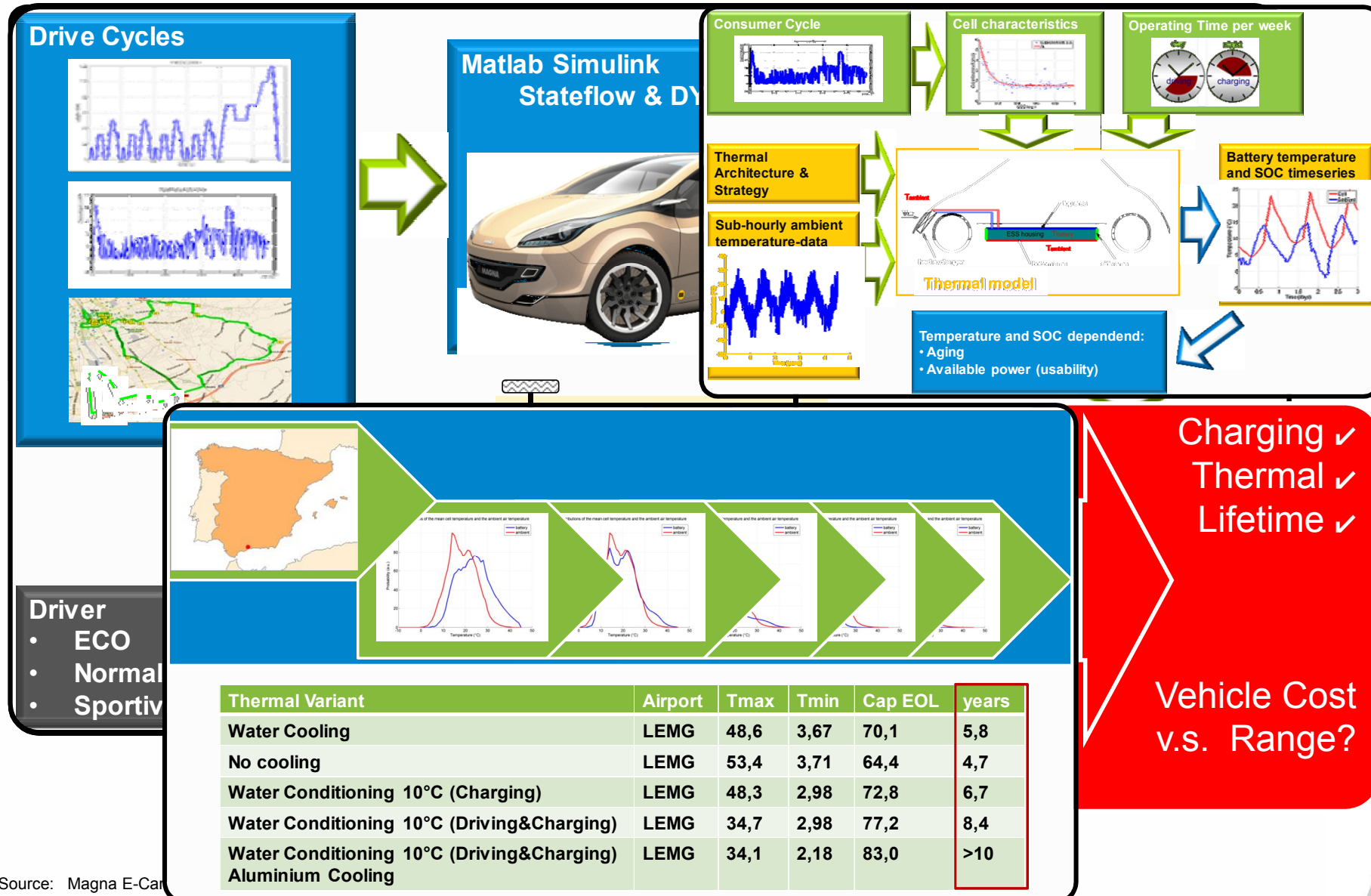
Thermal Challenges



Source: Magna E-Car Systems



Methodology



