High Efficient and Low Cost Plug-In-Hybrid-System

Automotive Summit 2010

By Obrist Engineering GmbH

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European Legal Requirements Tailpipe Emissions

European Union legislation (April 23rd, 2009)

- Regulation (EC) No. 443/2009
  "Setting emission performance standards for new passenger cars"

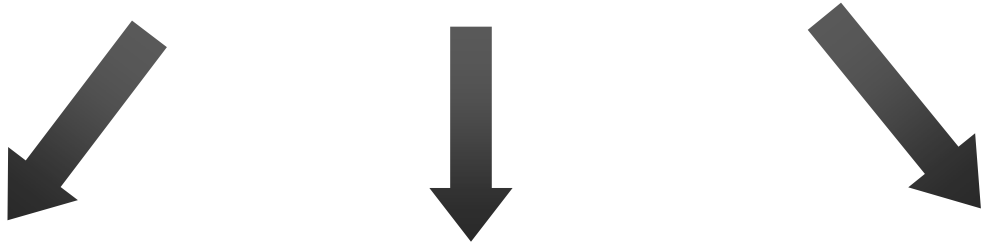
- CO_2 emission target until
  - 2015: 130 g/km (average fleet and depending on vehicle mass)
  - 2020: 95 g/km (following review January 1st, 2013)

Source: Regulation: 443/2009

European Legal Requirements Tailpipe Emissions

CO_2 Emission Calculation UN ECE 101 (2005)

