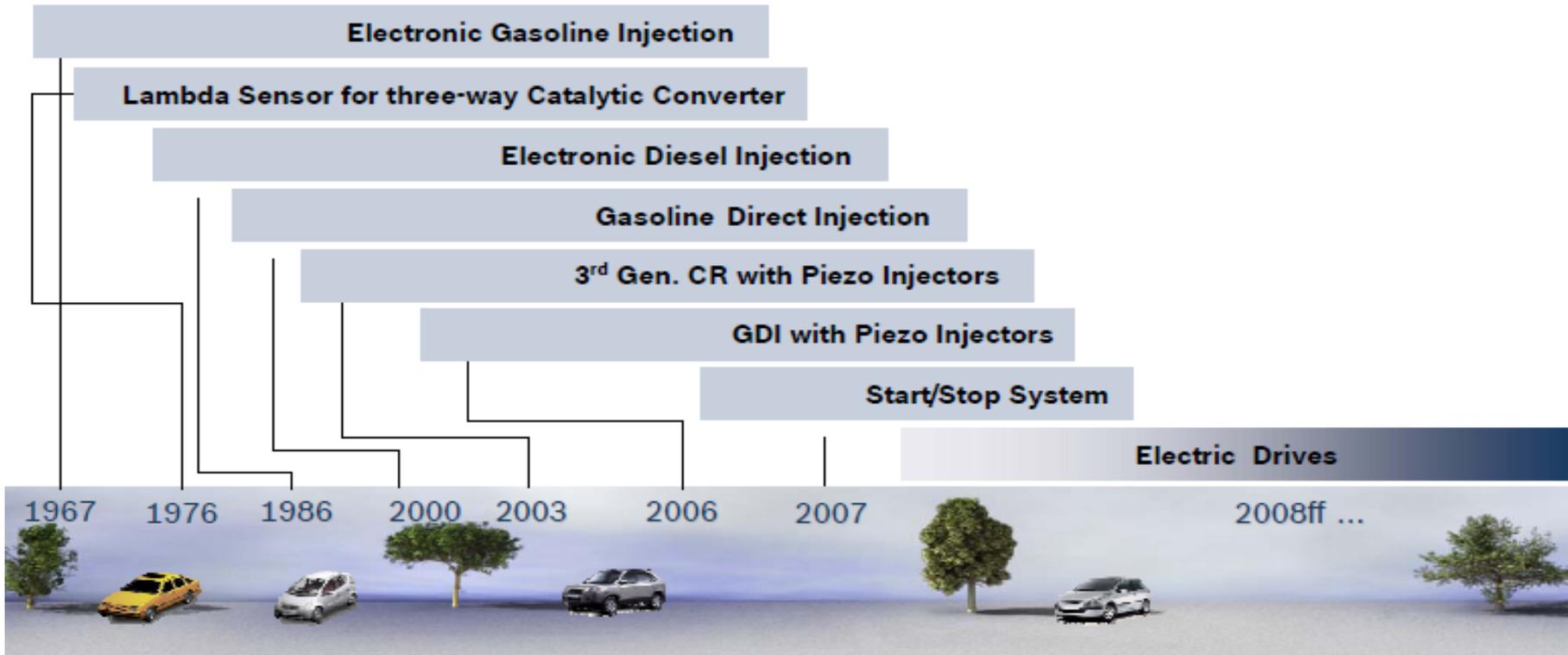


Fondamenti di Motorizzazione Ibrida

Pietro Capaldi

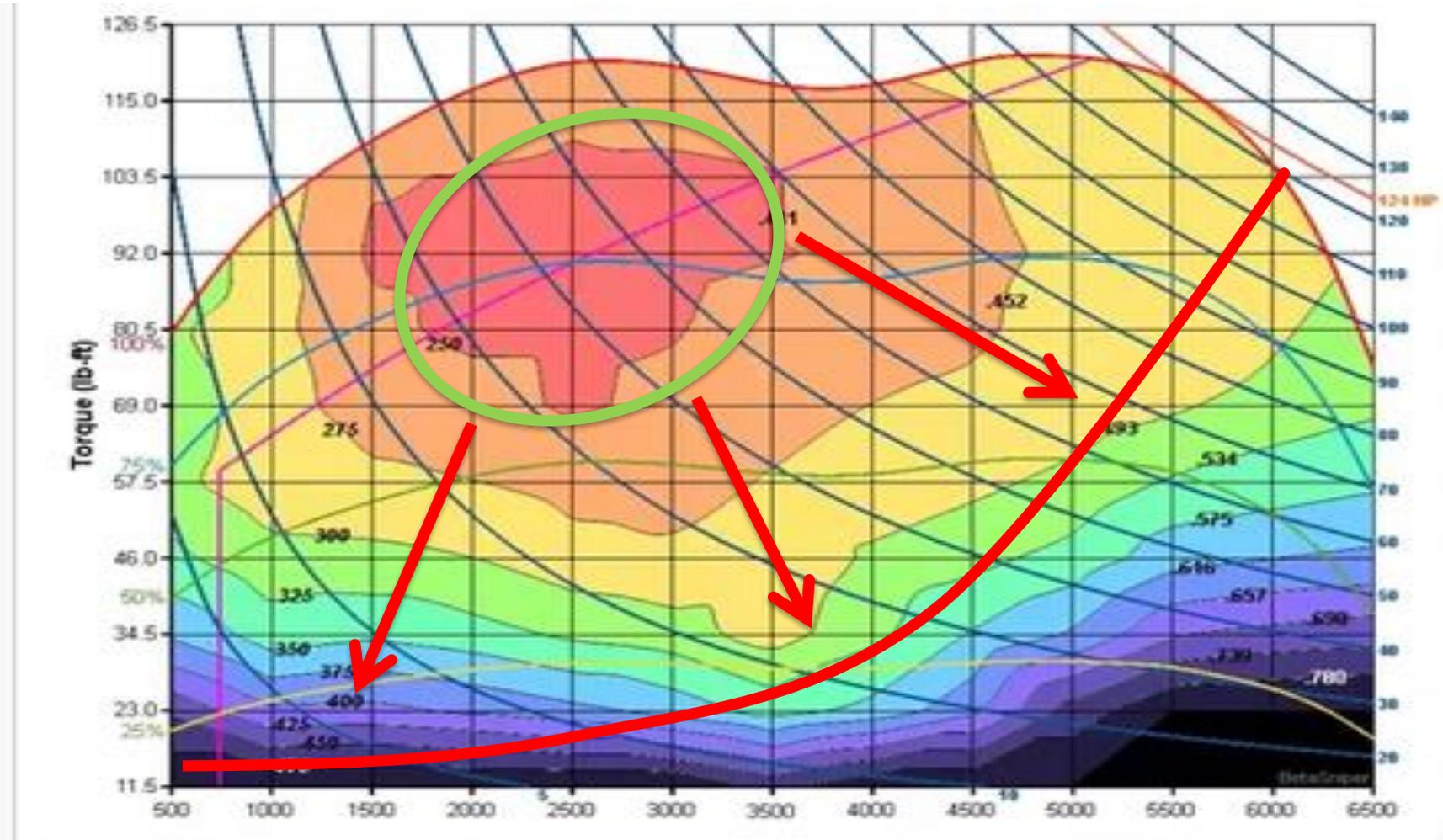
Istituto Motori C.N.R.

Development in Powertrain Technology (Examples)



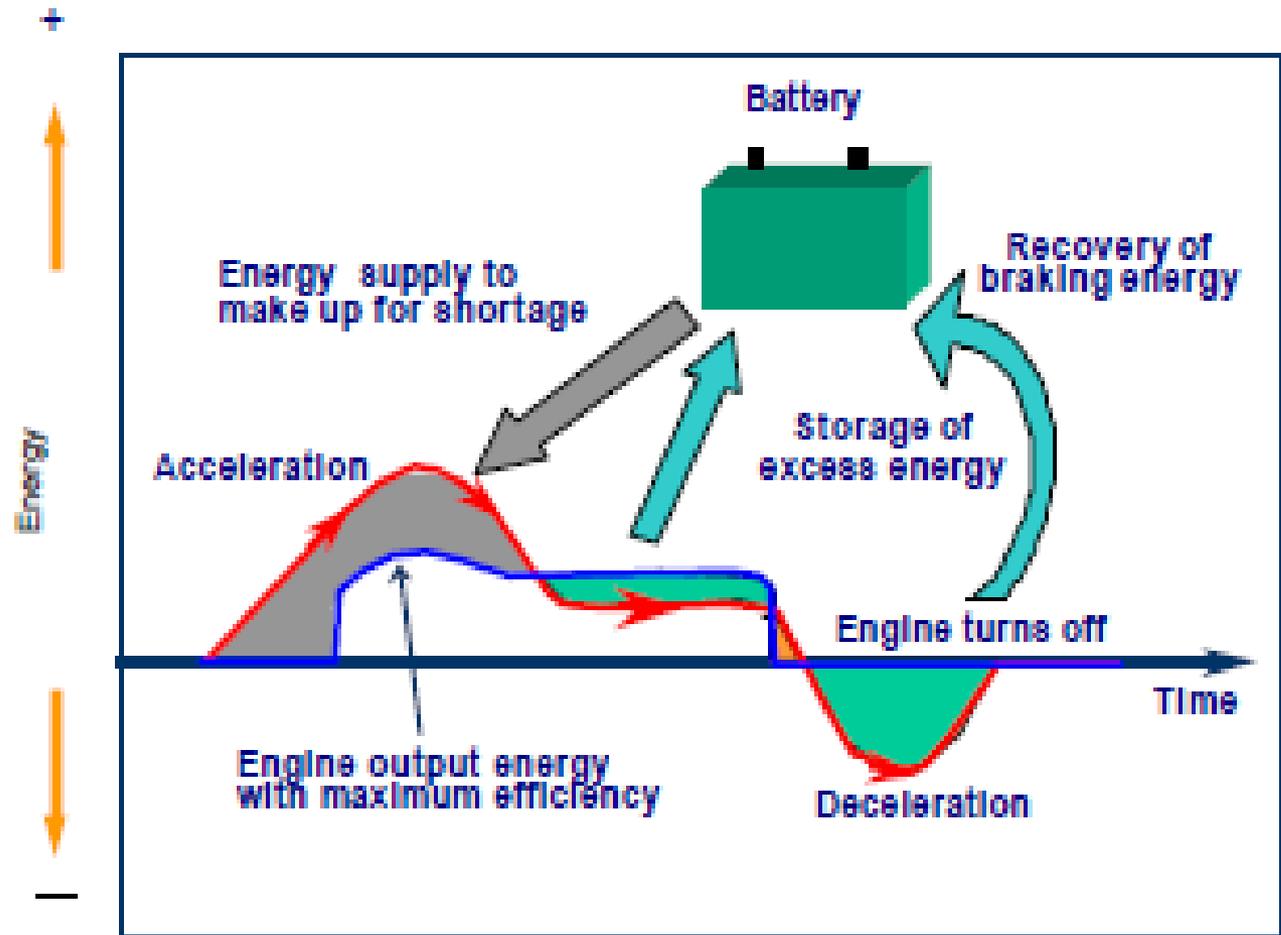
➤ Hybrid Drives are the latest technology milestone for CO2 reduction

Massimo rendimento e carico strada



MANAGEMENT DELL' ENERGIA

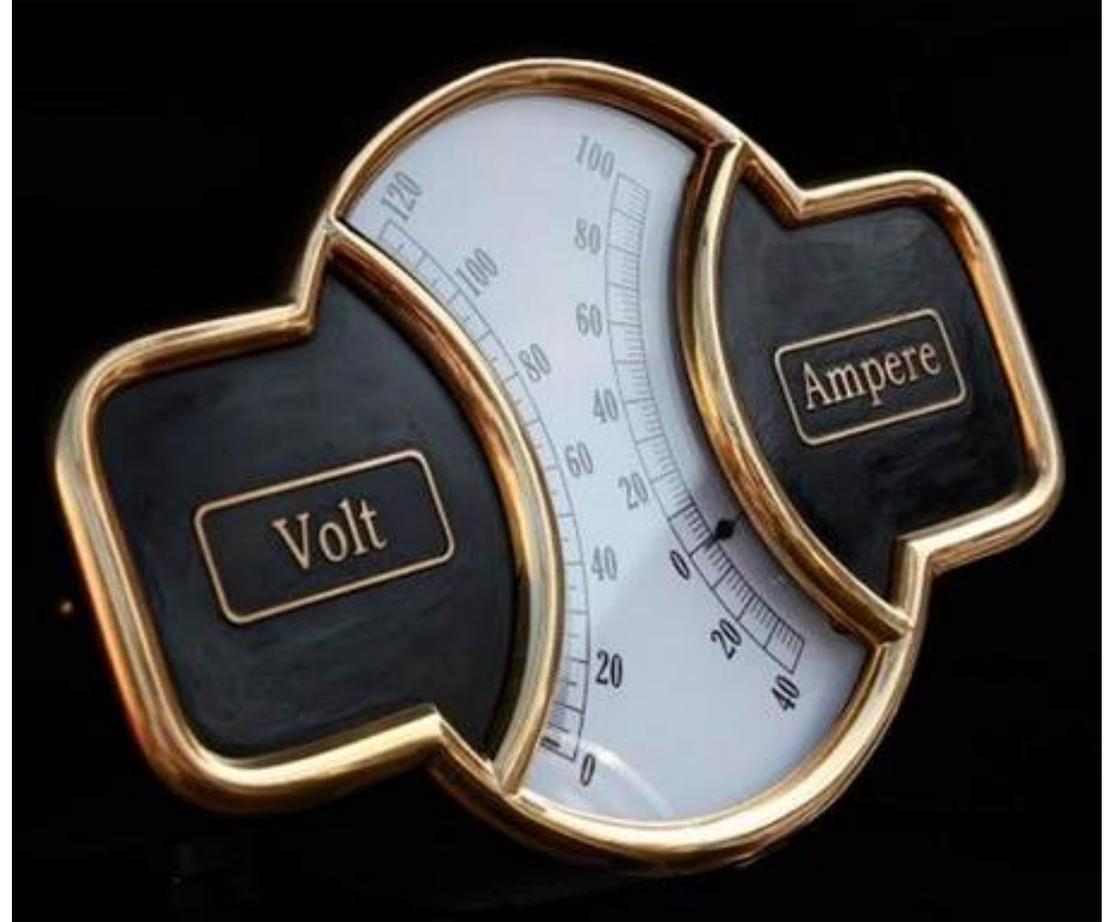
La principale caratteristica degli ibridi e' la presenza di un sistema reversibile di storage elettrico che consenta l'uso del m.c.i. in condizioni vicine al massimo rendimento



