

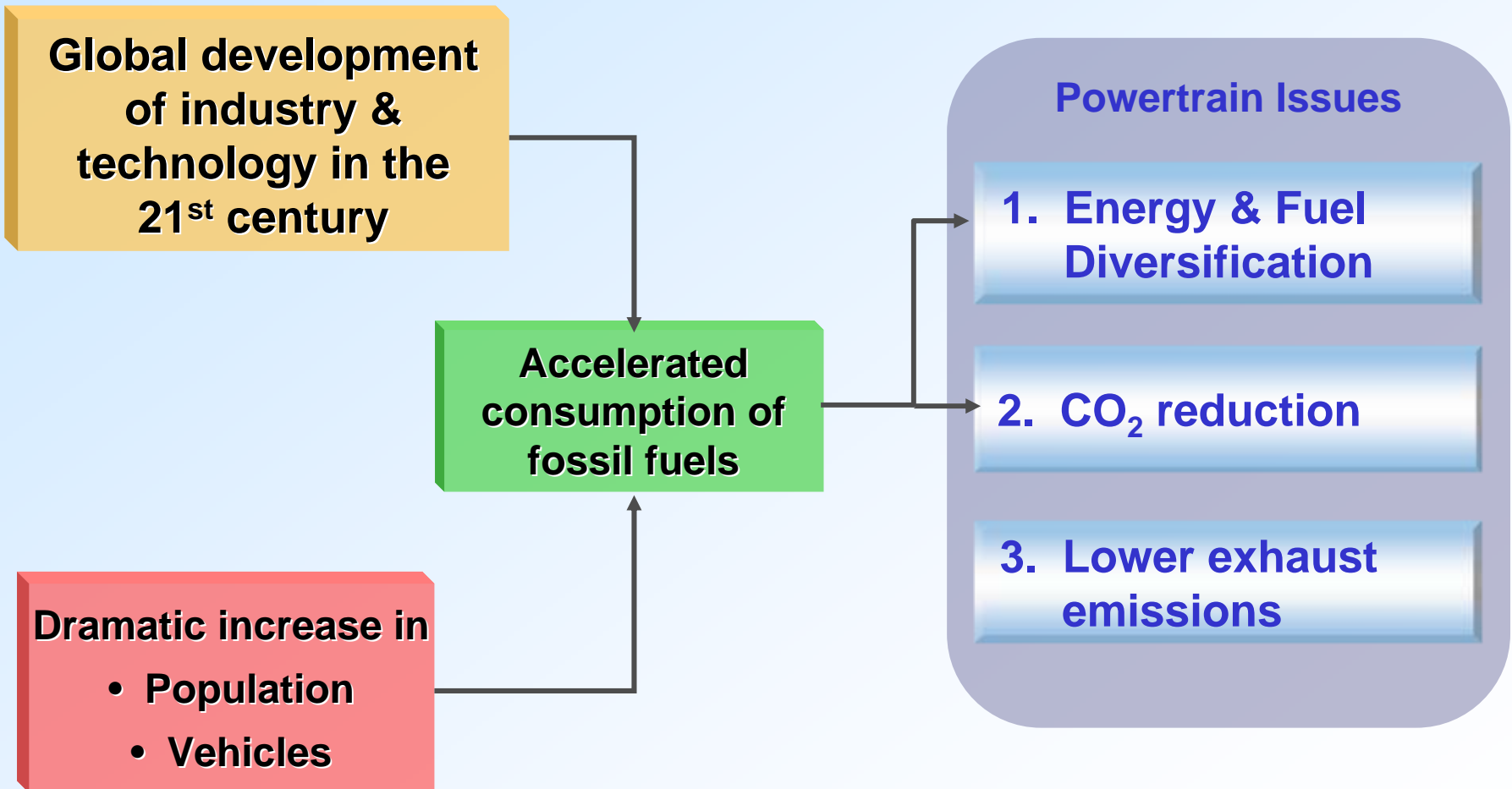
Sustainable Mobility and the Role of Hybrid Vehicles