Test cycle = 1 x NEDC



Electric Vehicle

M = 0 gCO_2/km

HEV

$$M_0 = M - K_{CO2} \times Q$$

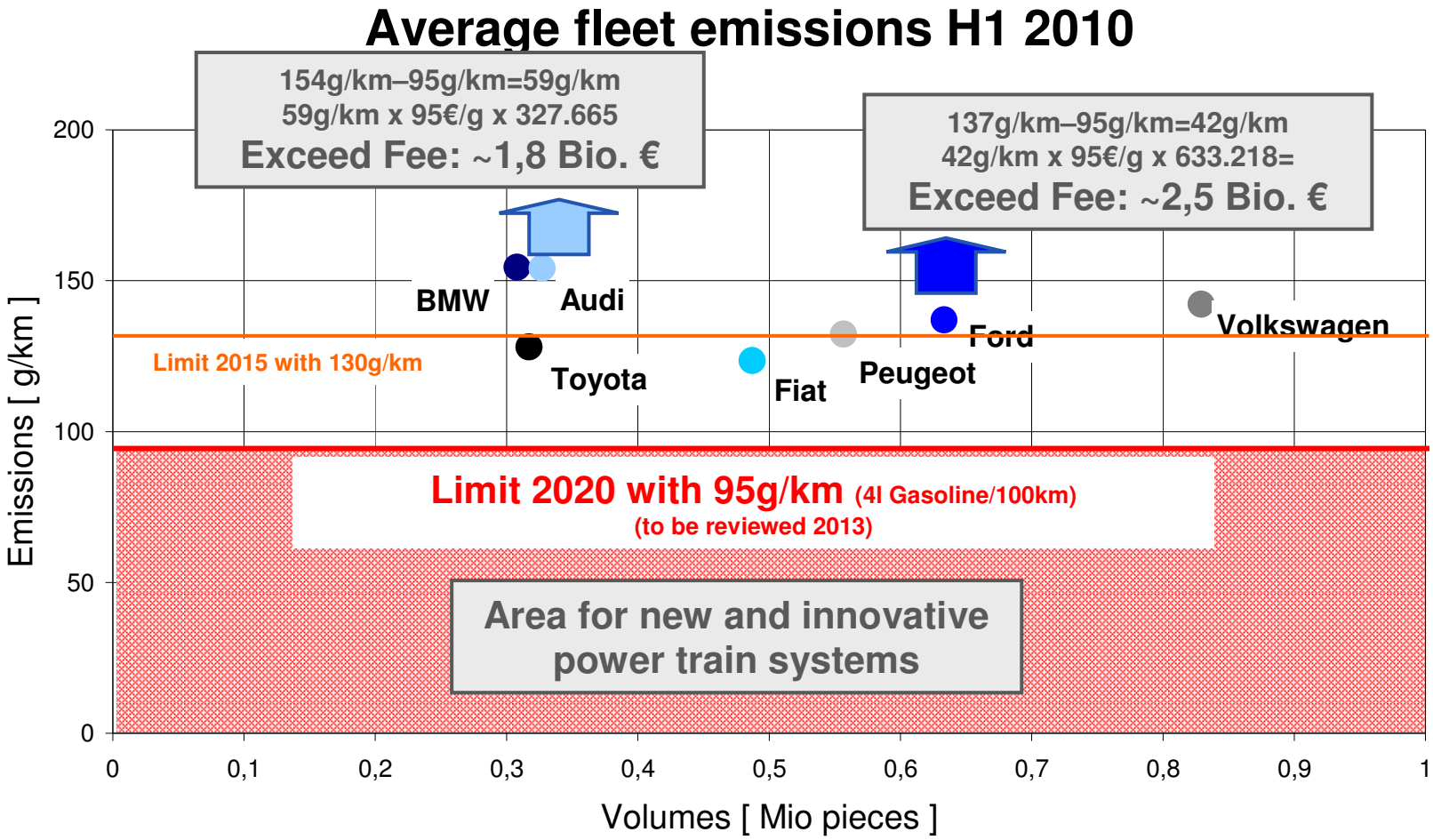
PHEV

$$M = \frac{(D_e \times M_1 + D_{AV} \times M_2)}{(D_e + D_{AV})}$$

- Driving distance in electric mode is calculated with “Zero” CO_2 emissions
- Calculated emission value is baseline for “Credits and Exceed Fine”

Source: Regulation: 443/2009

Current Emission Situation (EU)



Source: JATO
H1: Jan-June 2010

Potential Emission Reduction Technologies

Emission reduced fuels

Emission optimized Powertrains

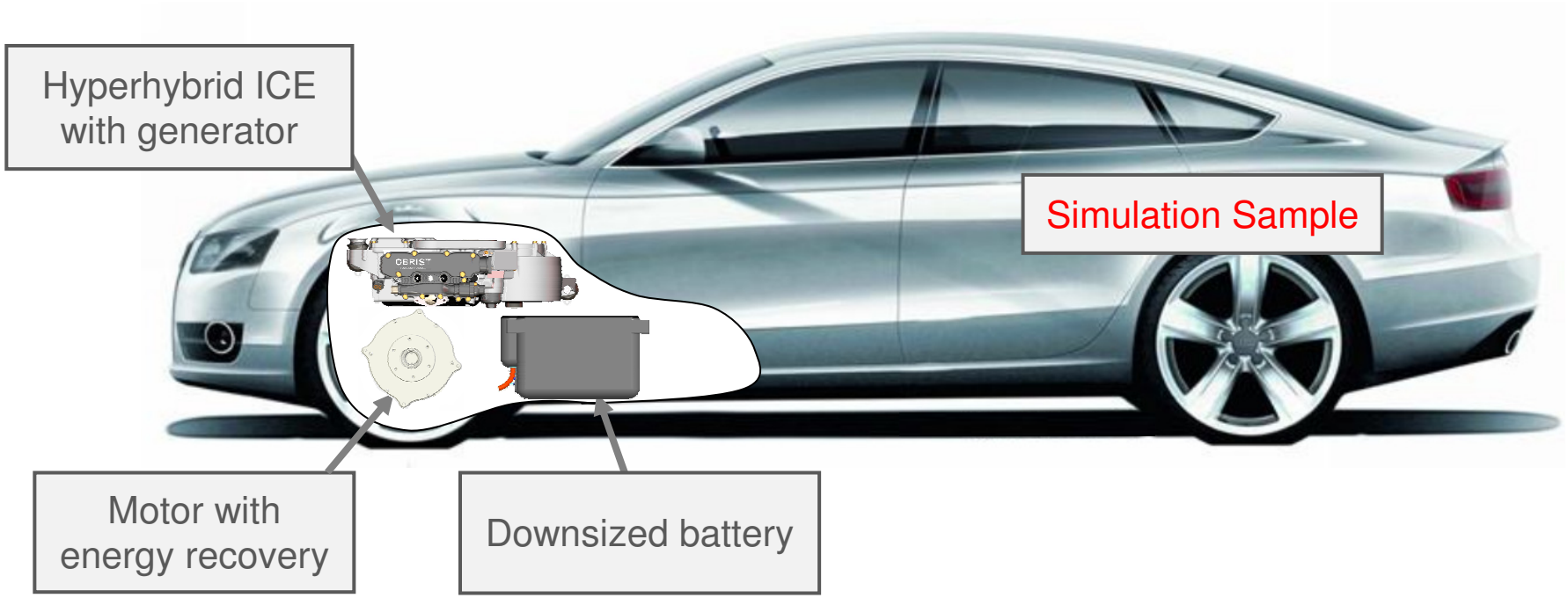
- Based on Obrist Engineering experience in the fields of:
  - Fuel cell technology
  - Variable valve drive for combustion engines
  - Exhaust gas energy recovery
  - Development for mass production PHEV

