Hybrid Technology – System and vehicle design for mass production



A3PS Conference "Alternative Propulsion Systems and Energy Carriers: Vehicle Integration and System Optimization" Vienna, 18-19.November 2010

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Powertrain map in future mobility





History of Toyota & Lexus Hybrid Vehicles





Benefits of a full hybrid





Example Prius III: Development Targets

Based on the THS architecture, which is well proven in ~3.000.000 Toyota/Lexus hybrid vehicles sold:

- 1. Improvement of fuel consumption Focus real world driving, highway cruising, winter season
- 2. Satisfaction of the most stringent emission regulations
- 3. Applicability of different vehicle models for full scale mass production (lightweight, system output, cost)



Evolution of Hybrid System





Engine Displacement

- Select 1.8L engine enlarged from current 1.5L engine to improve fuel economy during high speed cruising

Engine operating point (\star) at 120km/h cruising (same road load) 2nd Prius (1.5L) : 2,500 rpm **2**-300 rpm 3rd Prius (1.8L): 2,200 rpm



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6000

240g/kWh

220

230

4000

Motor speed reduction device





Motor speed reduction device





Concept of motor downsizing





Generator length -34%

Motor length -27%

Mass reduction of electric machines 35% Volume reduction of electric machines 40%

Transmission length -13mm (385 \Box) 372mm) Transmission weight -20% (109 \Box) 88kg)

Mechanical transmission losses -20% (bearing loss reduction, lubrication optimisation, chain \Box gear drive to diff.)







Power Control Unit

	2 nd Prius	3 rd Prius	
Cooling structure	Insulating substrate Heat sink (Cooper alloy) Grease	Direct cooling structure Punched plate	
	Cold plate (Al)	Cold plate (Al)	
Max.system voltage	500V +15	ov 650V	
Weight	21kg -45	% 13.5kg	
Volume	17.7L -37	% 11.2L	









Battery: Energy Density







Cost reduction for hybrid components: -40%



Fuel Economy, Emissions, Performance

- Fuel economy improvement: 7-14%

Test driving cycle	2 nd Prius	3 rd Prius
U. S. Combined Mode	46 mpg	50 mpg
NEDC Mode	104 g/km	[‰] ► 89 g/km
Japan 10-15 Mode	35.5 km/L ^{7.0%}	→ 38.0 km/L



Highway fuel consumption: 120km/h const. speed: -10%

Emission level:

- Europe: Step 5
- US: SULEV/ATPZEV
- Japan: S-ULEV



Fuel Consumption Improvement

Hybrid transmission contributes directly and indirectly by improving the engine operation





CO2 and NOx emissions



Hybrid transmission allows to use the full environmental potential of engines



The Next Step: Plug-in hybrid (PHV)

Gasoline station

Household electrical energy or public charging post



PHV: "the best of both worlds"



Driving range and convenience





EV range impact on vehicle package





Road trial: daily trip length





Road trial: fuel efficiency





Plug-in Hybrid: CO2 reduction potential



CO2 reduction in well-to-wheel highest with CO2-free electric energy



First PHV application

Limited lease, globally 600 (Europe ~200)

Cooperation with electricity providers (e.g. EDF France: Strassburg)

Development targets:

- EV range: ~20 km (Li-ion battery)
- CO2 figures: <60 g/km
- EV max speed: ~100 km/h
- Charging time: less than 2 hours (220V, 16A)
- Normal vehicle useability (5 persons + trunk)

Next: PHV mass production start 2012







Toyota Hybrid System applications









Conclusion

Hybrid is a key technology for all type of powertrains





Towards 1 million Toyota hybrid vehicles per year



Thank you very much for your kind attention!