Source: Magna E-Car

29.02.2012

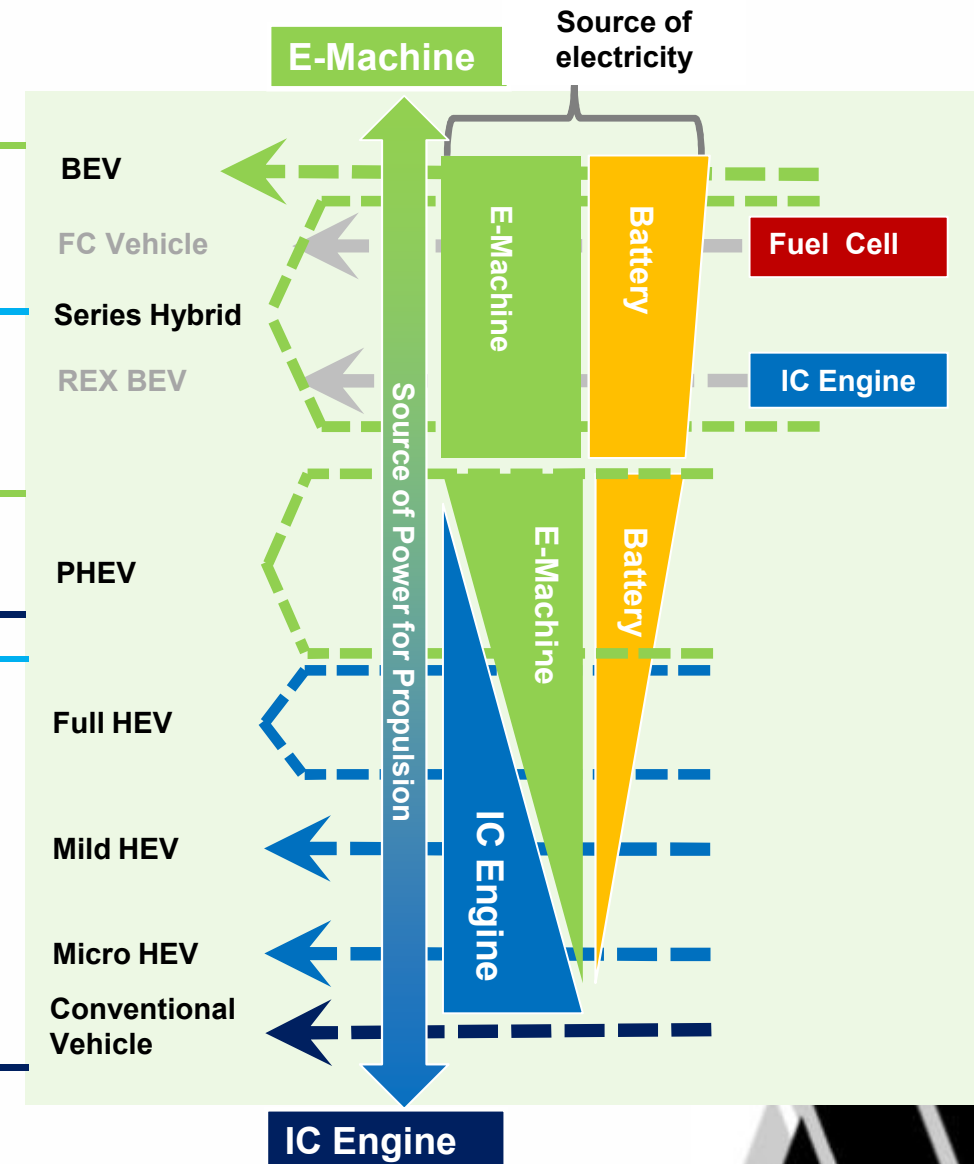
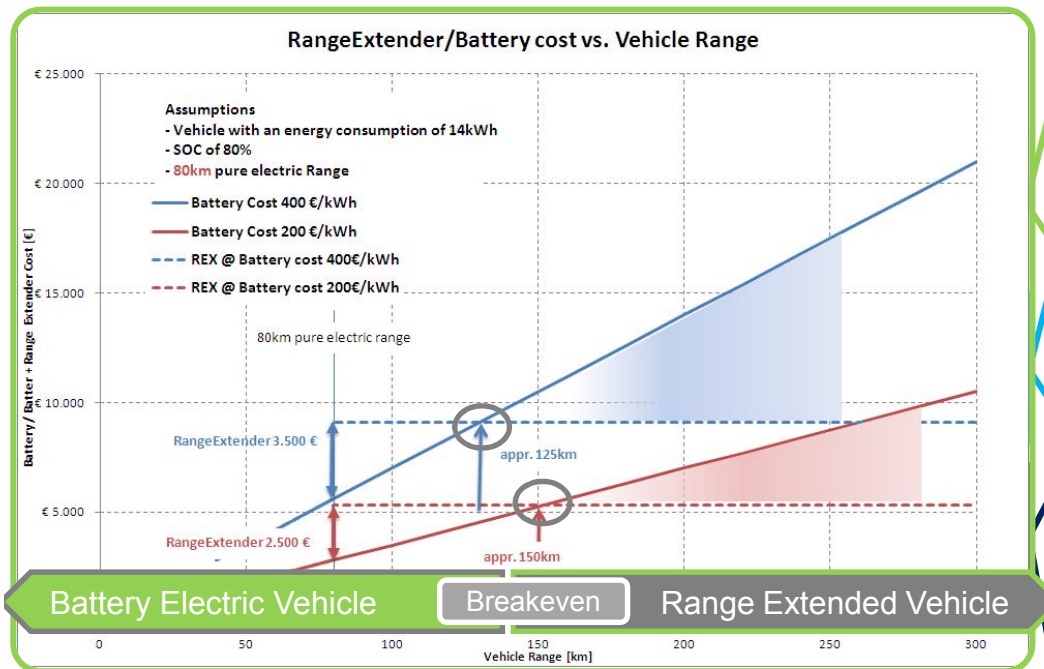
G. Teuschl