Obrist decided to focus the development on Serial-Plug-In-Hybrid technology called

“Hyperhybrid”

Hyperhybrid Powertrain

- Plug-In serial hybrid vehicle
- City drive in E-mode possible
- Comparable operating range to standard combustion system



Hyperhybrid Powertrain

- Key Features:
  - Compact and high efficient internal combustion engine “HICE” up to 60kW shaft power
  - Up to 125kW Motor shaft power
  - HICE operation only at maximum load without partial load
  - Downsized, high power Li-Ion battery with 8-12kWh with high discharge capacity (minimized size, weight and costs)
  - Regular battery stroke (DOD) only 20% (maximized lifetime)
  - Innovative thermal management for battery system (lifetime, operating range…)
  - Unique overall vehicle thermal management (energy and comfort optimized compartment heating, minimized cold start emission…)

Hyperhybrid Powertrain (Simulation Results)

2,0 TDI 125 kW

AUDI A5 Sportback

HICE: 40kW

EM: 125kW

Battery: 8kWh

Hyperhybrid 125 kW

1550 kg	Total weight	1550 kg
137 gCO_2/km	CO_2 emission according to UN ECE Regulation No.101	36 gCO_2/km
5,2 l/100km Diesel	ECE-101 equivalent fuel consumption	1.6 l/100km Gasoline
8,7 sec.	Acceleration 0-100 km/h	8 sec.
~1000 km	Highway range	~1000 km
STOP	Inner city access / electric range	GO 46 km
228 km/h	Max. speed	205 km/h (short term) 145 km/h permanent
	CO_2 emission / Consumption constant drive	
140g/km (5,3 l/100km)	120 kph	156g/km (6,6 l/100km)
118g/km (4,45 l/100km)	80 kph	98g/km (4,1 l/100km)
109g/km (4,1 l/100km)	60 kph	77g/km (3,3 l/100km)

Hyperhybrid Powertrain (Simulation Results)

2,0 TDI 125 kW

AUDI A5 Sportback

ICE: 40kW

EM: 12[illegible]kW

Hyperhybrid 125 kW

Price calculation 2,0 TDI:

137g/km – 95g/km = 42g/km Exceed

42g/km x 95€/g = 3.990€ Exceed Fee

Price calculation Hyperhybrid:

Additional Hybrid Powertrain Costs: 2.000€

95g/km – 36g/km = 59g/km Credit

59g/km x 95€/g = 5.605€ Credit

36.050	**Current sales price Germany [€]**	**38.050**
36.050 **(+ 3.990 Exceed Fee)** **40.040**	**Sales price in 2020 [€]**	**38.050** **(- 5.605 Credit)** **32.445**

Internal Combustion Engine “HICE”

- Market research for requirement and available technologies has shown:

Ranking May 2010

1 Cost

2 Size

3 Power

4 Noise

5 Efficiency

6 Weight

Based on these findings different engine technologies have been evaluated !