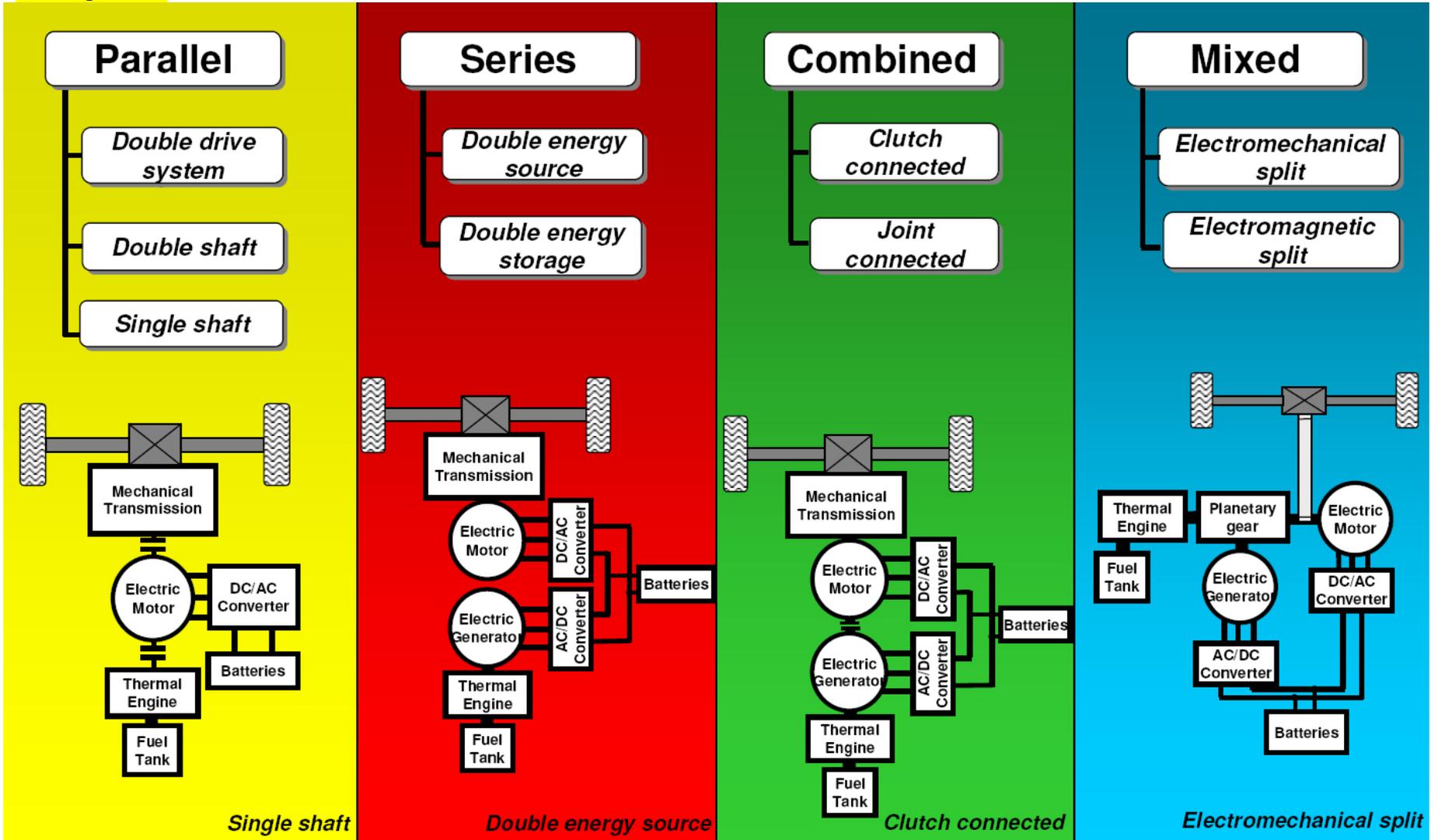
Il primo ibrido della storia: Porsche Semper Vivus



Il primo ibrido della storia: Porsche Semper Vivus



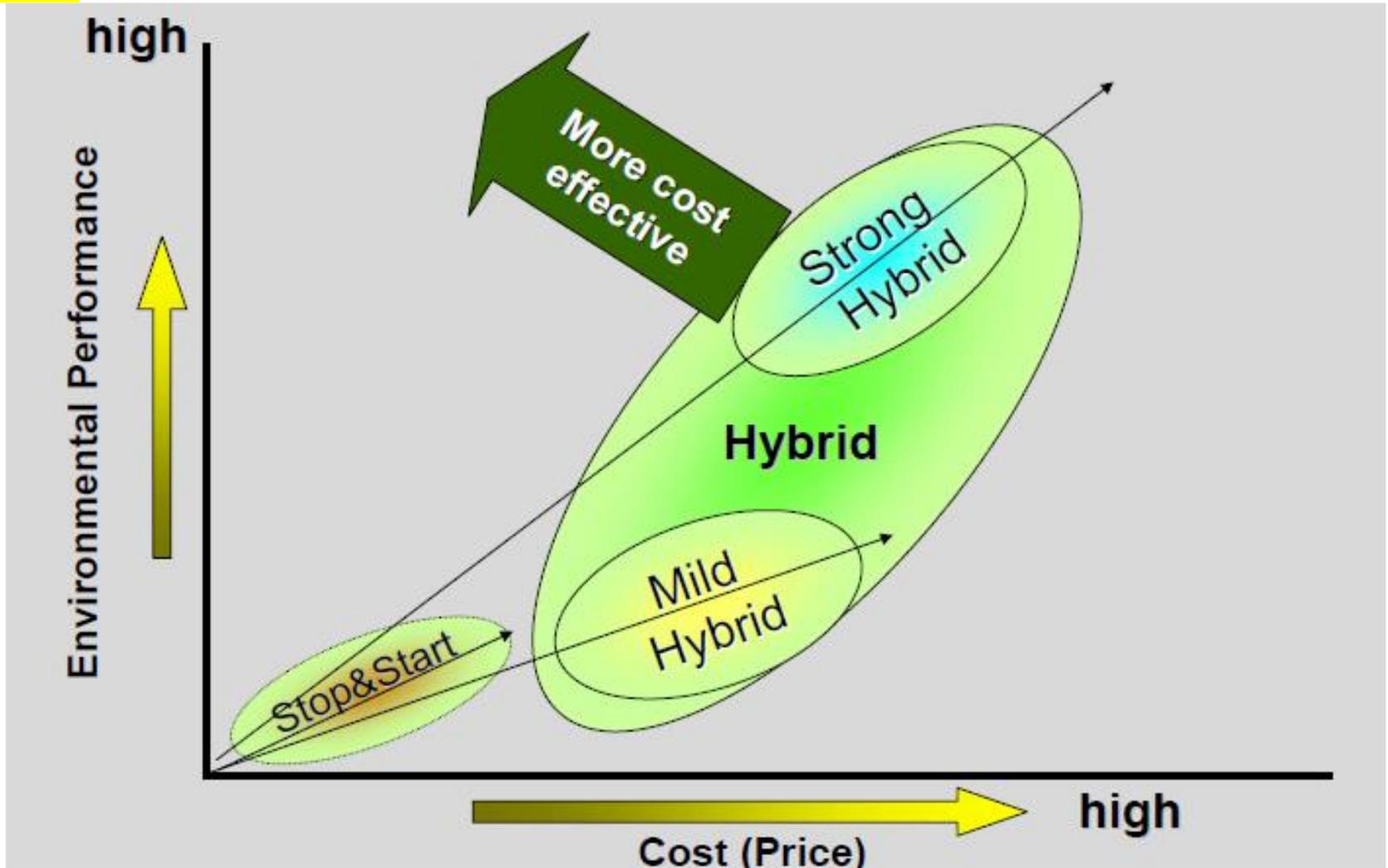
Tipologie di Ibridi



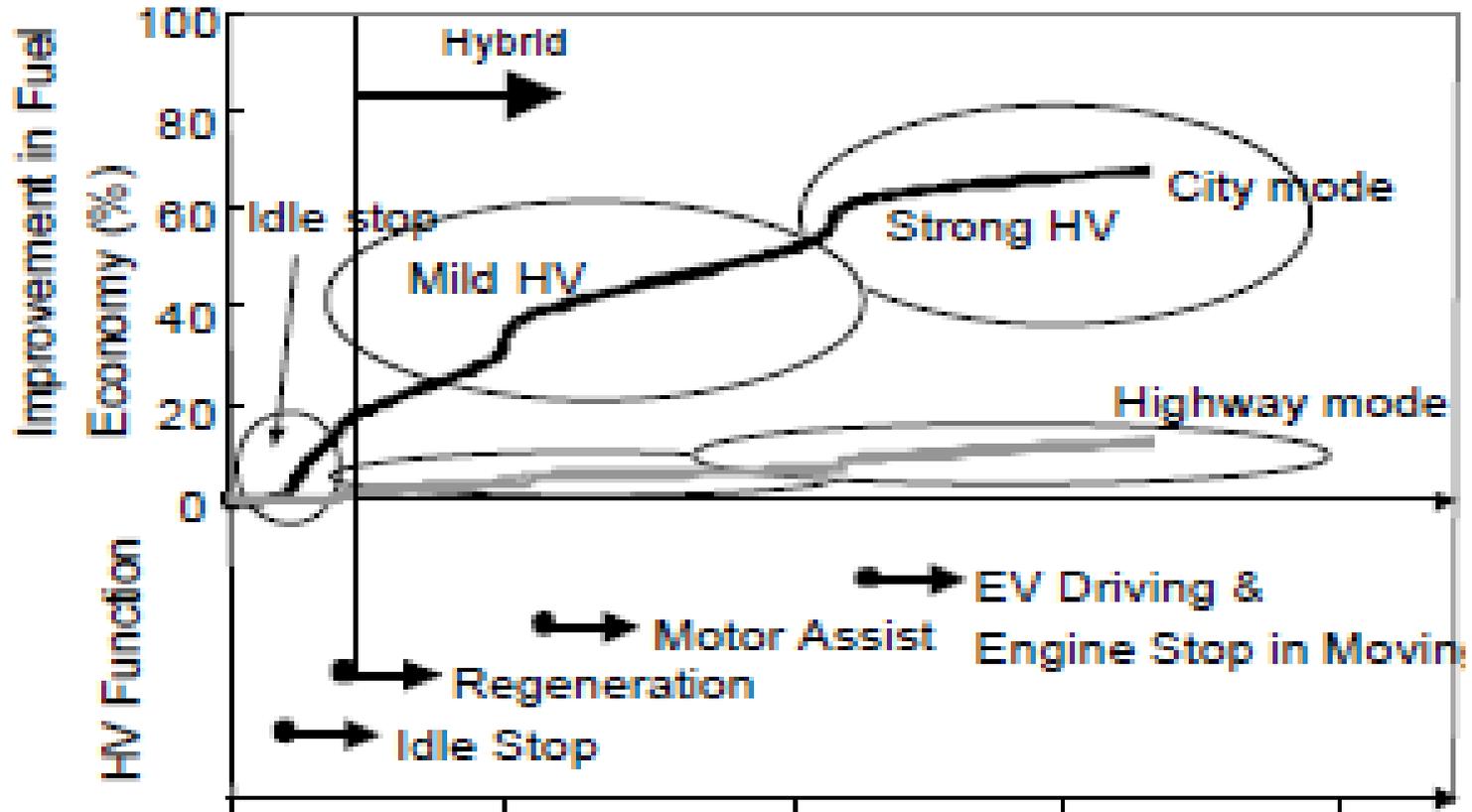
Ibridi Mild e Strong

- In generale è possibile suddividere i veicoli ibridi mediante il rapporto tra le potenze generate dal mci e dal gruppo motore/batteria. $HG = E_p/T_p$
- Ibridi “mild” hanno un $HG < 0.30$ ed hanno funzione di ricarica della batteria a bassa tensione ($< 60V$) per i carichi di bordo e l’energia cinetica in frenata) per fornire assistenza al MCI durante i transitori
- Gli ibridi “strong” hanno un $HG > 0.30$, con potenze che consentono (a seconda degli schemi) anche la marcia in elettrico e con il mci funzionante a massimo rendimento

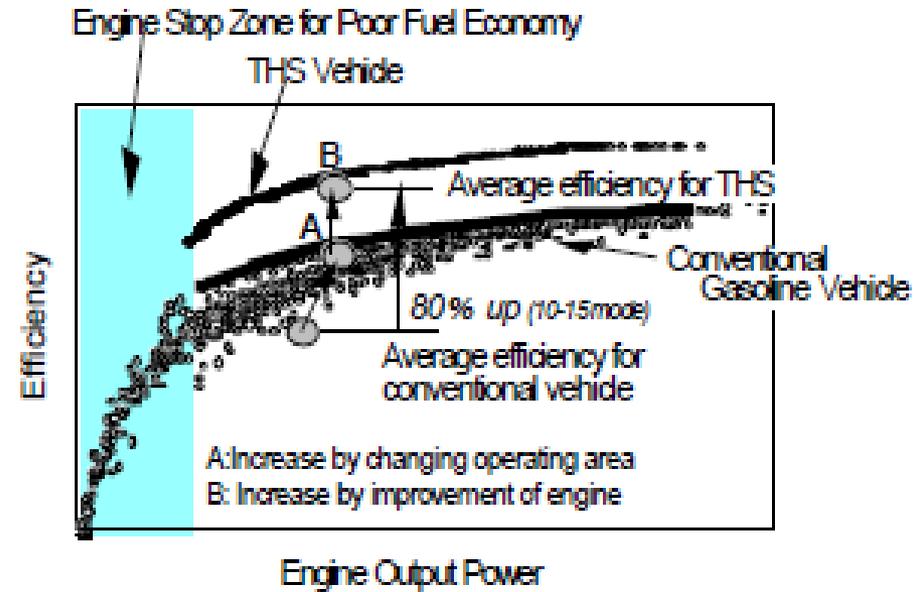
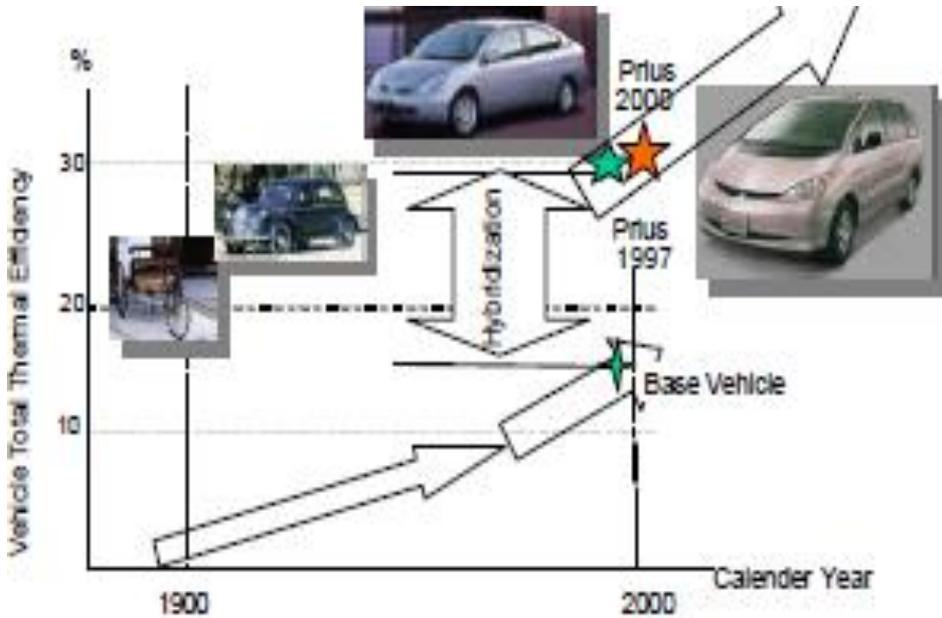
Costi e prestazioni ambientali