Disclosure or duplication without consent is prohibited

18



BEV vs. REX Vehicle



Source: Magna E-Car Systems

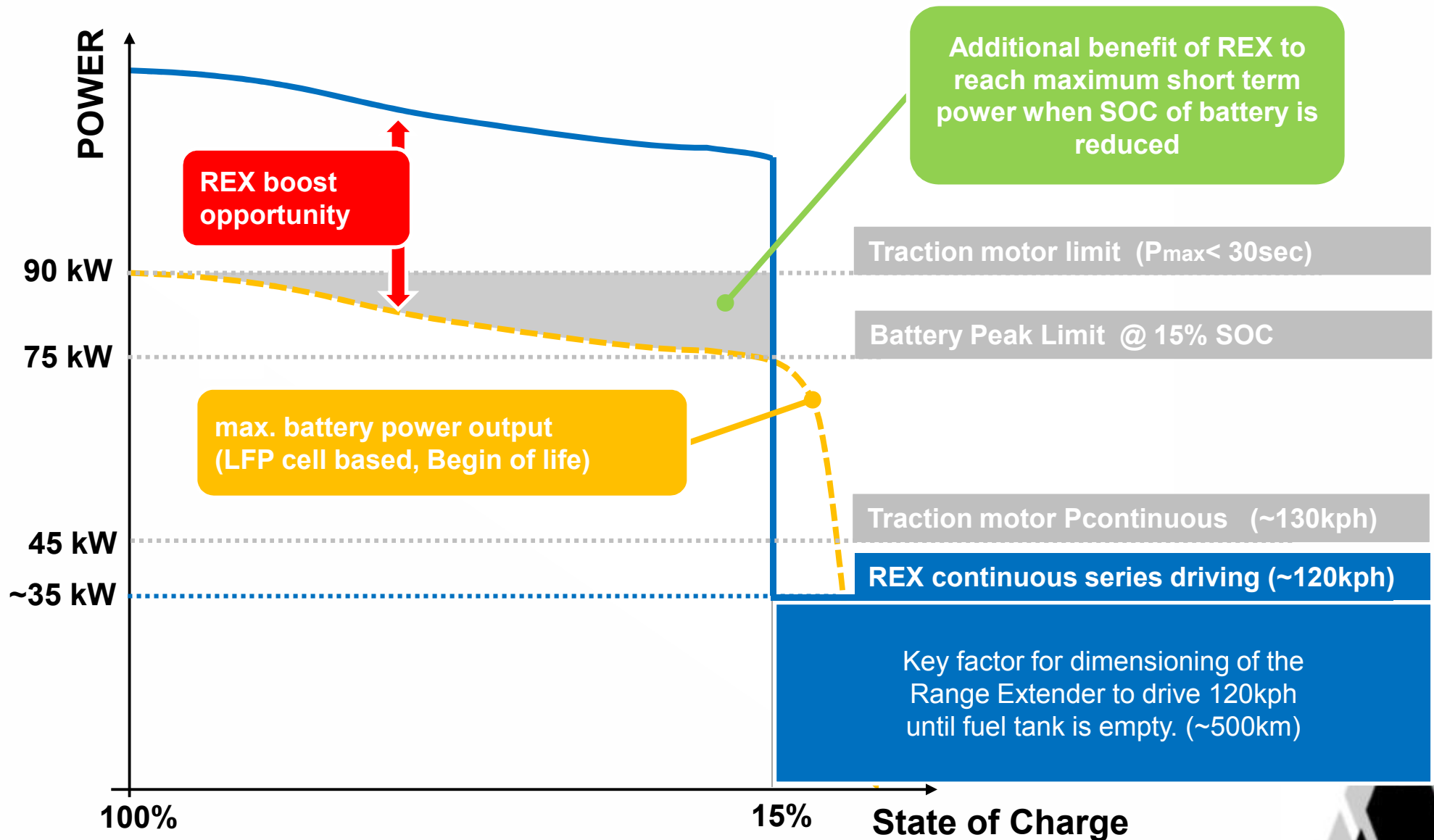
29.02.2012

G. Teuschl

Disclosure or duplication without consent is prohibited

19

REX Concept Assumptions



Source: Magna E-Car Systems

29.02.2012

G. Teuschl

Disclosure or duplication without consent is prohibited

20

REX Activities



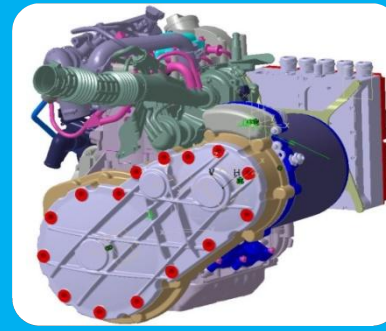
Demonstrator REX
PHEV 2009
„direct drive“

Rotax 810 - V2 Motor
 $P_{\text{Duration}} = 15\text{-}20 \text{ kW}$



Production
Intended Design
„2nd generation“

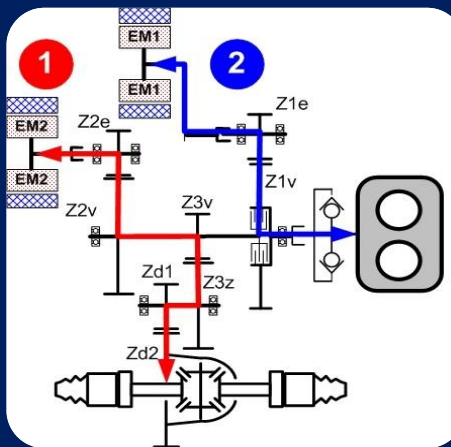
2 Cylinder inline engine
Power $P_{\text{cont}} = 25\text{kW}$
4 stroke, 800 ccm



Concept Design

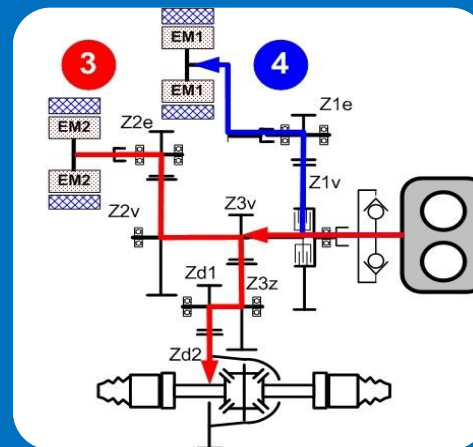
Range Extender
for serial driving

REX - Direct Drive



1 Electric drive and recuperation

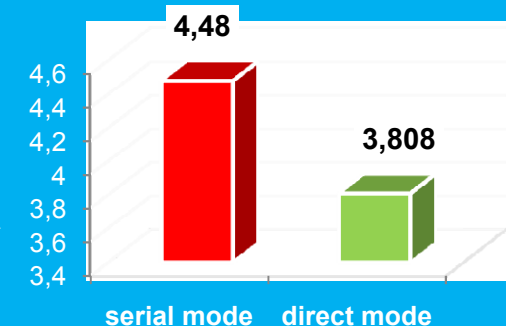
2 Generator mode



3 „direct drive“ e.g. from 80kph to v_{max}

4 „load point“ shifting

Fuel consumption
serial vs. direct
drive @ 100kph



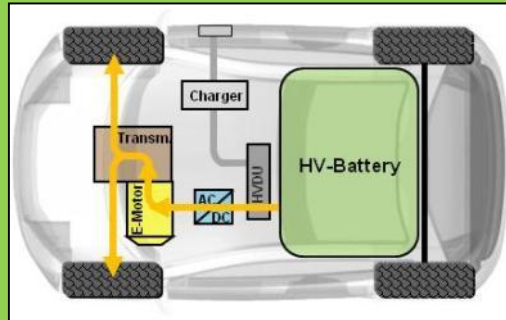
■ serial mode ■ direct mode



* Rig test result MINI PHEV drivetrain

EV – REX COMPARISON

Electric Vehicle (EV)