Technologies

3 cylinder
4 stroke

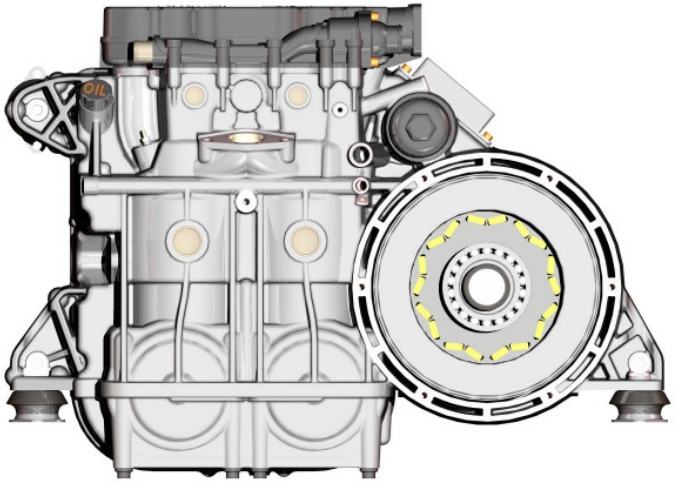
2 cylinder
4 stroke

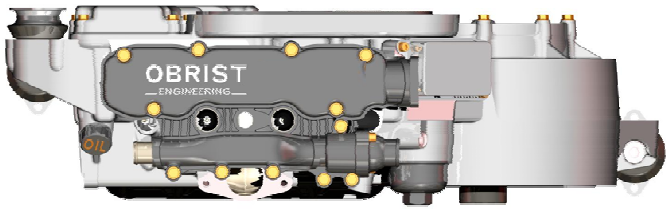
Wankel
single disc

Internal Combustion Engine “HICE”

- Engine design in cooperation with mass production supplier

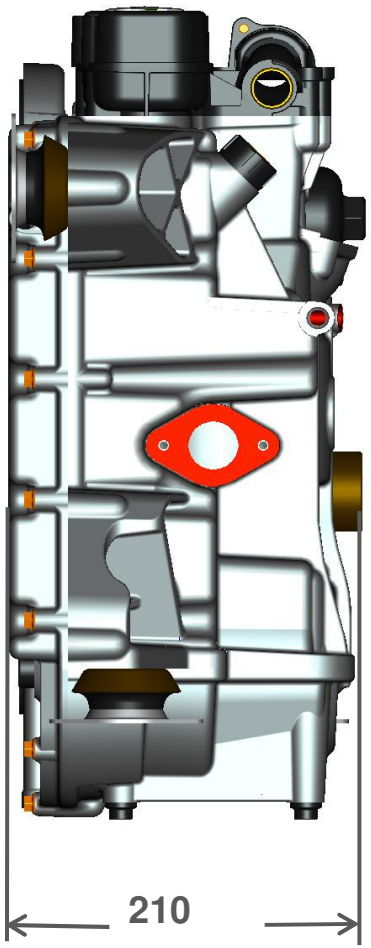
- Design and simulation completed
  - ✓ Engine displacement: 1098ccm
  - ✓ Compact design: 590 x 500 x 210mm
  - ✓ Engine weight with generator: 76kg
  - ✓ Specific fuel consumption: 225g/kWh
  - ✓ Generator size up to 60kW





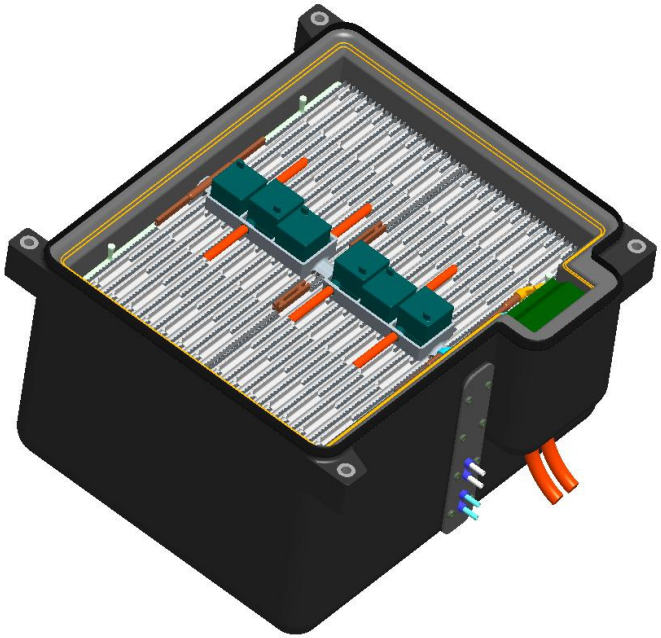
Internal Combustion Engine “HICE”