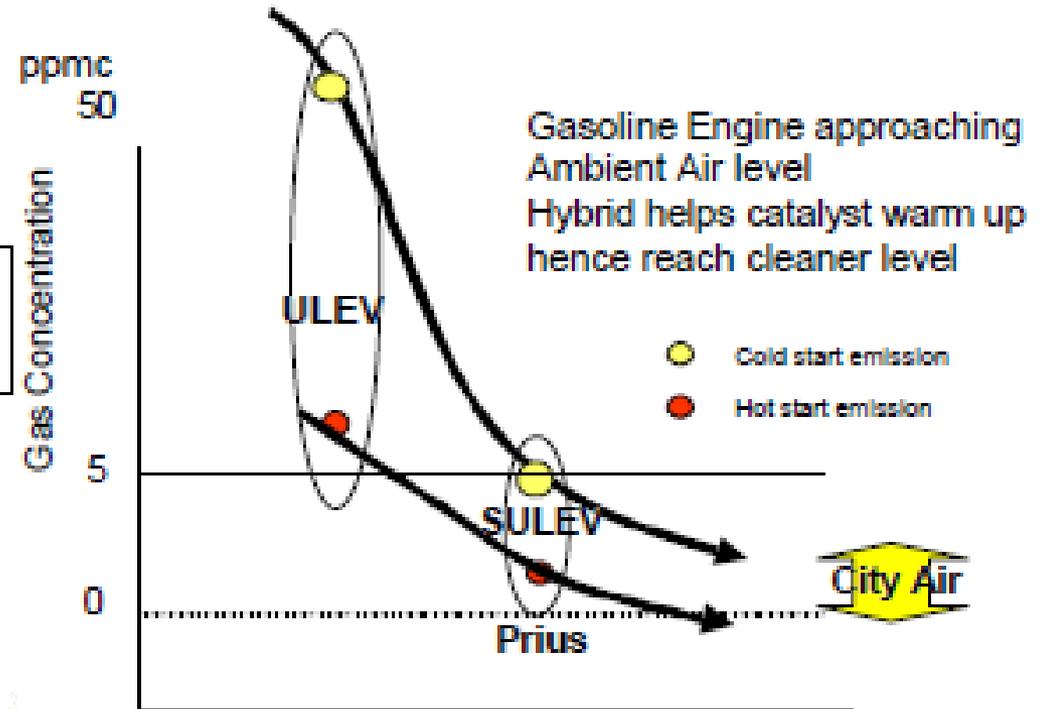
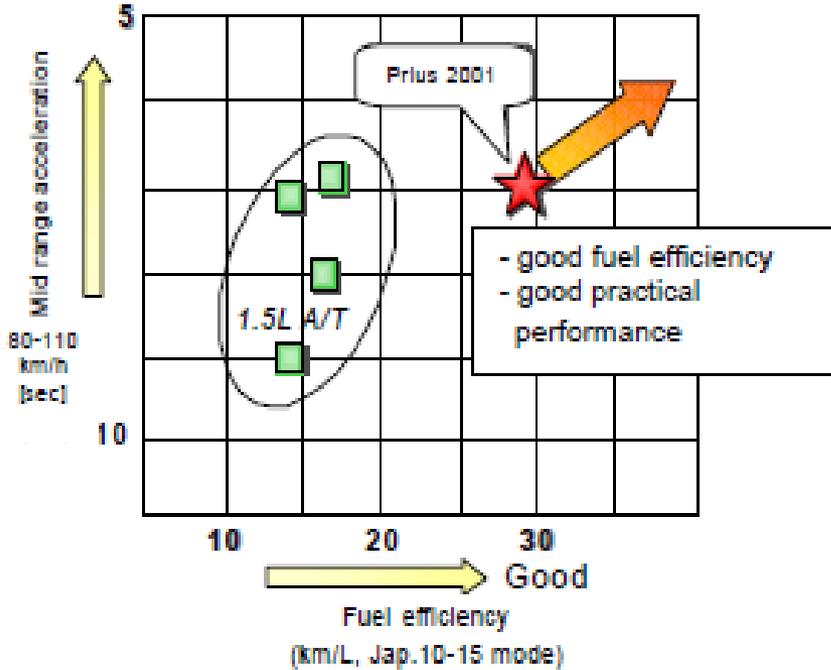
Rapporto di potenza MCI/BATT e Fuel economy



Ottimizzazione dell' area di utilizzo del motore

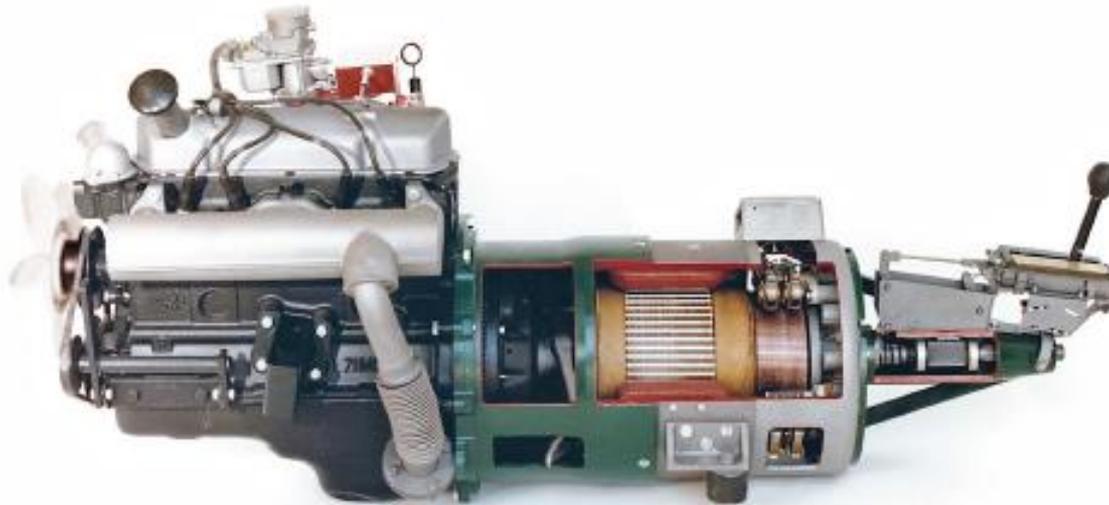


Prestazioni generali dichiarate Toyota Prius 2003



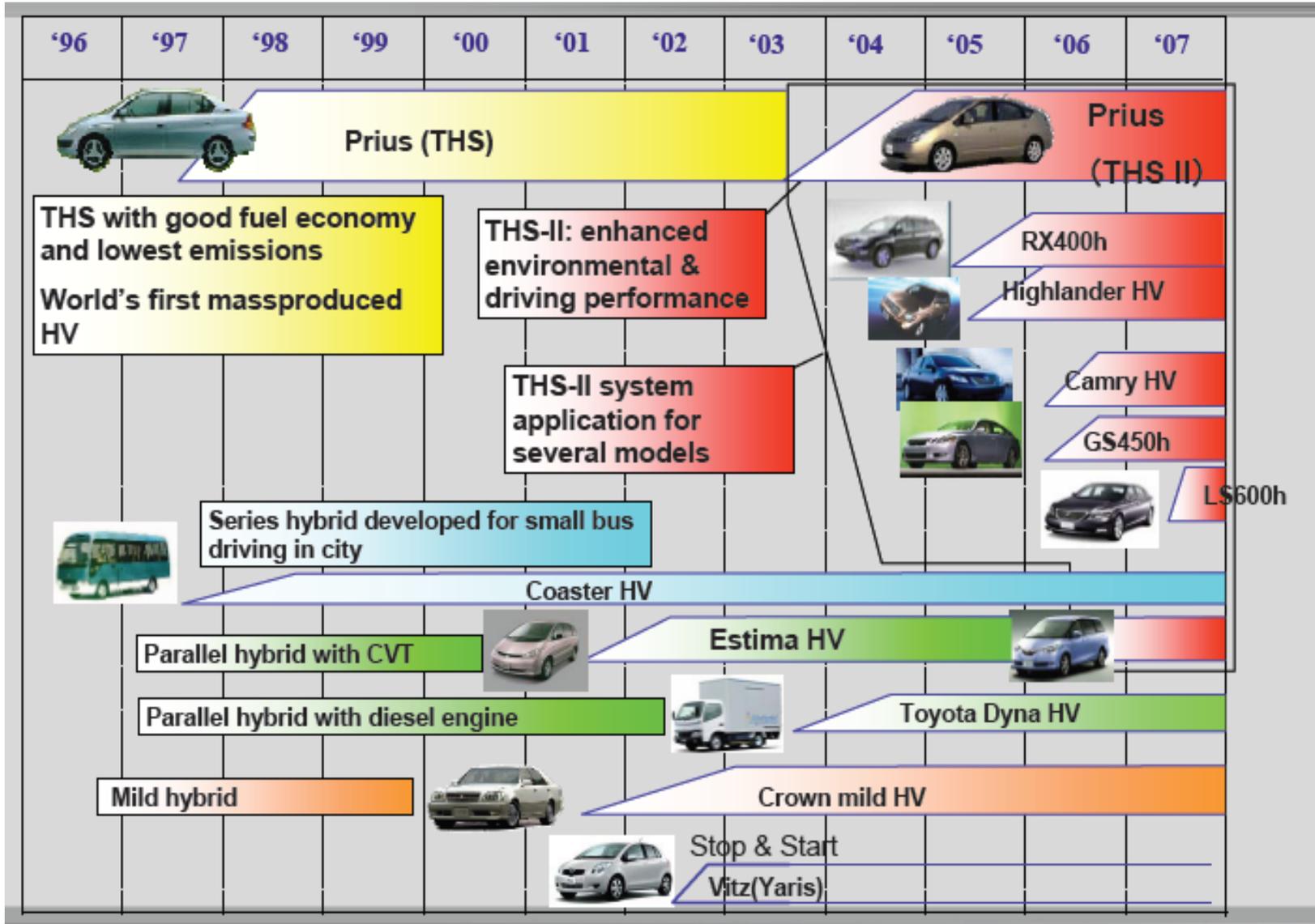
I primi ibridi «moderni»

1973



Ford-Escort, DC-Motor

L'evoluzione della produzione Toyota

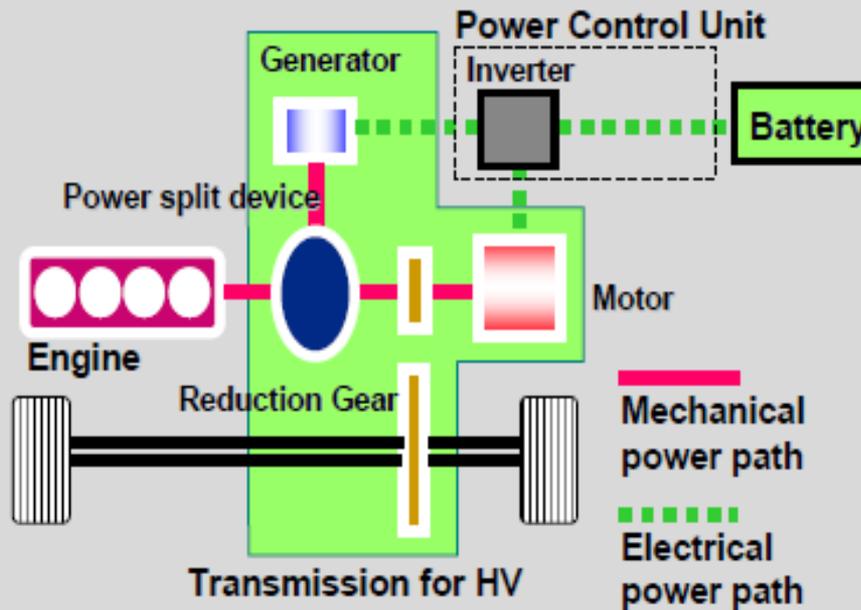


Prius (THS) 1997~2003



Features of System

1. Two electric motors
2. Ni-MH battery
3. Power split device

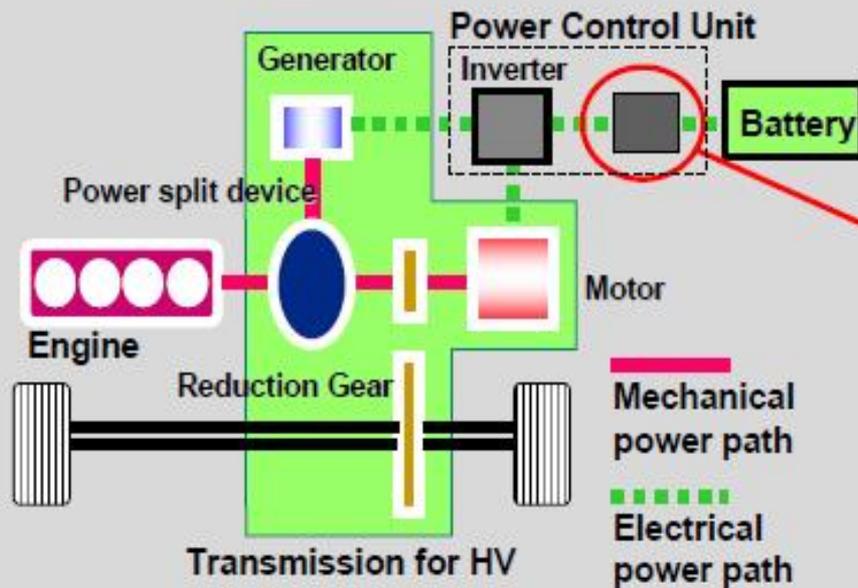


Prius (THSII) 2003~



Features of System

1. Two electric motors
2. Ni-MH battery
3. Power split device
4. High-voltage boost



circuit

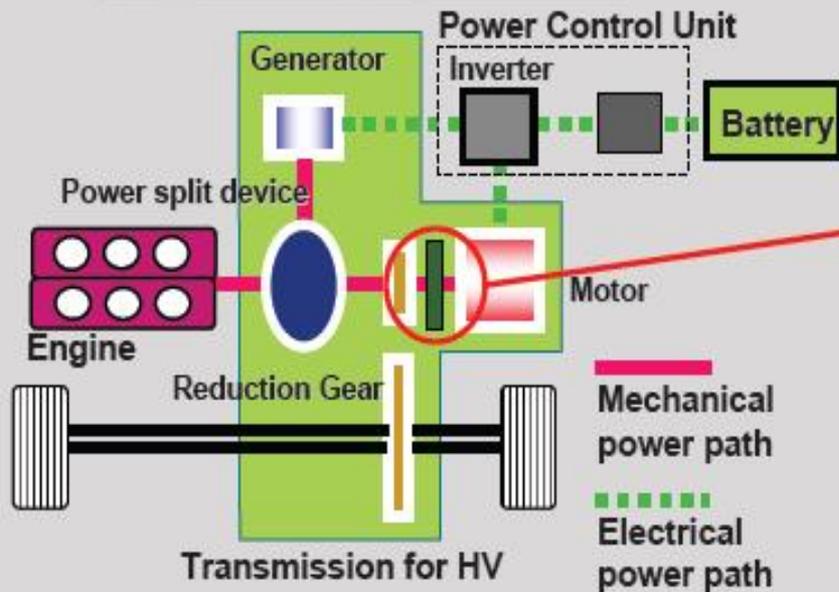
High-voltage boost
circuit

RX400h (THSII) 2005~



Features of System

1. Two electric motors
2. Ni-MH battery
3. Power split device
4. High-voltage boost circuit
5. Motor speed reduction device