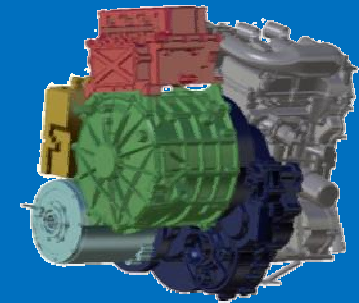
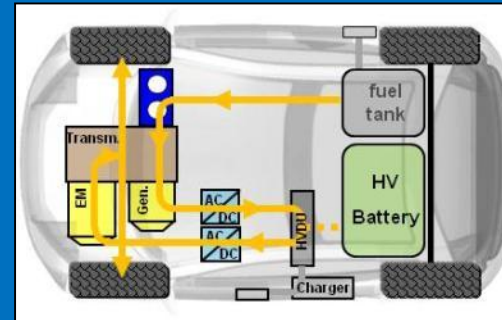


Electro machine with single speed transmission and large battery capacity for maximum driving distance.

EV range enlarging opportunity with optional battery change concept.

Climate or heating comfort functions strongly limit the driving distance.






Range EXTENDED Electric Vehicle (REX)



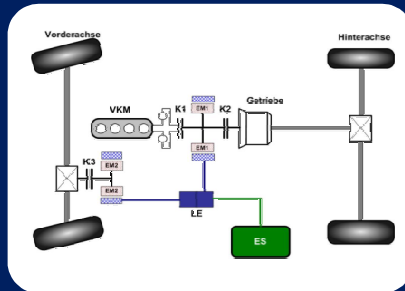
Additional internal combustion engine + generator to increase driving distance and reduce battery capacity and cost.

Enlarging vehicle **range** with ICE (fuel)
→ Reducing „range anxiety of customer“

Additional functionalities:

-  Boost = **Additional electric power** (ICE+Generator)
-  Battery sustaining or **battery charging** mode
-  Comfort functionality (heating/climate) without battery energy demand
-  Ability to drive the vehicle at very cold temperatures and in parallel to heat up the battery
-  - Vmax with ICE if direct drive installed

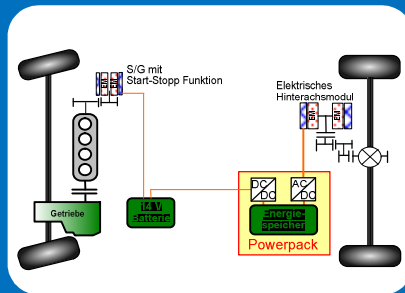
MAGNA concept studies



Power Hybrid

- Fuel Efficiency Increase > 20%
- Boost-Function, Optimized Driving Dynamic
- Recuperation with both Axles
- Electric Range < 2.5 km

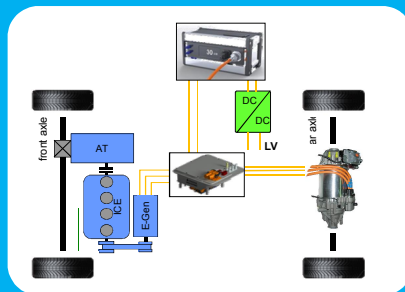
MAGNA Demovehicle



Clean energy E4WD

- Limited all wheel drive
- Fuel Efficiency Increase 10-15%
- Boost-Function
- Recuperation on rear axle
- Electric Start / Manoeuvring

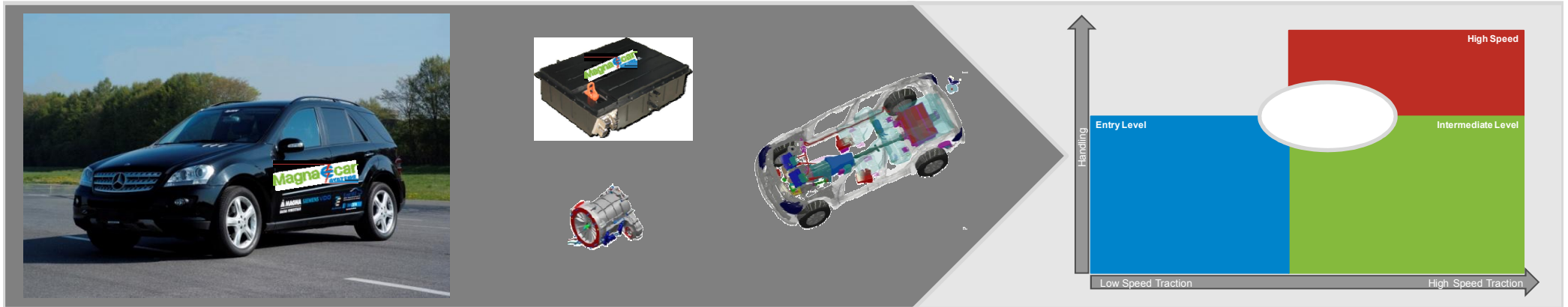
MAGNA Demovehicle



PHEV - ERAD

- All wheel drive
- Higher Efficiency (~50g CO2)
- Boost-Function
- Recuperation on rear axle
- Electric Driving ~40km