- Unique ultra compact 2 cylinder design
- Mounting position freely selectable
- Integrated generator
- Friction optimized mechanism
- Twin crankshaft configuration for total mass balancing
- Maximum load operation only
- Optimized specific fuel consumption for max load point

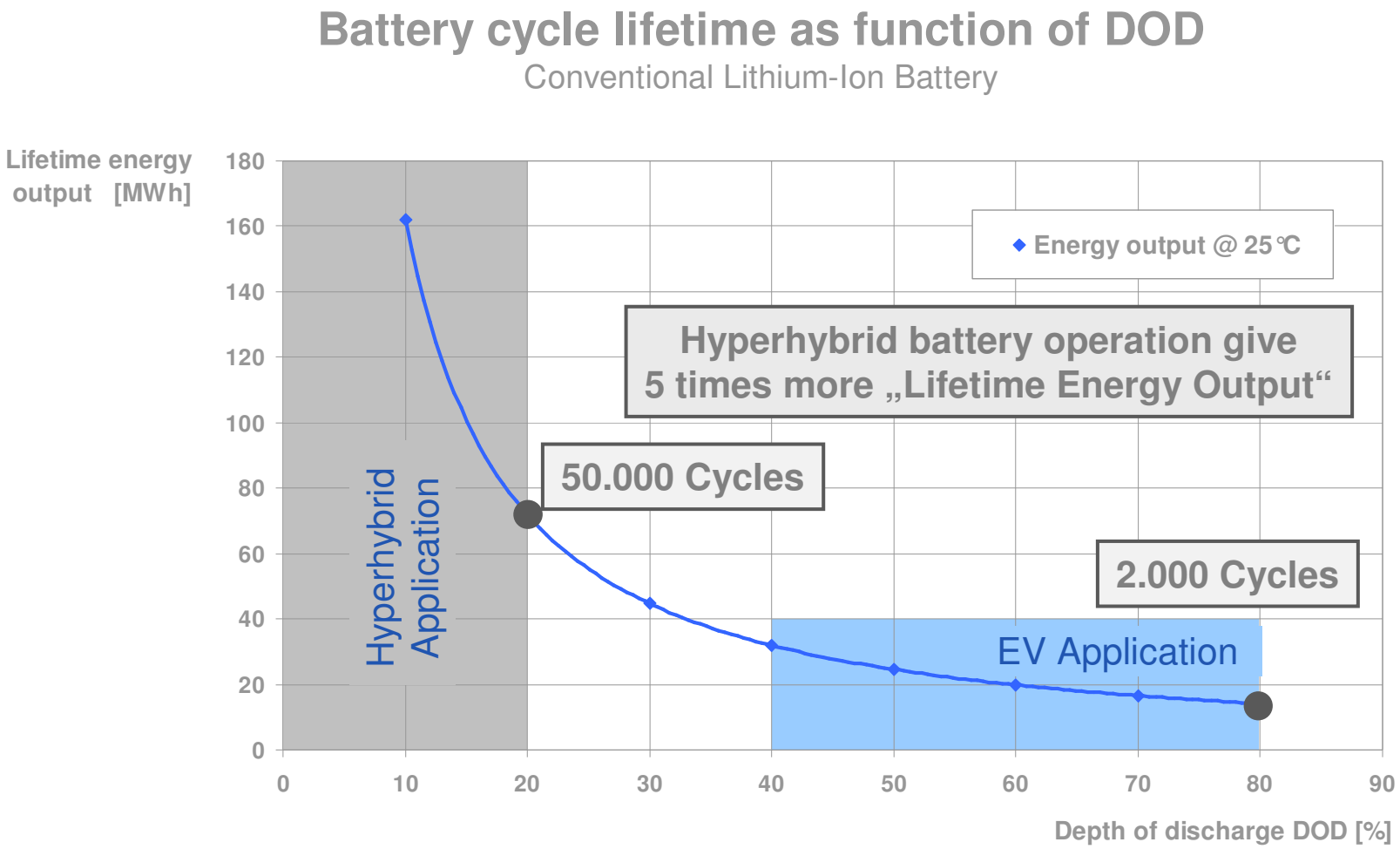


Downsized Battery System

- Modular high power battery system with 8-12kWh
- High power cells >= 15C discharge
- Internal fluid cooling system for homogenous cell temperature distribution
- External interface for cooling and heating system
- Innovative internal cell fixation system
- Compact system with no mounting limitations
- Regular DOD during operation only 20%
- Plug-In chargeable