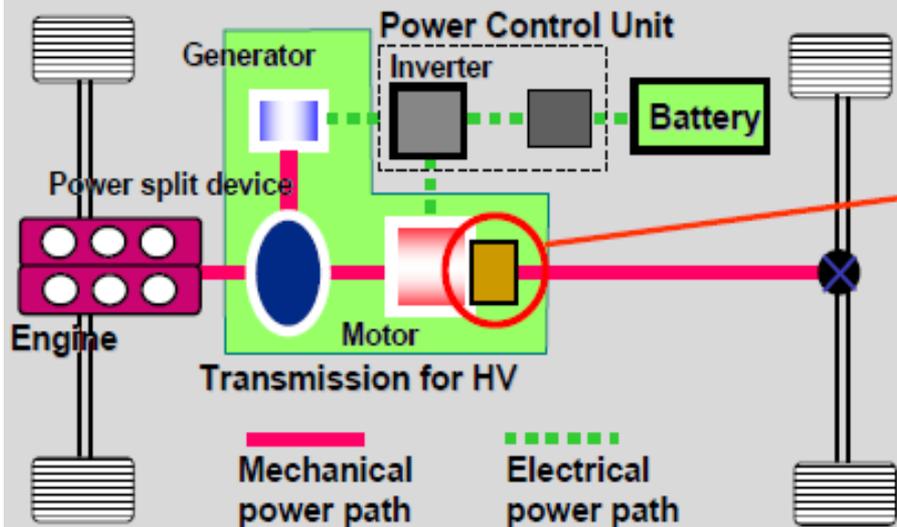
Motor speed reduction device

GS450h (THSII) 2006~



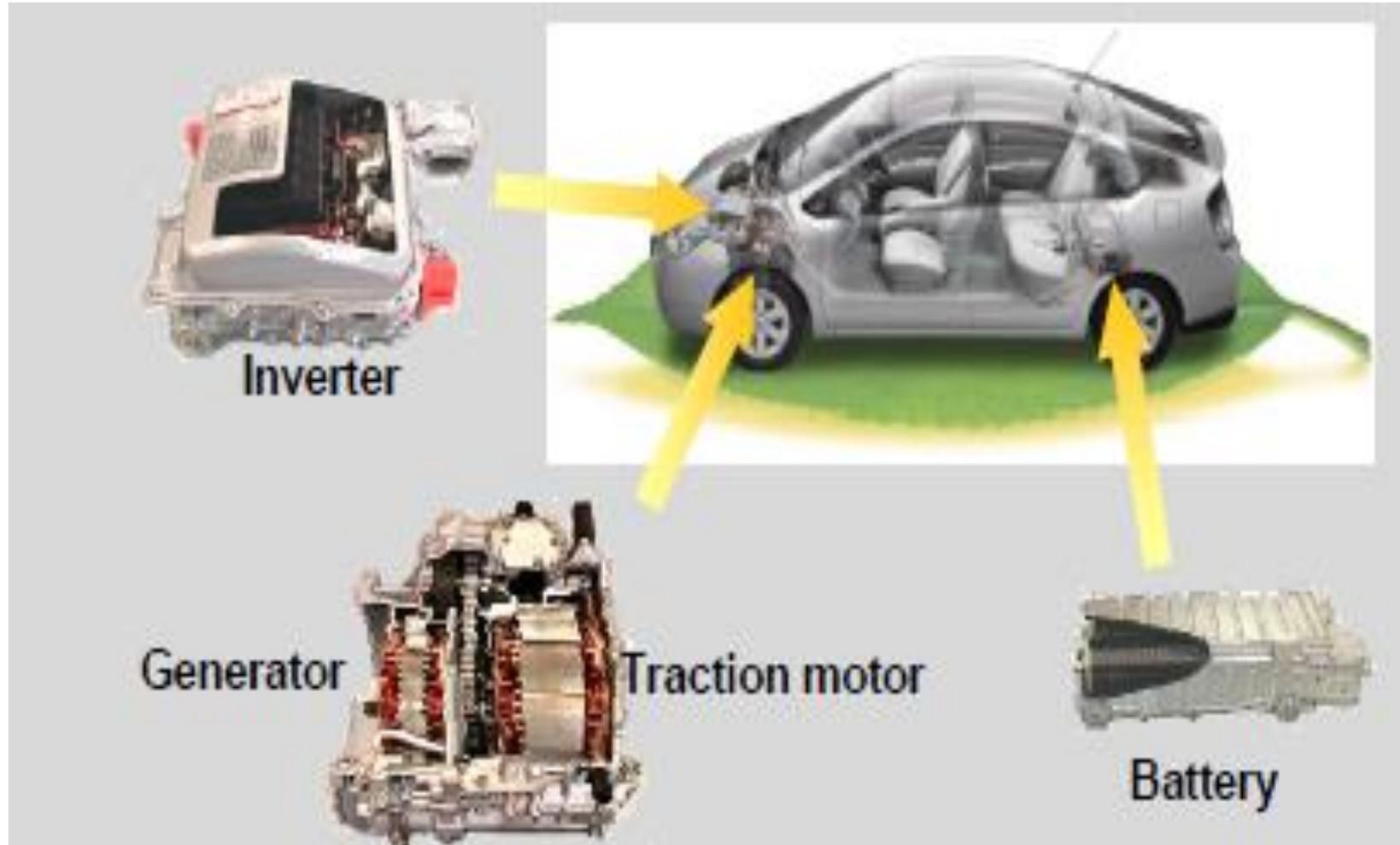
Features of System

1. Two electric motors
2. Ni-MH battery
3. Power split device
4. High-voltage boost circuit
5. **Motor speed reduction device**



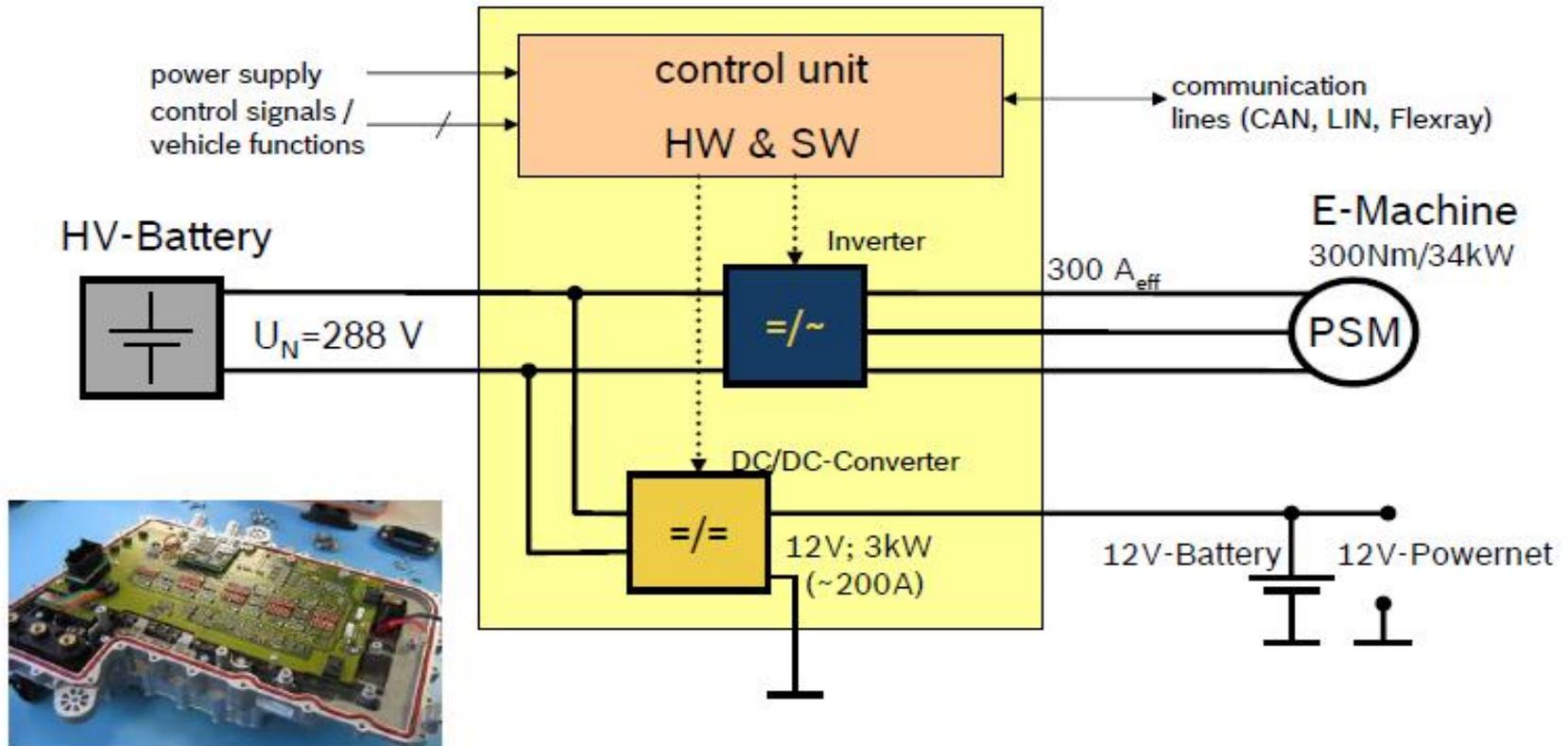
2-stage motor speed reduction device

I componenti critici da ottimizzare



Schema Funzionale

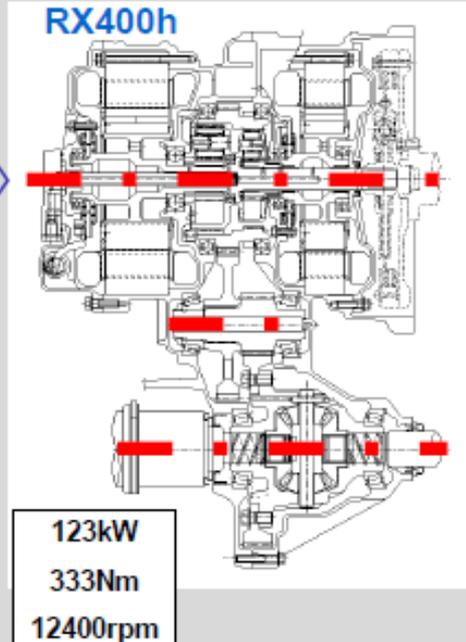
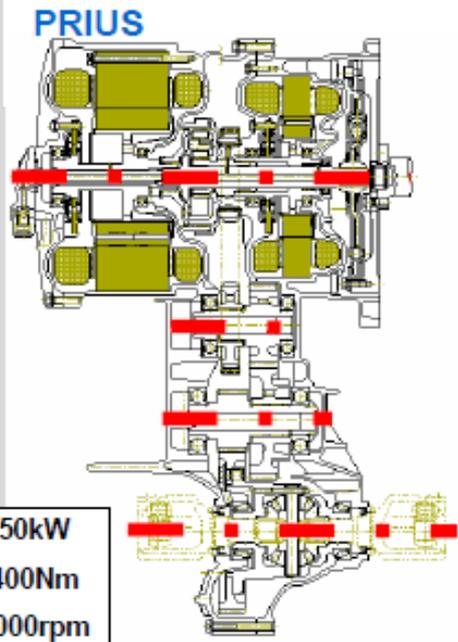
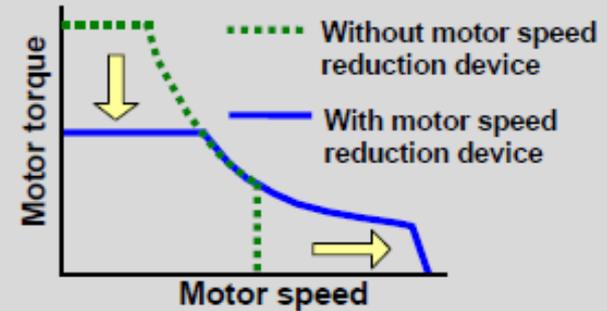
Functional overview – Power Electronics



Il motore-generatore

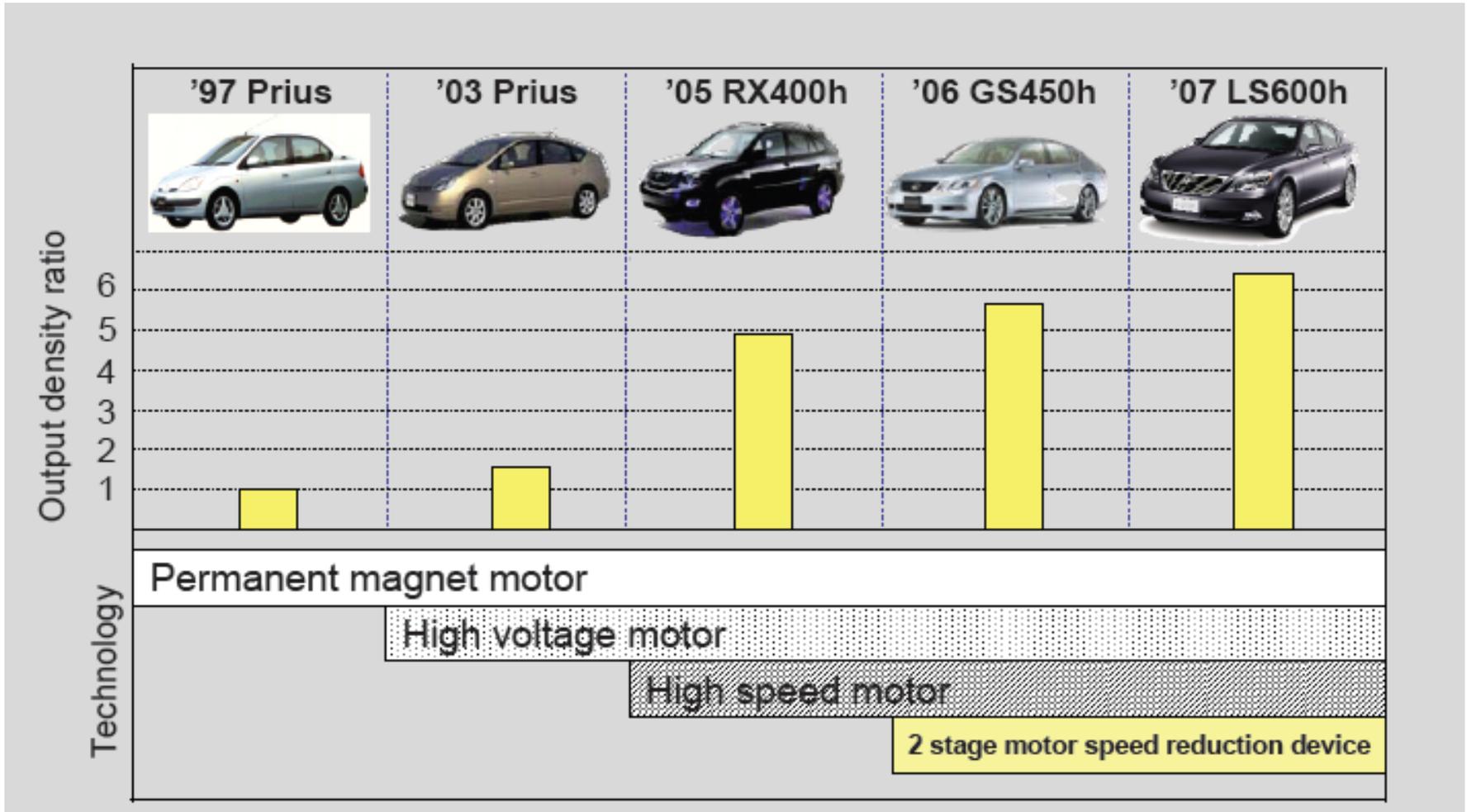
Unit for FWD vehicle

- RX400h
- Camry HV
- Estima HV



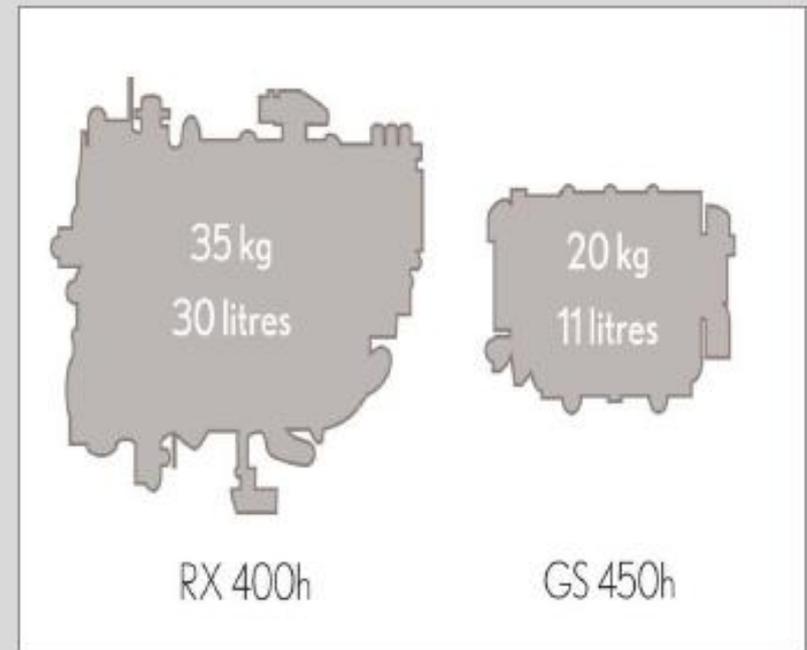
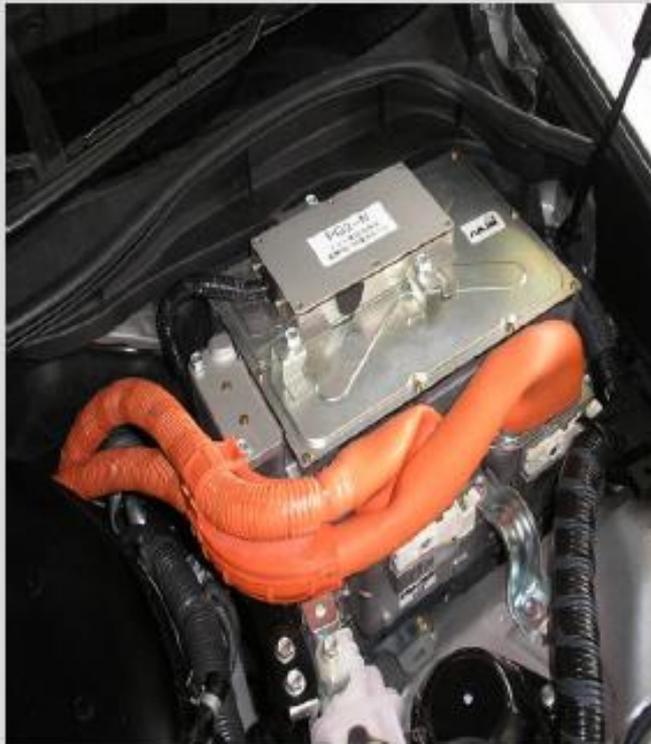
**Output
increase
to 250%,
same size**