Example 1: Power Hybrid (AWD): HySUV™



- Series and parallel hybrid with e-4WD capability
- flexible power front or rear axle
- MAGNA E-Car Lithium-Ion battery
- Operating strategy including start/stop, load shifting for recharging battery, regenerative braking and electric driving
- Electric air-conditioning compressor, electric steering and other electric auxiliaries
- AWD module between ICE and AMT
- fuel savings up to 24 %

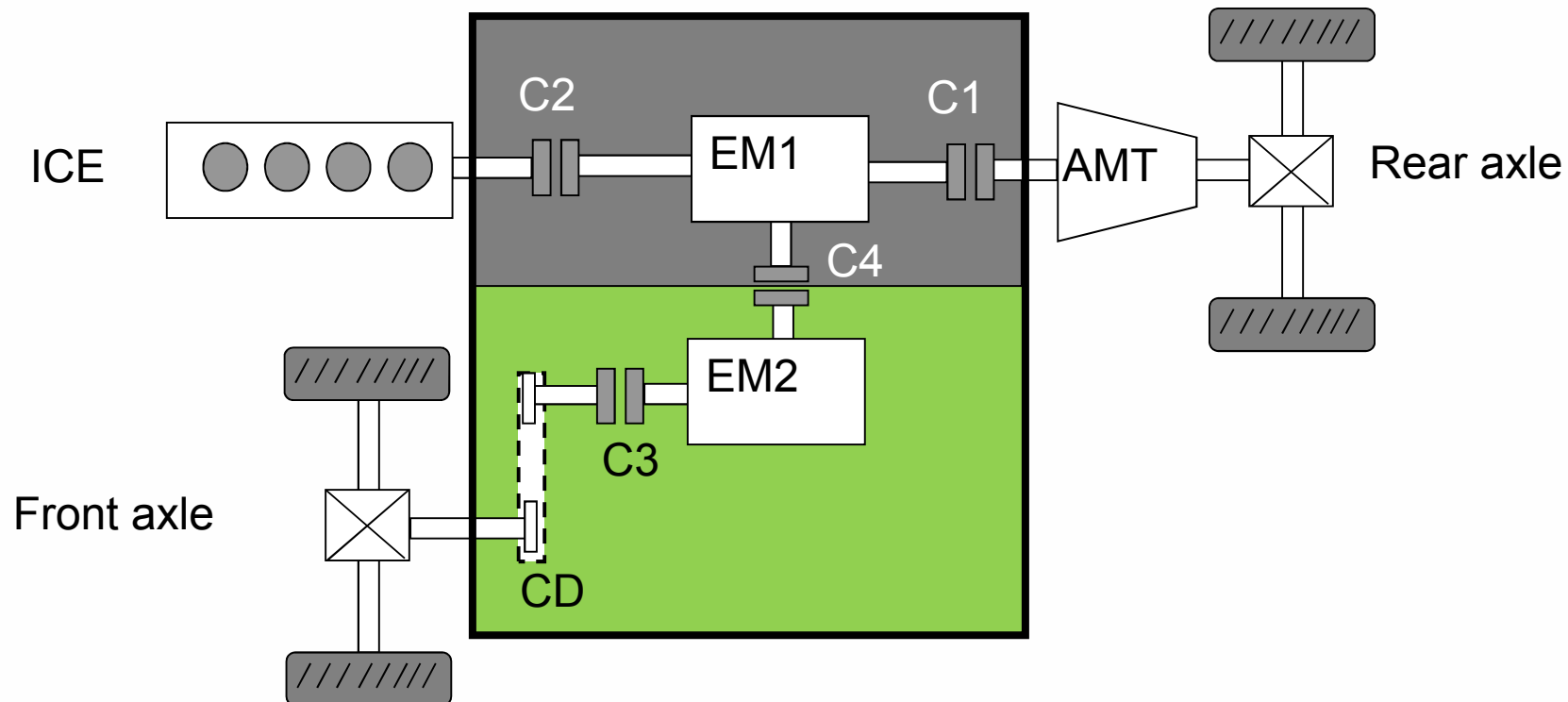
	Energy Storage System		Inverter	Motor Front	Motor Rear
Peak Power	70kW		50kW	55kW	55kW
Cont. Power	35kW		20 kW	25kW	25kW
Peak Torque	-		-	500Nm	350Nm
Cont Torque	-		-	250Nm	175 Nm
Energy Content	2,9 kWh				
Voltage	360V				
	Discharge	Charge			
Peak Current	200 A	150 A			
Cont. Current	120 A	80 A			