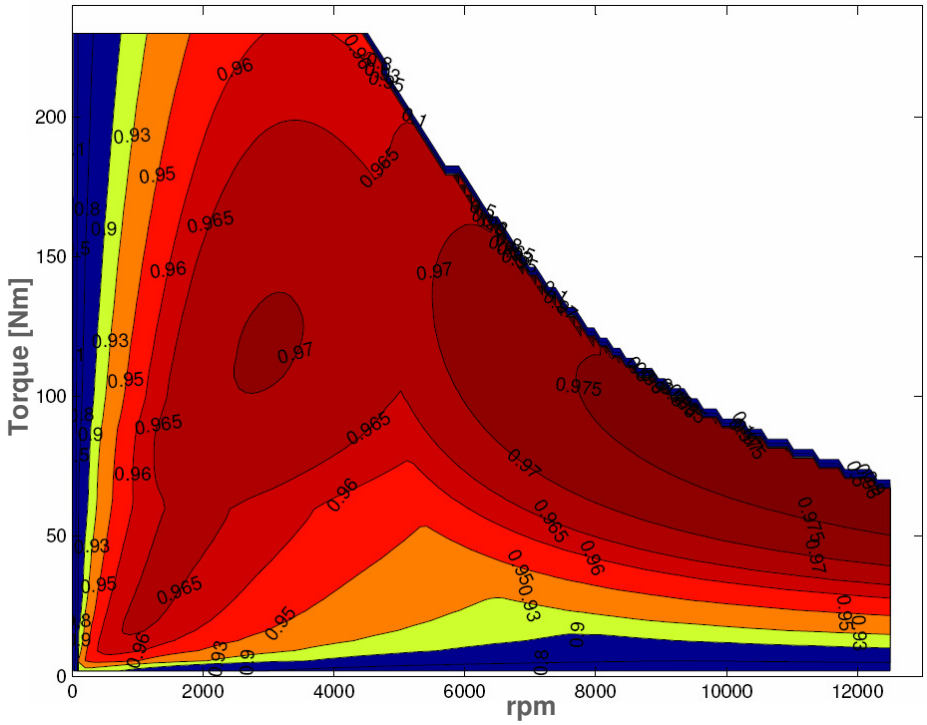


Downsized Battery System

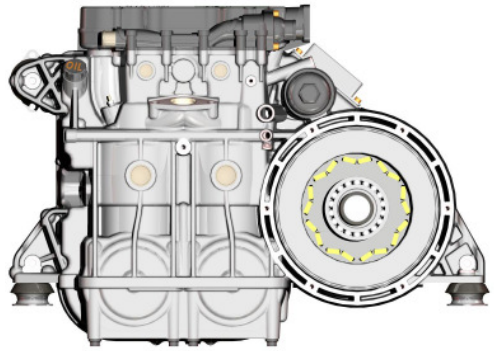


High Efficient Motor

- A key part for a low emission hybrid system is a high efficient Motor/Generator system
- High efficient mass production system available (including inverters)
- Efficiency values > 97%



Innovative Thermal Management



- Innovative “HICE” insulation
  - ✓ Energy optimized compartment heating
  - ✓ Emission reduced warm start up
  - ✓ Use of the HICE as a “Energy Storage Unit”
- Battery insulation system
  - ✓ Minimization of energy demand for thermal management
  - ✓ Extension of battery operating range (Hot and cold application)
  - ✓ Optimization of battery lifetime
- Interior thermal management
  - ✓ Effective heating and cooling system to maximize mileage

Summary Hyperhybrid Powertrain

- ✓ Exceeds EU Emission regulations
- ✓ Low emission values allows credits for other platforms
- ✓ Low cost PHEV with more then 40km City E-drive range
- ✓ No restriction for the costumer vehicle use

"Hyperhybrid"

Is the power train solution for the high volume market

INTERESTED IN A DEMONSTRATOR ?