La Tecnologia del Motore



POWER CONTROL UNIT

GS450h(155kW motor) vs Weight reduction -43%
RX400h(123kW motor): Volume reduction -63%



Le Batterie

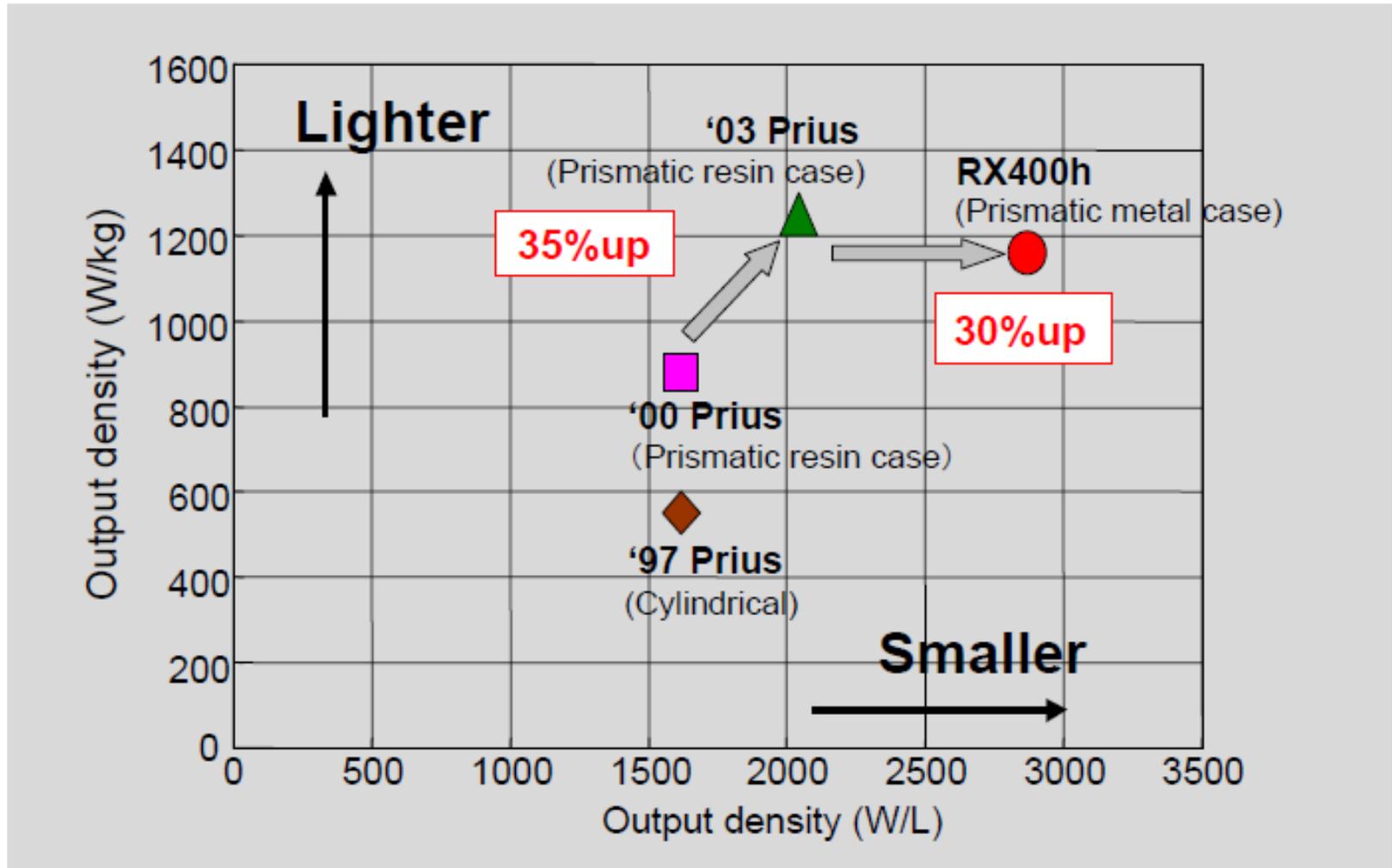
	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07
HV		'97 Prius			'00 Prius			'03 Prius			
Battery module		Cylindrical		Prismatic			New prismatic resin case				
											
									New prismatic metal case		
									'05 RX400h		
Battery pack											
									New		
											

Tecnologie per le batterie

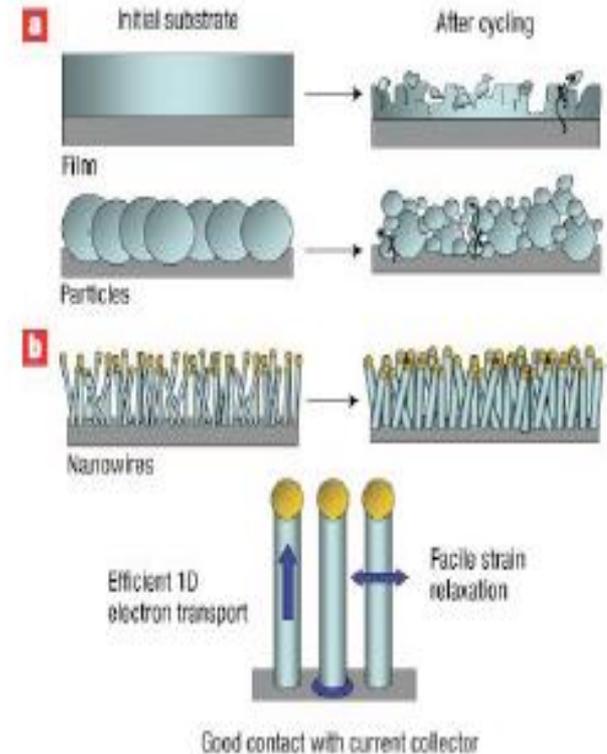
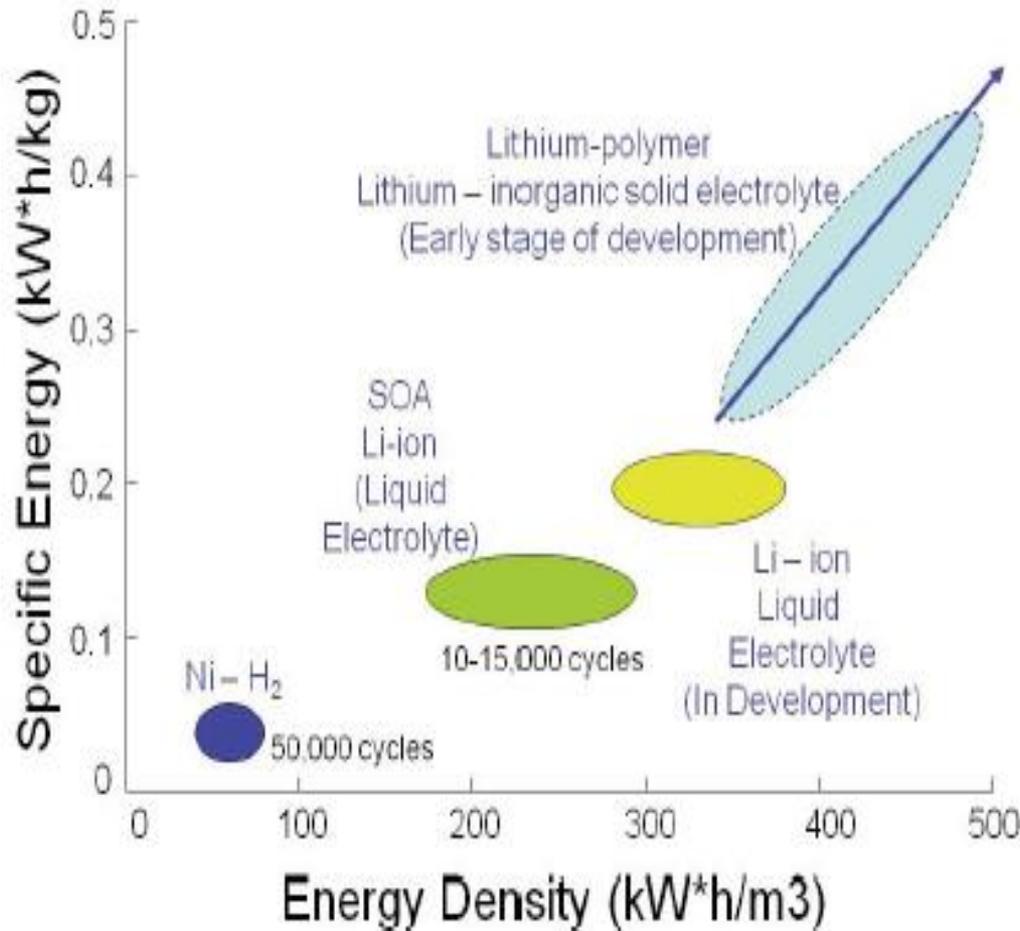
Applications	Low voltage (36 V _{DC})			High Voltage (100÷300 V _{DC})		
	Pb	Ni-MeH	Li	Pb	Ni-MeH	Li
BATTERY TECHNOLOGY	Pb	Ni-MeH	Li	Pb	Ni-MeH	Li
SPECIFIC ENERGY [Wh/kg]	30 - 35	35 - 50	60 - 105	19 - 30	35 - 47	54 - 80
ENERGY DENSITY [Wh/l]	65 - 80	32 - 132	80 - 230	33 - 80	34 - 180	40 - 175
SPECIFIC POWER [W/kg]	280 - 560	430 - 550	540 - 1480	300 - 550	650 - 1000	1350 - 1800
POWER DENSITY [W/l]	520 - 1100	530 - 1100	1170 - 1960	700	870 - 3600	1370 - 3000
LIFE CYCLE [CYCLES] (0+80% DOD)	600	1500 - 1800	600 - 800	600	1500 - 1800	600 - 800
COST FORECAST [€/kWh] (100 000 unit/year)	100 - 150	300 - 400	150 - 400	100 - 150	300 - 400	150 - 400
INFORMATION SOURCES	Hoppecke Exide Delphi	Ovonic Varta	SAFT Delphi	Optima Hawker Johnson Control	Panasonic Ovonic Varta Sanyo SAFT	SAFT Shin Kobe

The higher cost of Ni-MeH and Li-ion batteries is compensated in hybrid applications by a longer life and less critical demand in term of electric balancing. Even if further cost reduction is required (lower than 100 €/kWh) the life cost of Ni-MeH may already be competitive with the Lead batteries.

EVOLUZIONE DELLE BATTERIE



IL FUTURO DELLE BATTERIE

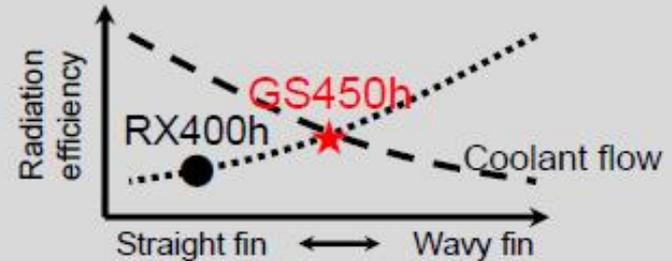
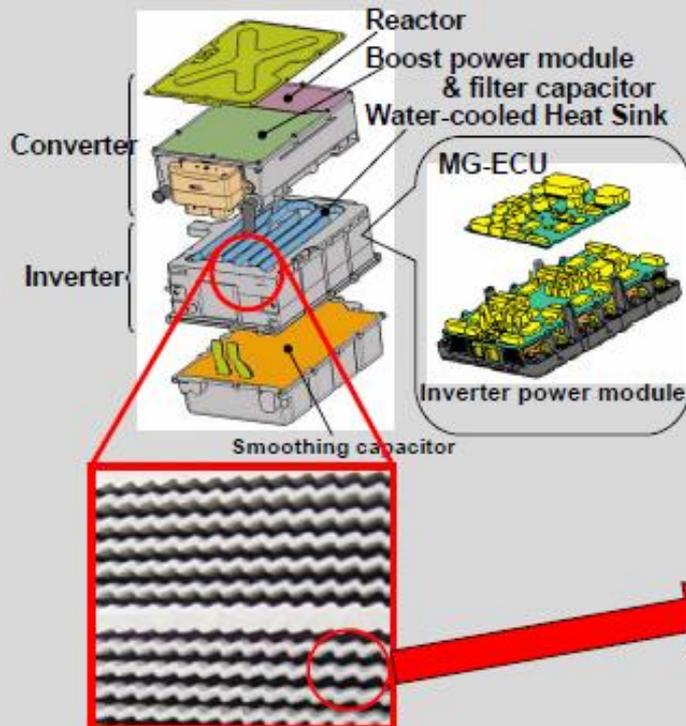


Li-ion batteries with nano-Si wire electrodes offer potential for 10X increase in storage capacity

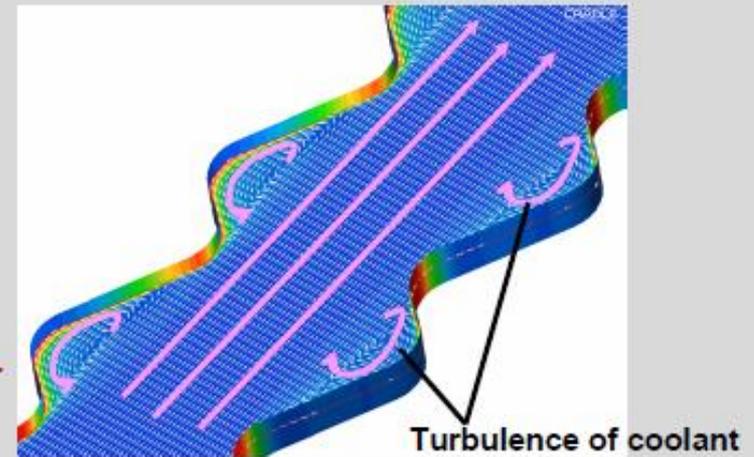
Gli azionamenti di potenza (inverter) ed i sistemi di innalzamento della tensione

Compact size (10L volume)