Example 1: E4WD Drive



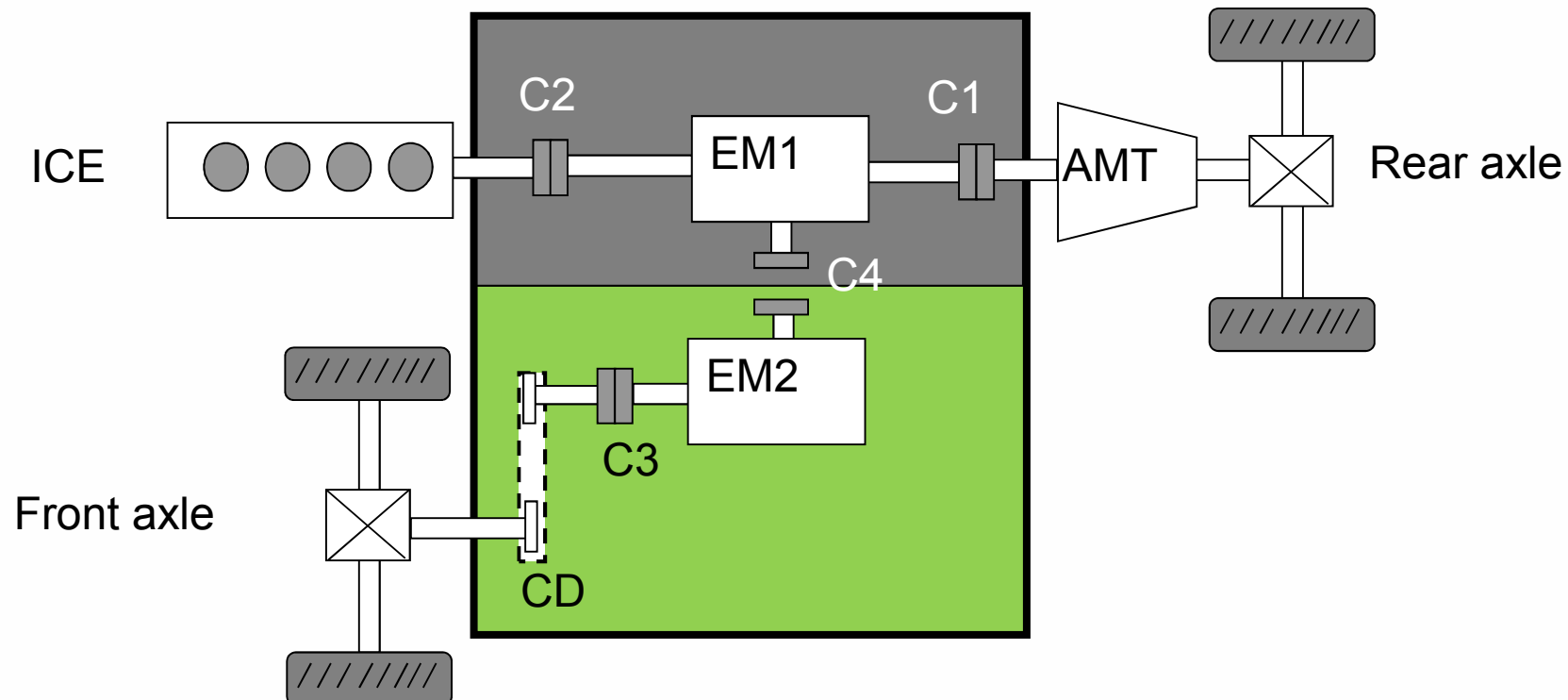
Topology



Example 1: E4WD Drive



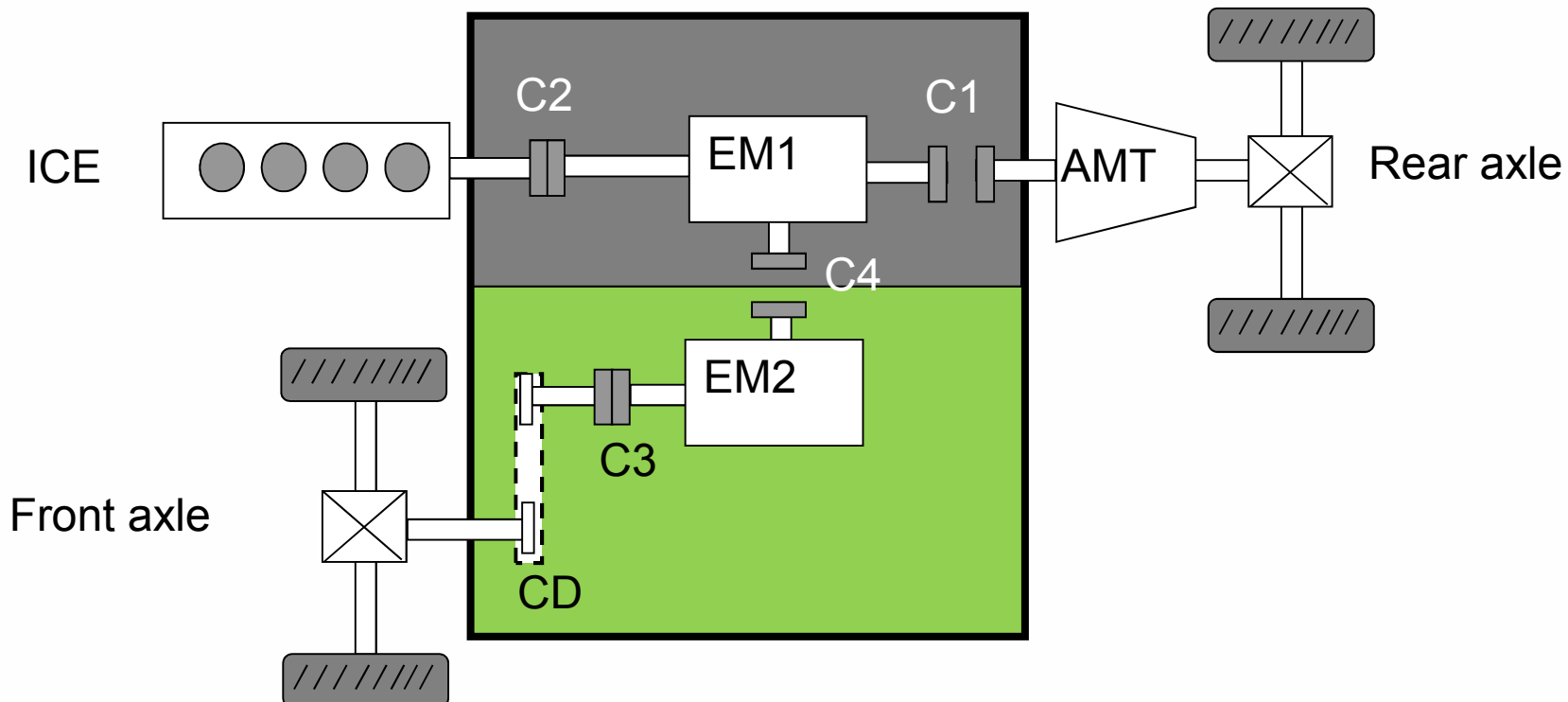
**Parallel Hybrid with
electric Front Axle
C1, C2, C3 Closed**