- GS450h
- Camry / Estima



Wavy fin heat sink



Aumento della densità di potenza degli azionamenti

'97 Prius



'03 Prius



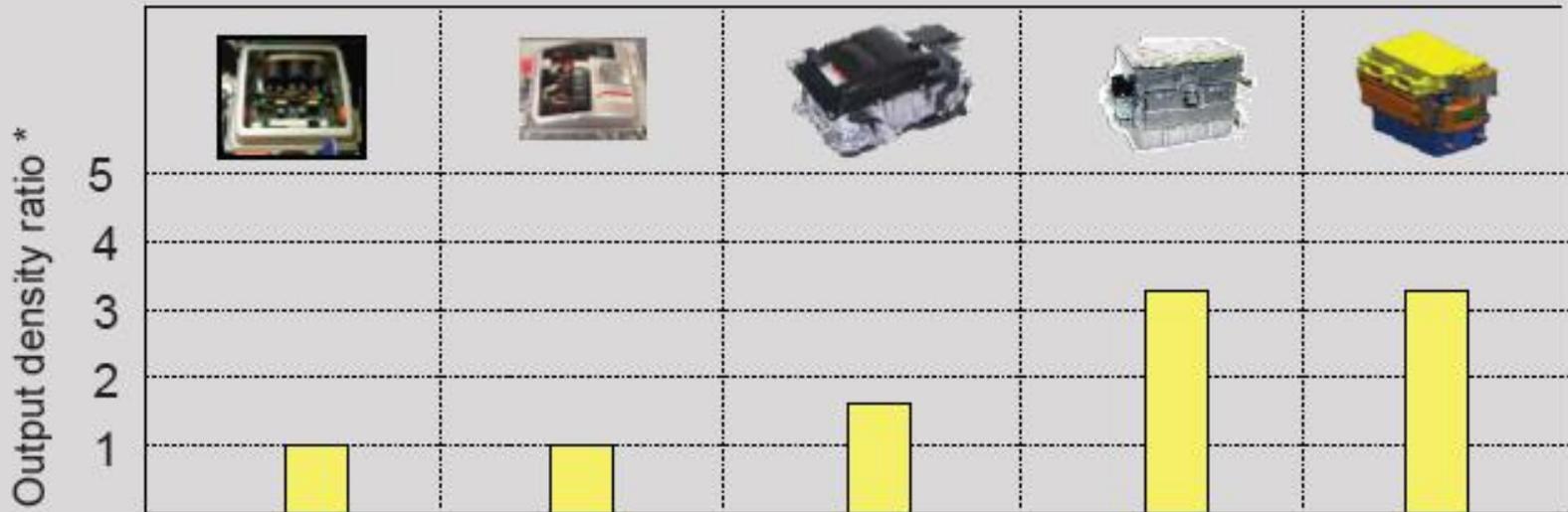
'05 RX400h



'06 GS450h

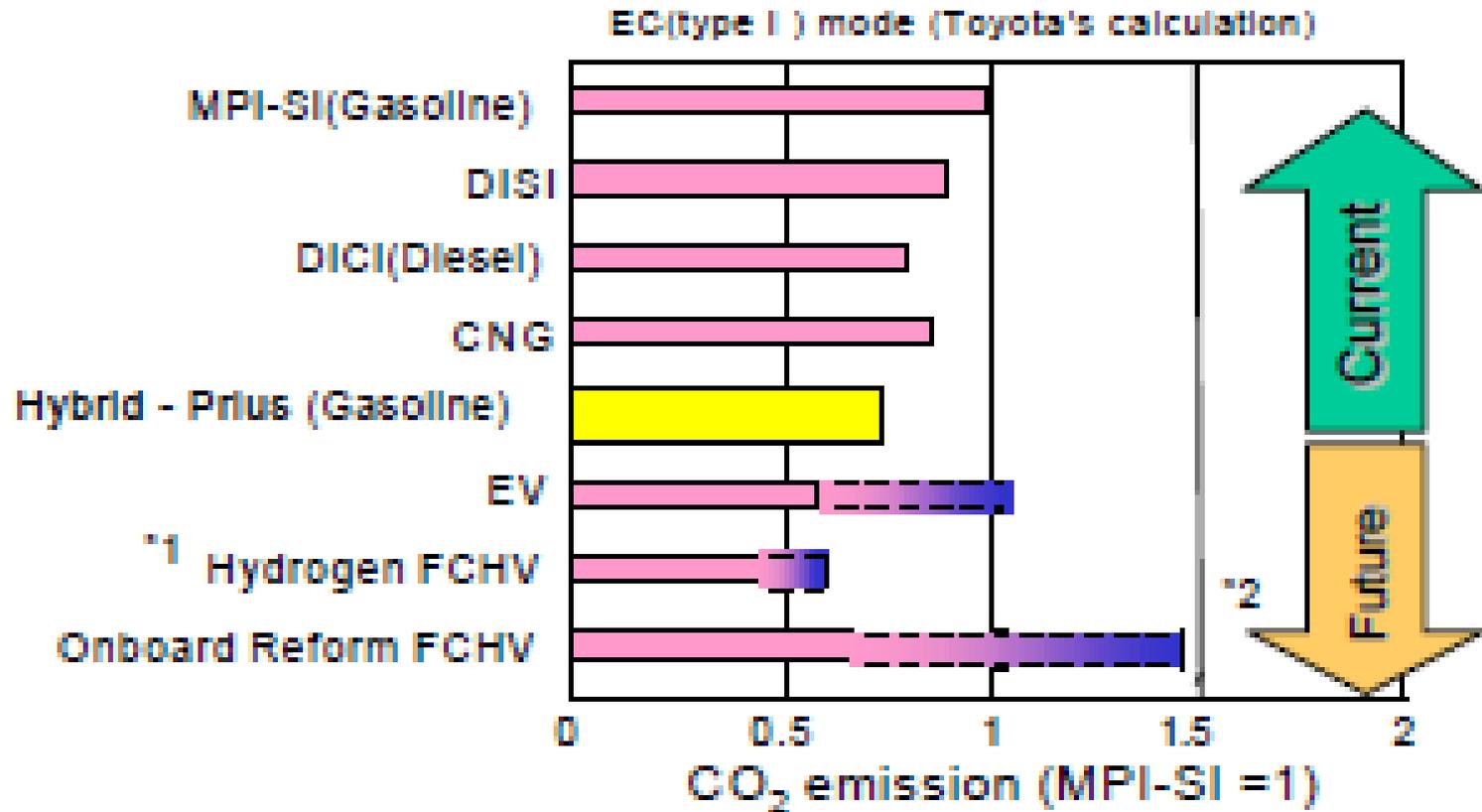


'07 LS600h



* Volumetric base

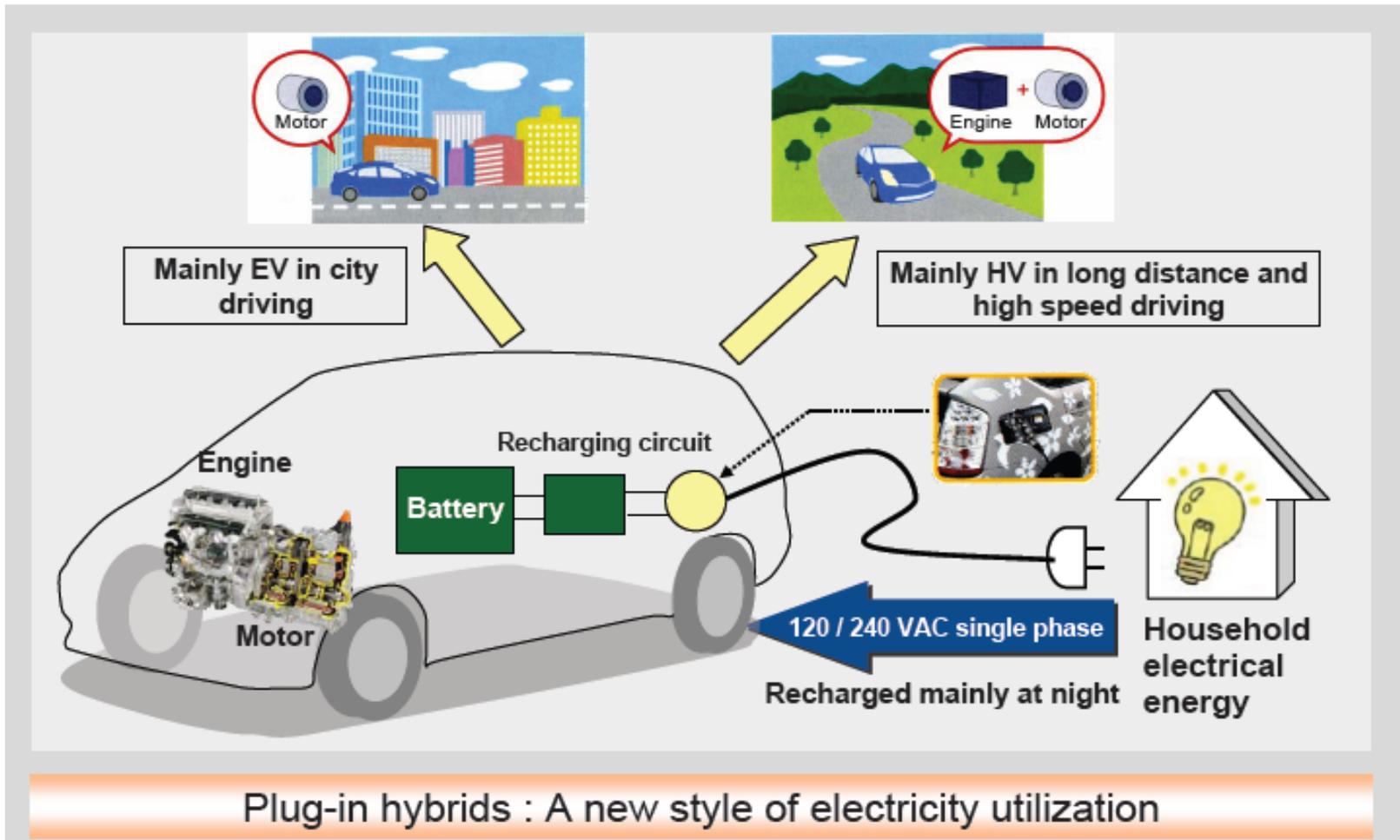
Emissioni dal Pozzo alla Ruota



*1: Made from CNG.

*2: CO₂ emission of FCV is an estimation.

Gli ibridi Plug-In



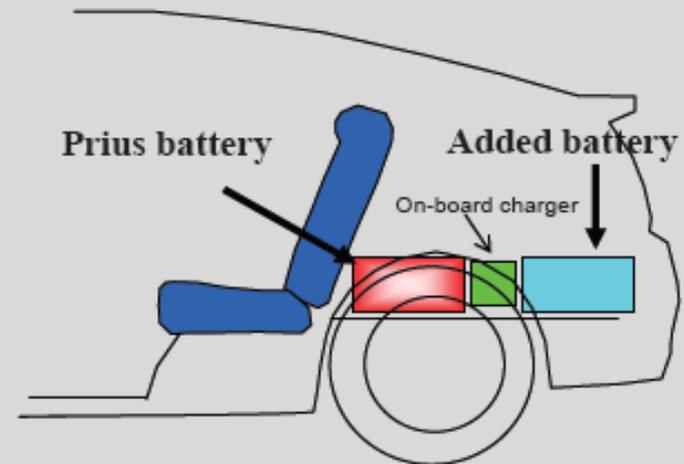
Ibridi Plug-In

Plug-in Hybrid Vehicle Issues

Twice the battery capacity of current Prius

13km electric drive range in Japanese 10-15 mode

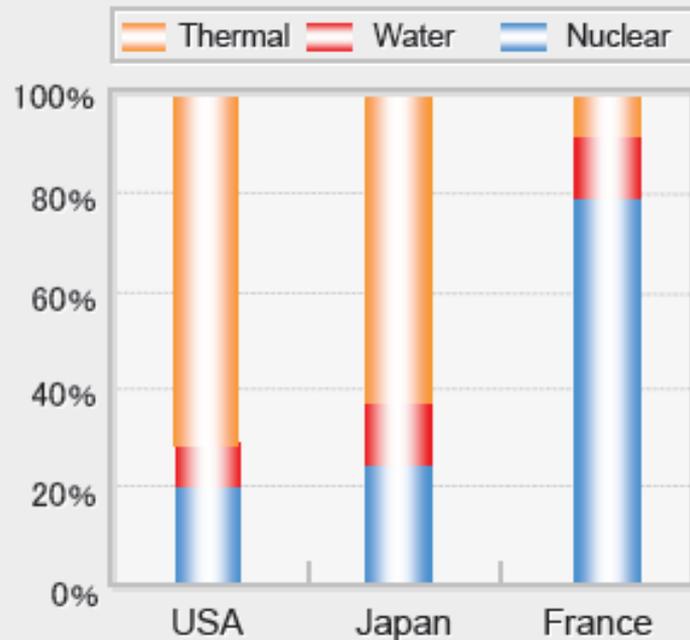
Need more electric range



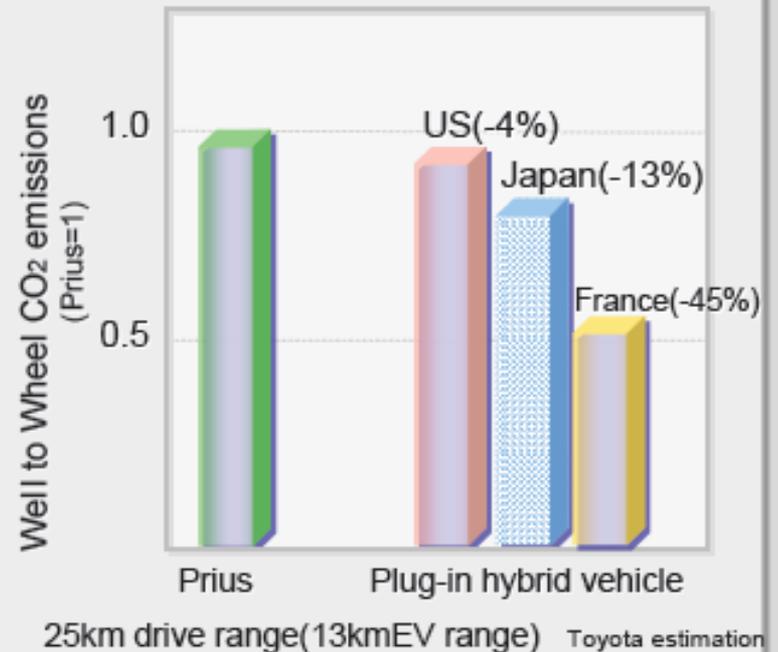
Battery innovation = Key for plug-in hybrid concept

Ibridi Plug-In

Electric generation in each country

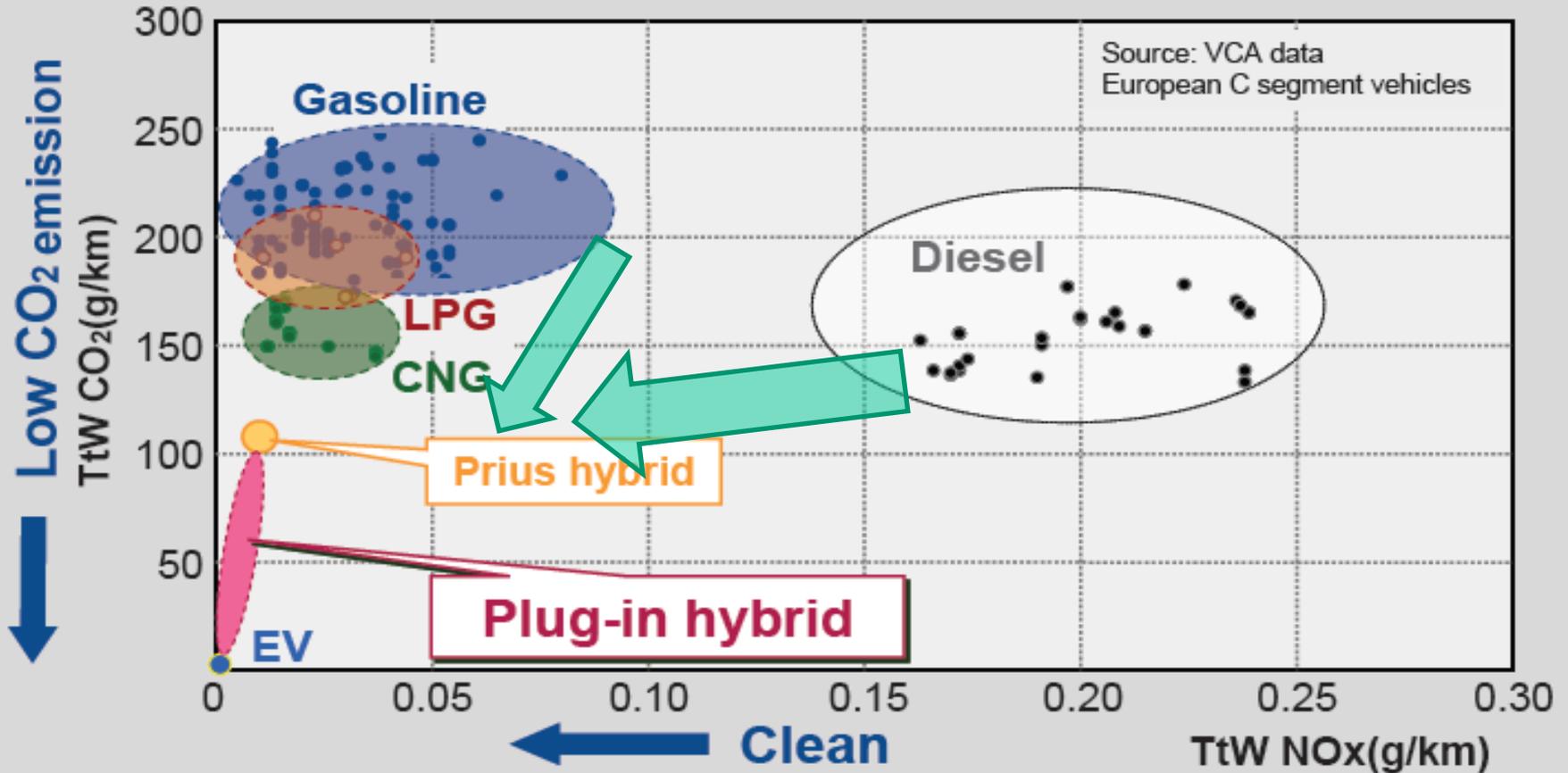


Well-to-wheel CO2 emissions



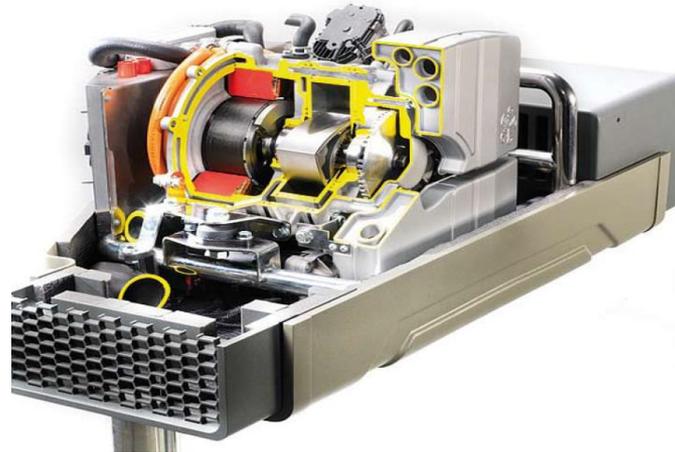
Environmental benefit: CO2 reduction in well-to-wheel

EFFICIENZA Vs. INQUINAMENTO

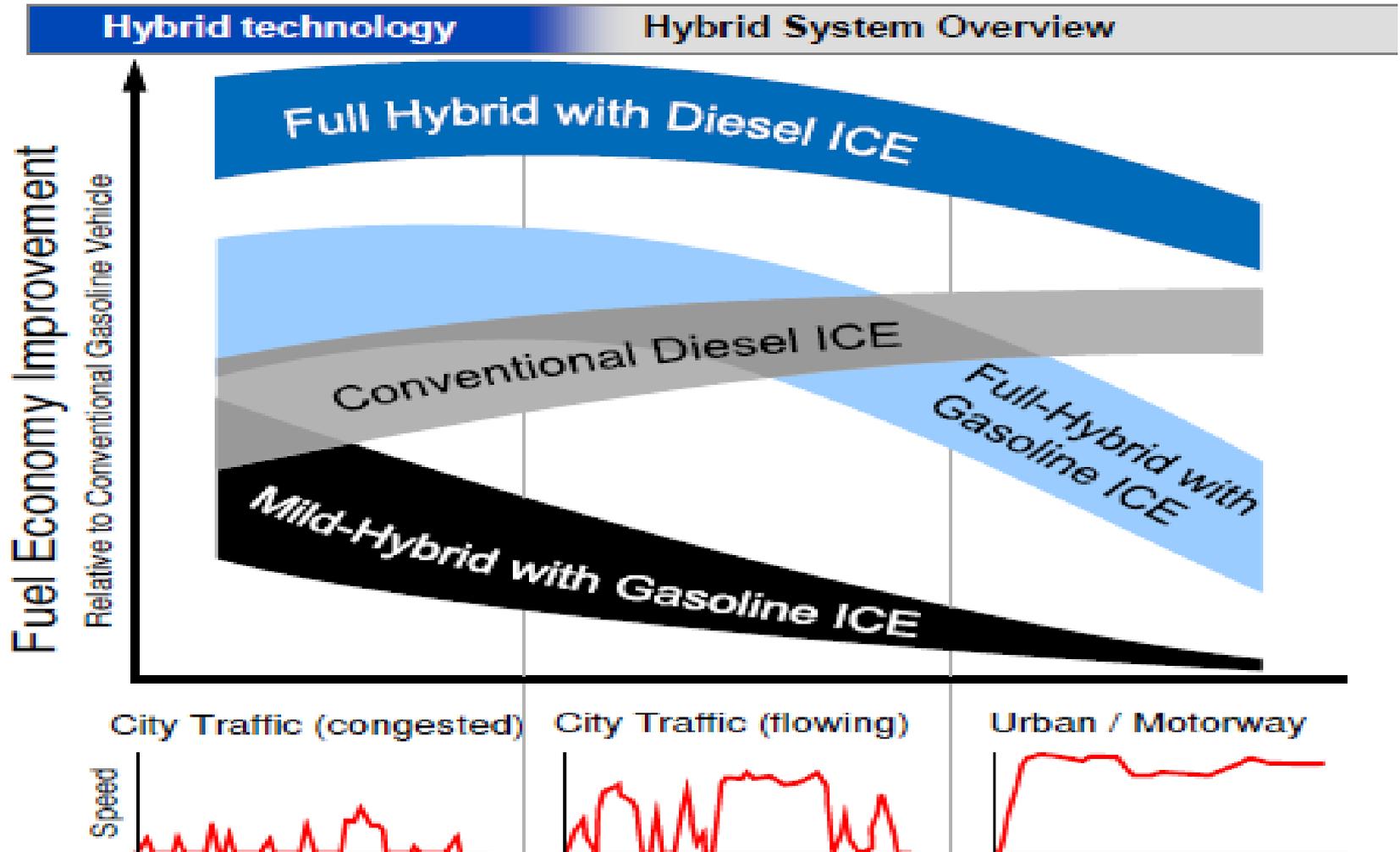


Plug-in technology can further enhance the environmental performance of hybrids both in CO₂ & pollutant emissions

I RANGE EXTENDER

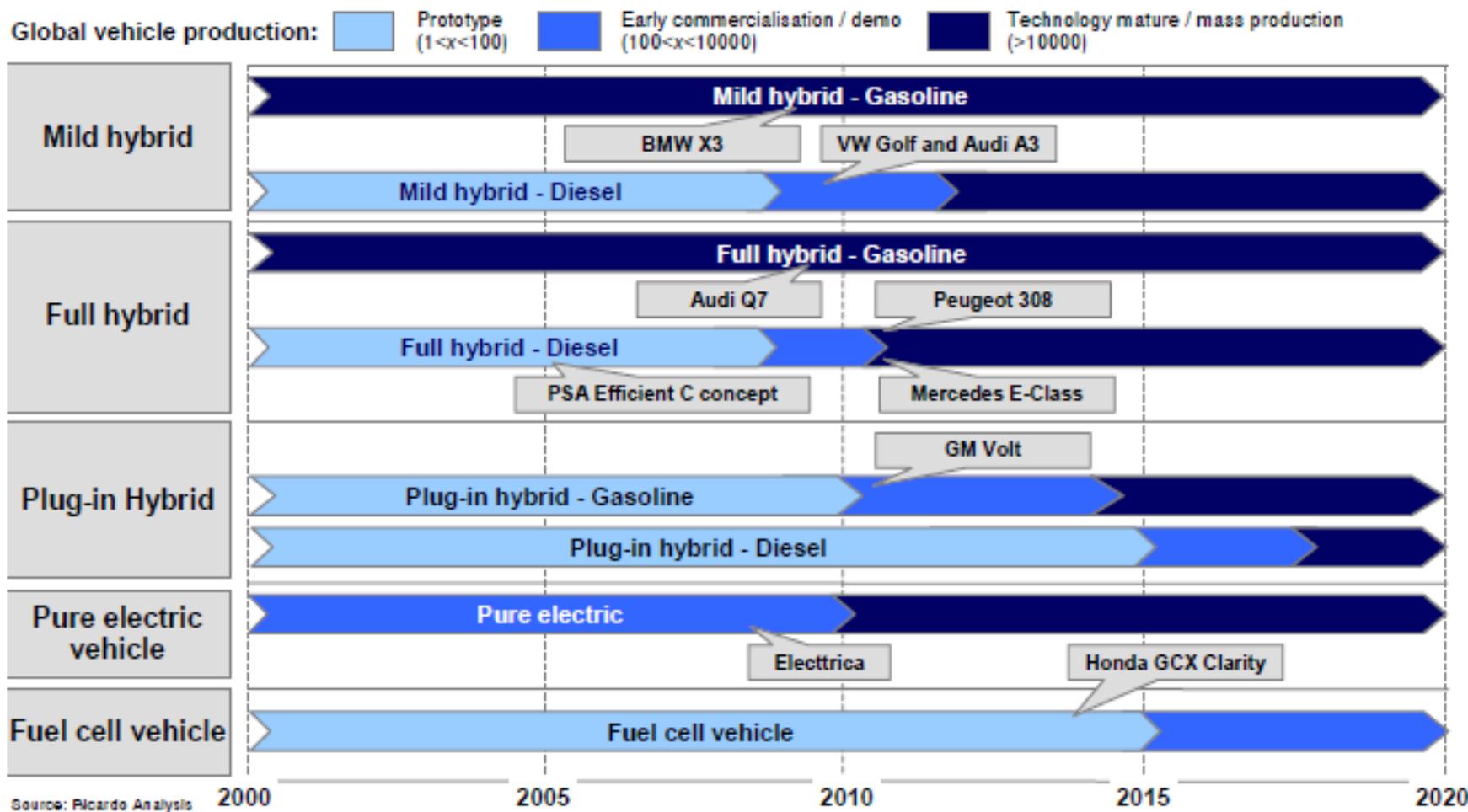


IL RISPARMIO ENERGETICO EFFETTIVO

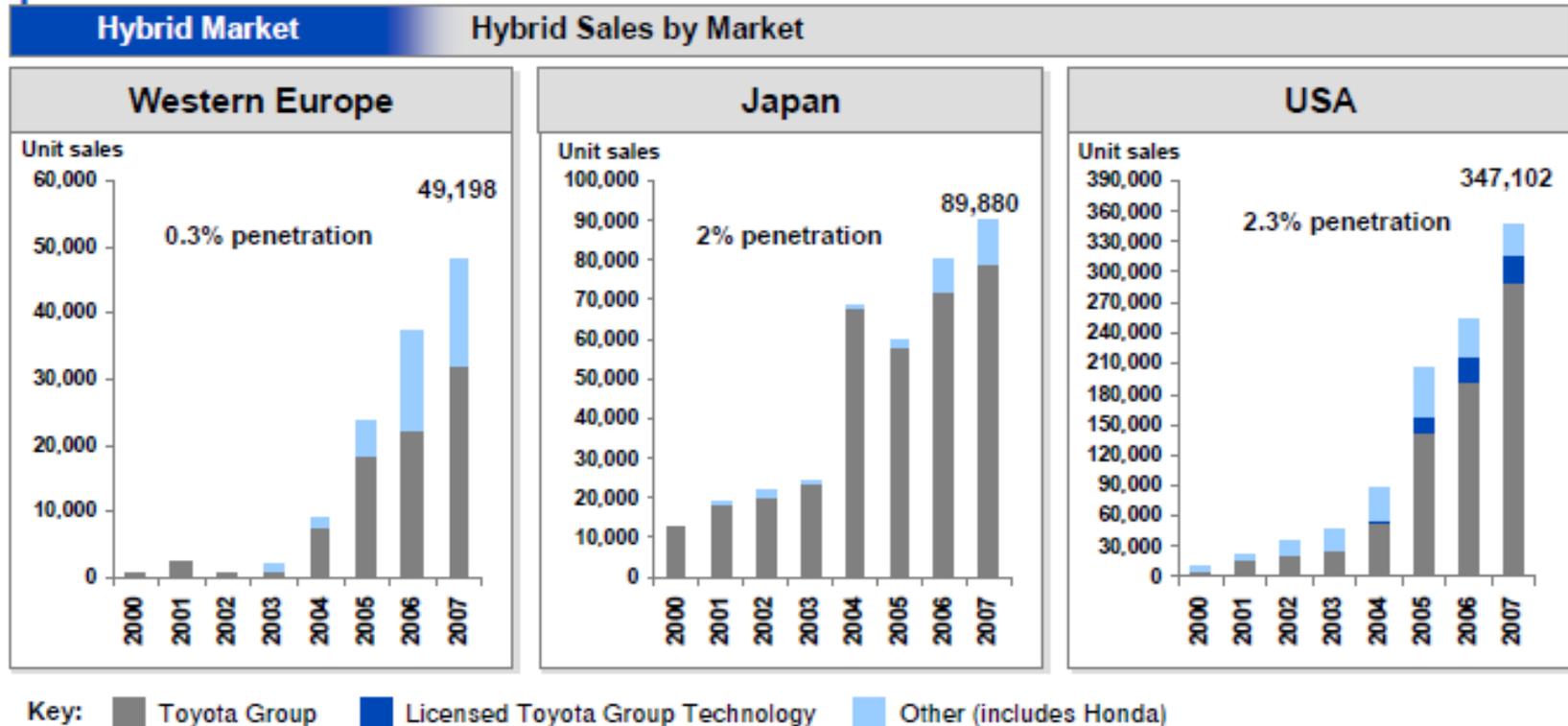


TAPPE DI DIFFUSIONE DELL'IBRIDO

Hybrid System Roadmap

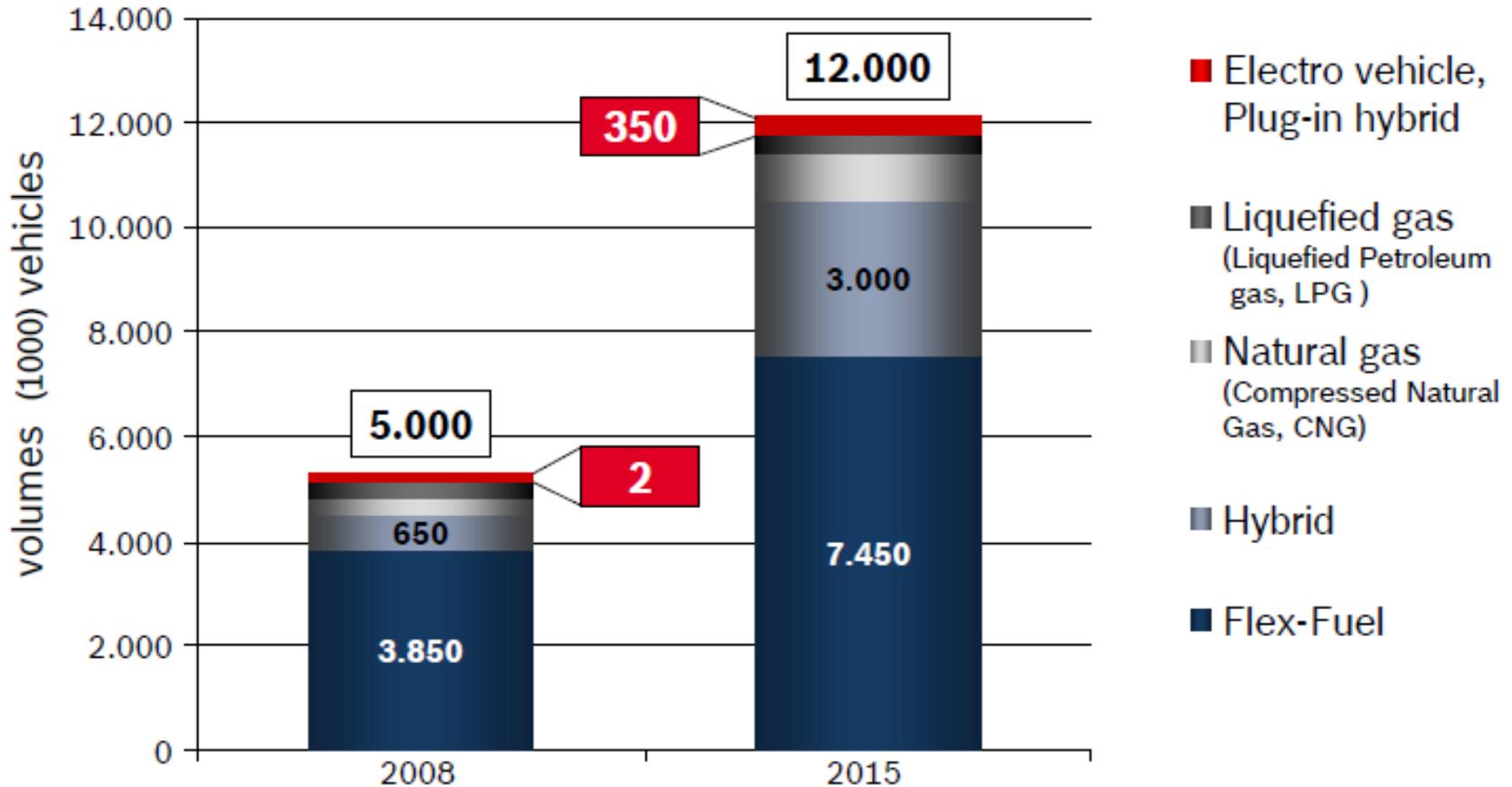


USA is significantly the largest market for hybrid vehicles; recent growth in the USA and Western Europe has been faster than in Japan