Example 1: E4WD Drive



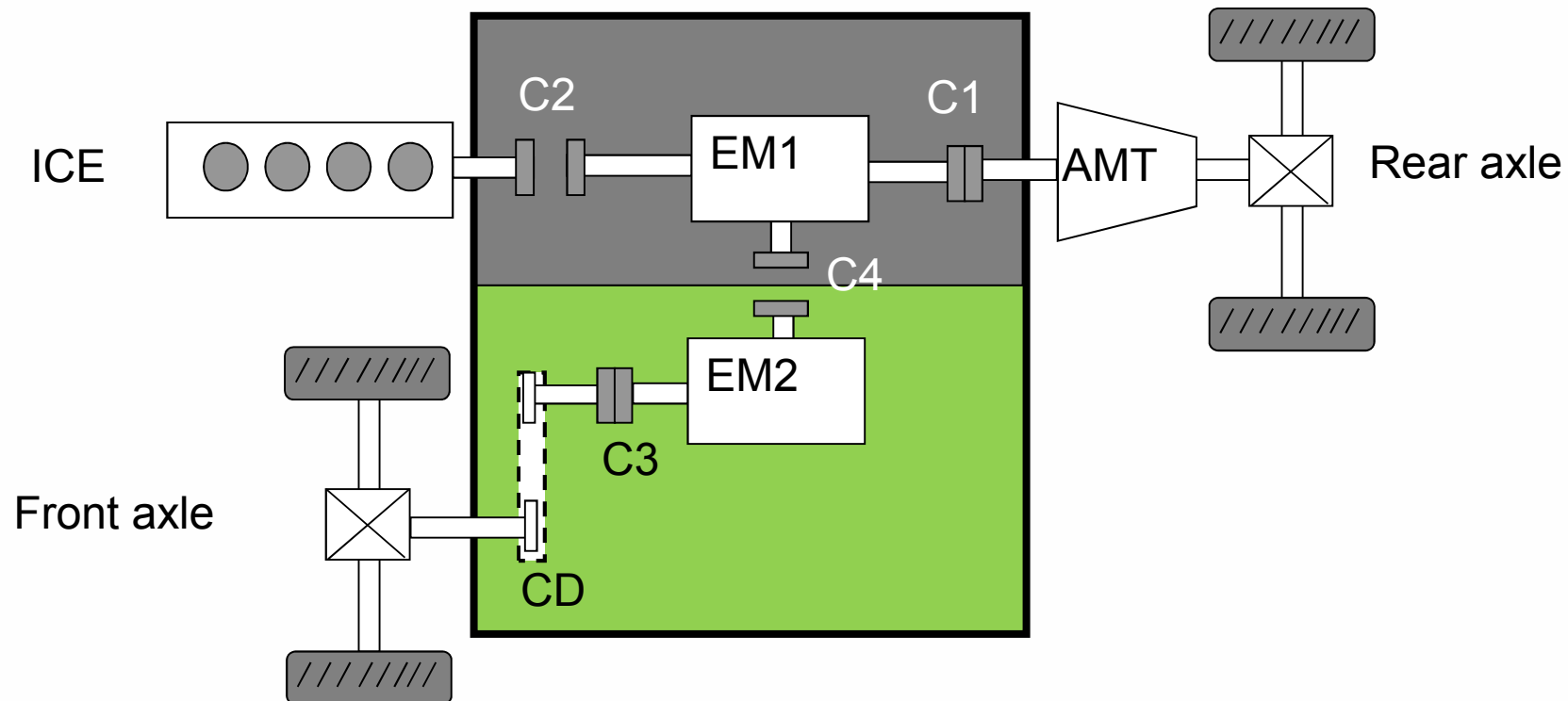
**Serial hybrid or pure
electric front axle drive
C2, C3 closed**