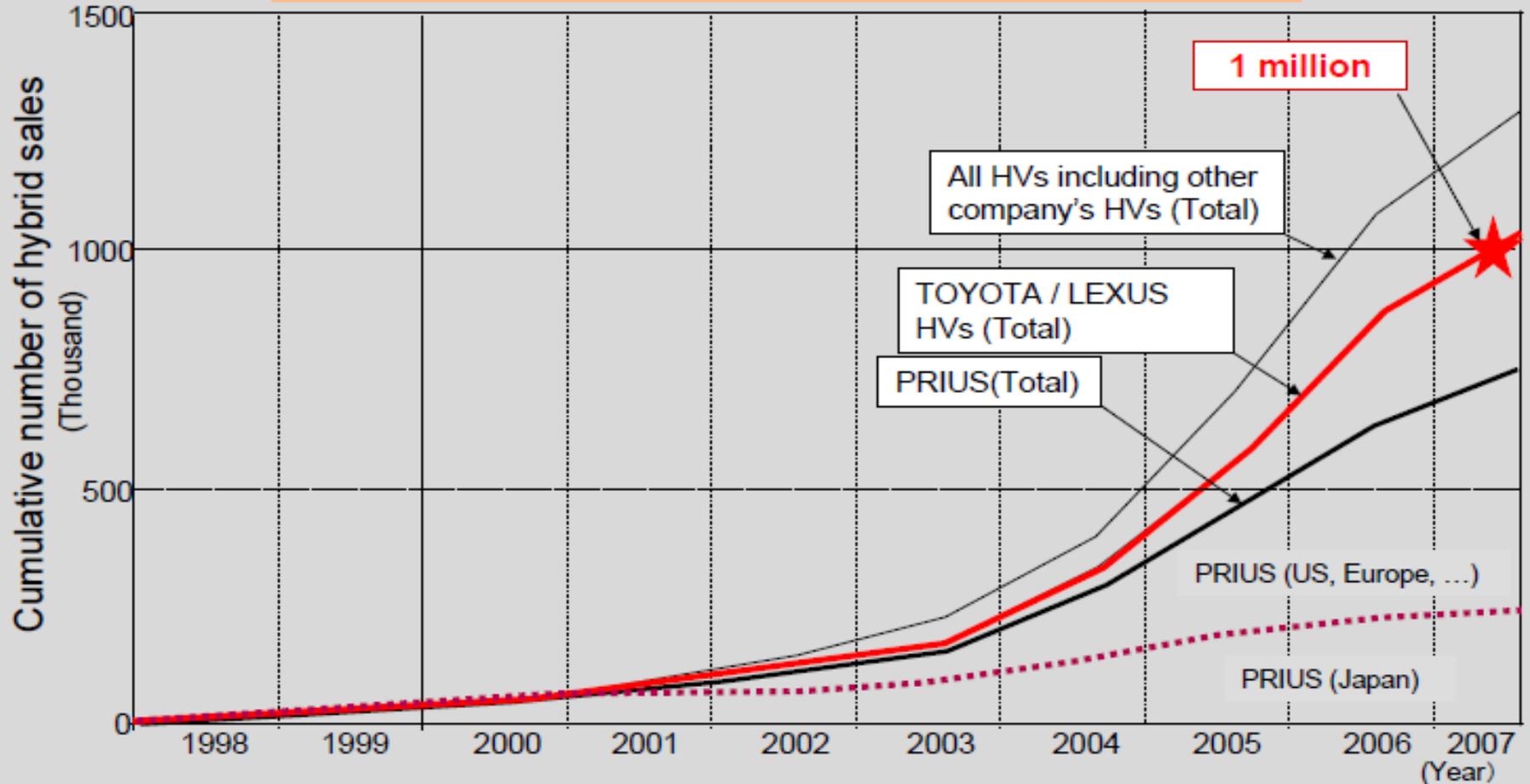
Toyota is the global market leader in hybrid vehicles, selling a total of 402,158 worldwide in 2007, of which 79,429 were sold in their home market

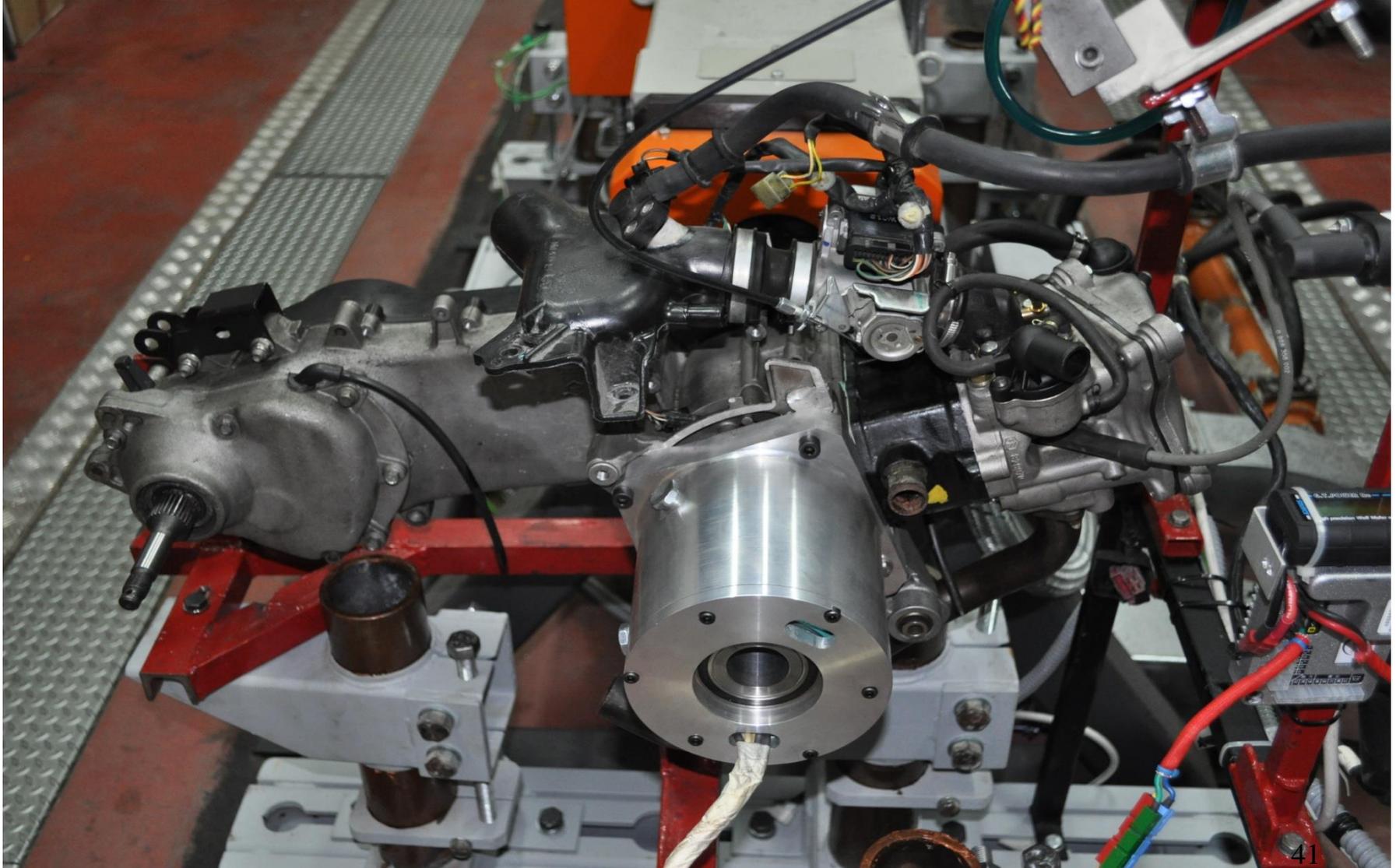
Market development alternative drives world-wide



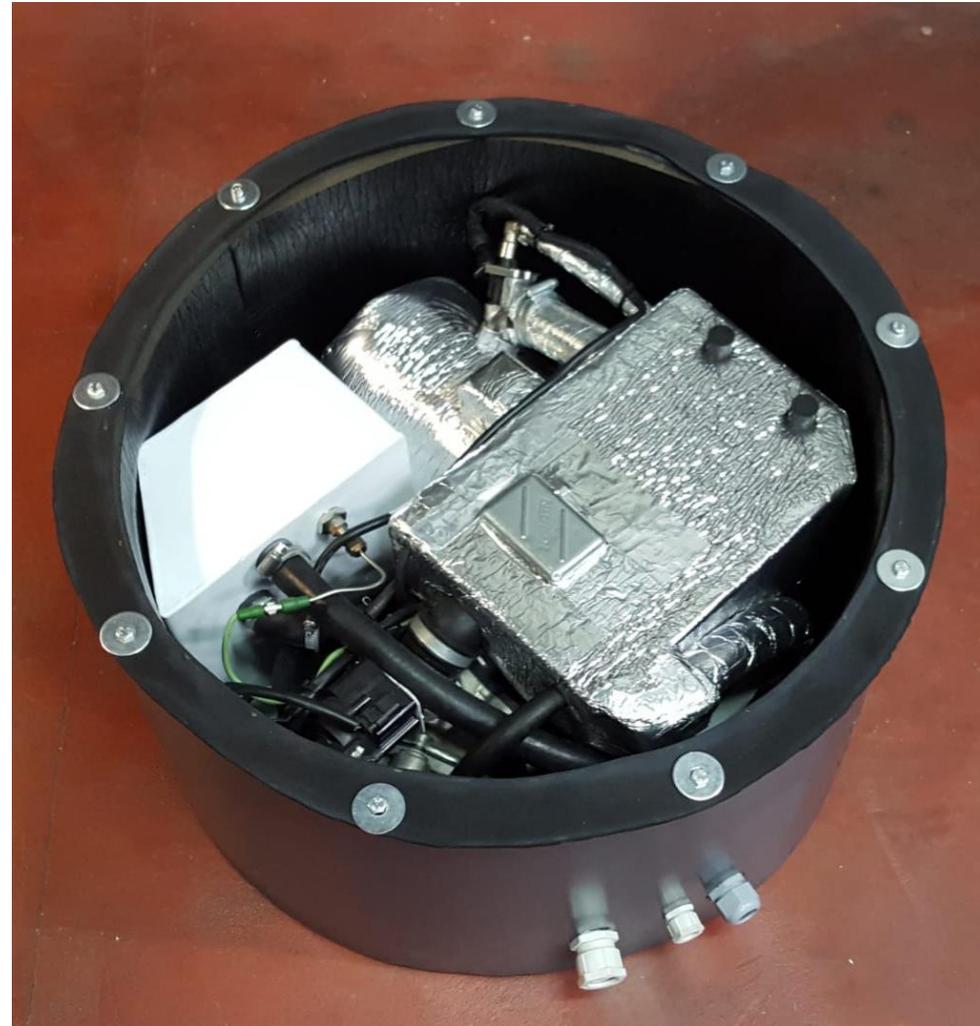
Il Mercato

Cumulative sales (worldwide)





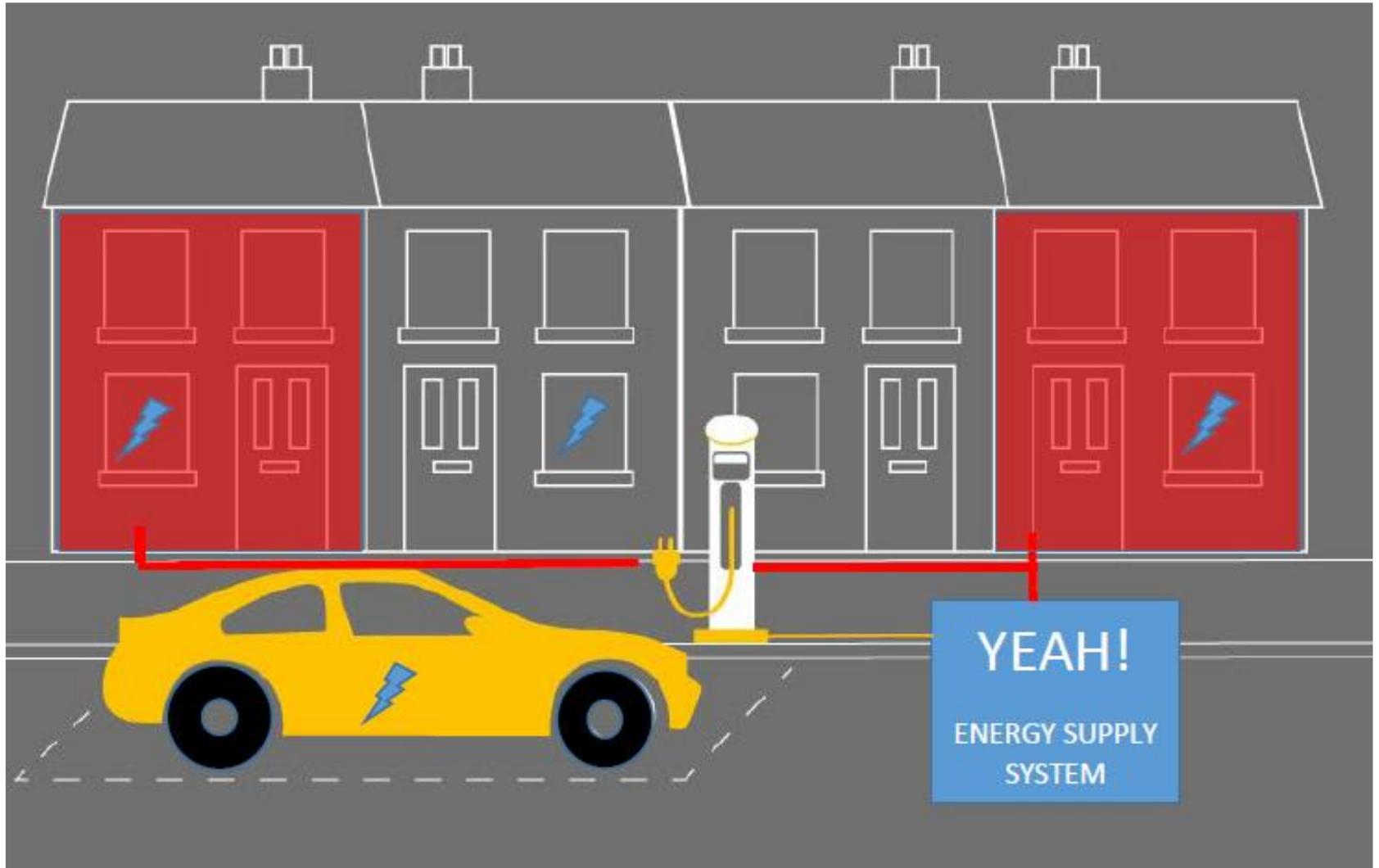
- Motore monocilindrico (derivaz. Piaggio) da 276 cm³ e 11 kWm @5700 rpm.
- Potenza elettrica 10 kW
- Generatore a magneti permanenti



RANGE EXTENDER = ELETTRICO SUBITO



GENERAZIONE DISTRIBUITA = ELETTRICO SUBITO





MICROCOGENERATORI DA 10 E 20 kW_e