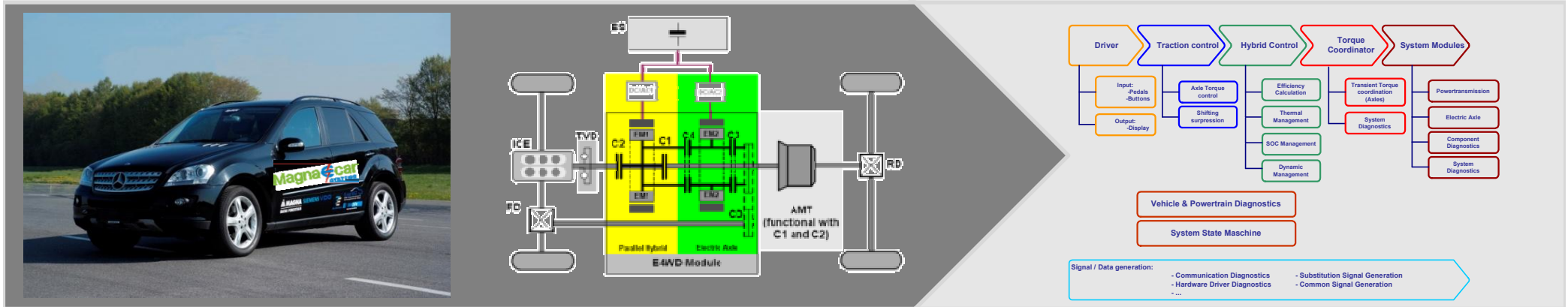
Example 1: E4WD Drive



Pure electric AWD
ICE decoupled



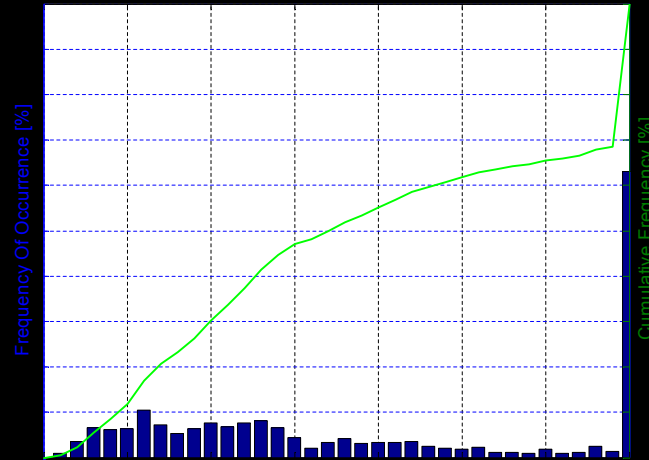
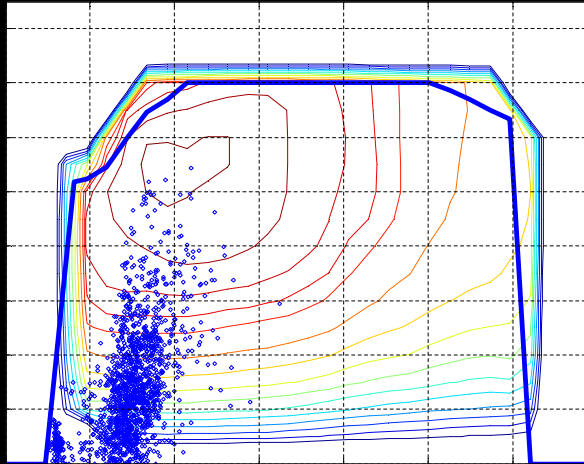
Example 1: Consumption - Standard Cycle



		ML 350 (Datenblatt)	ML 500 (Datenblatt)	HySUV	Datenblatt ML350	Datenblatt ML500
ECE	[l/100km]	15,4/15,2	18,6	kalt/warm 8,7 / 6,7		
EUDC	[l/100km]	9,6/9,4	10,4	11,0 / 11,0		
NEDC	[l/100km]	11,7/11,5	13,4	10,2 / 9,4	18%	30%
FTP75	[l/100km]	14,68	16,78	- / 11,2	24%	

Example 1: Consumption - Consumer Cycle

Basic Vehicle



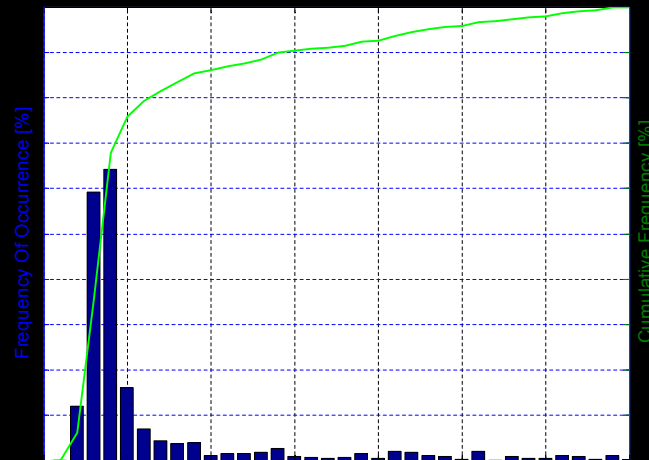
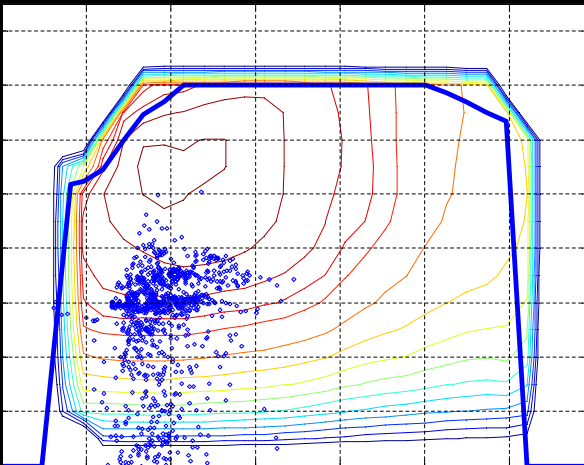
ML350

2387kg

11 l/100km

-10%

HySUV™



HySUV

2714kg

9,9 l/100km

SOC: +2%

Distance: 27 km

Example 2: Clean energy E4WD



- Enhanced performance and (electronically distributed) all wheel drive functionality
- E-AWD: boost and recuperation
- Pure electric driving possible (limited range)
- CO₂ reduction up to 15%
- MAGNA E-Car Systems Li-Ion power battery modules: approx. 1 kWh

	Energy Storage System		Inverter	Motor Belt	Motor Axle
Peak Power	42kW		50kW	6kW	12kW
Cont. Power	21kW		20 kW	12 kW	23 kW
Peak Torque	-		-	45 Nm	72 Nm
Cont Torque	-		-	20 Nm	38 Nm
Energy Content	1,2 kWh				
Voltage	180V				
	Discharge	Charge			
Peak Current	240 A	150 A			
Cont. Current	120 A	80 A			

Source: Magna E-Car Systems

Innovation out of Graz



HySUV™



compactcityhybrid^{64WD}



Mila EV