Justin Ward
Toyota Motor Engineering
& Manufacturing North America

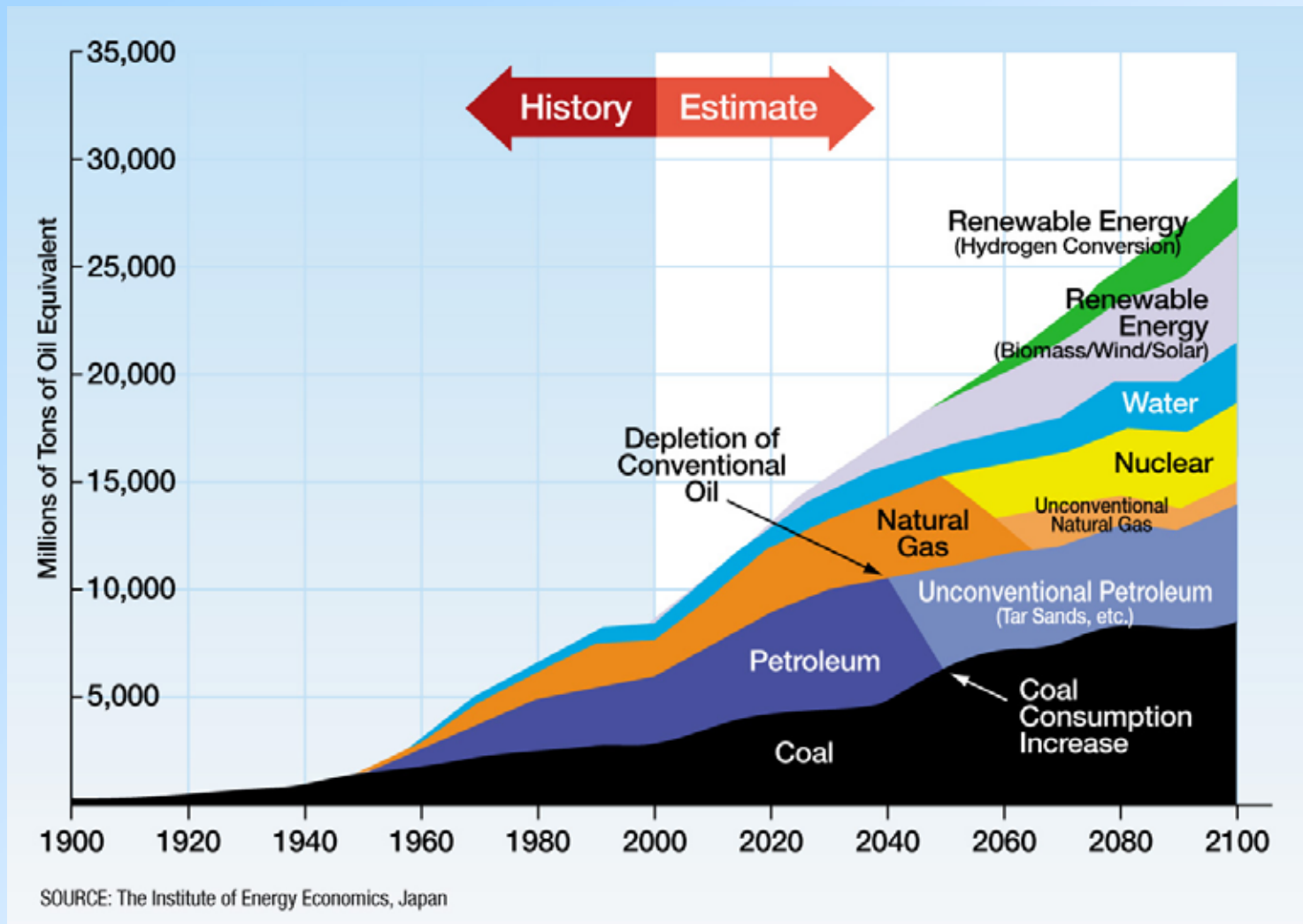
October 19, 2007



Drivers for change in the Auto Industry



Energy and Fuel Diversification

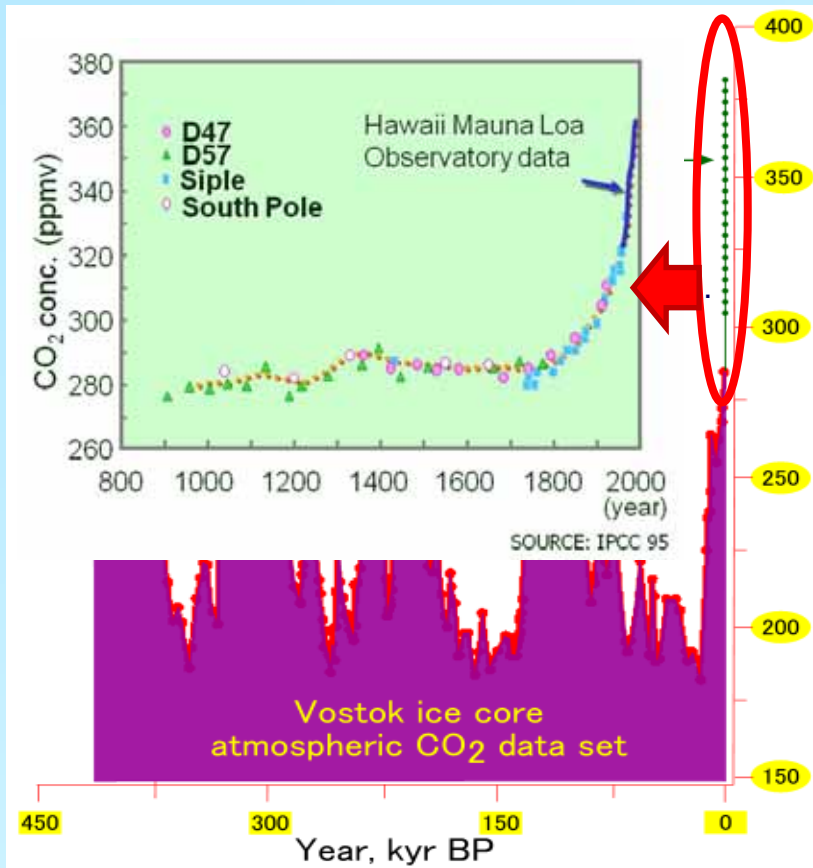


Increasing demand and limited resources driving diversity

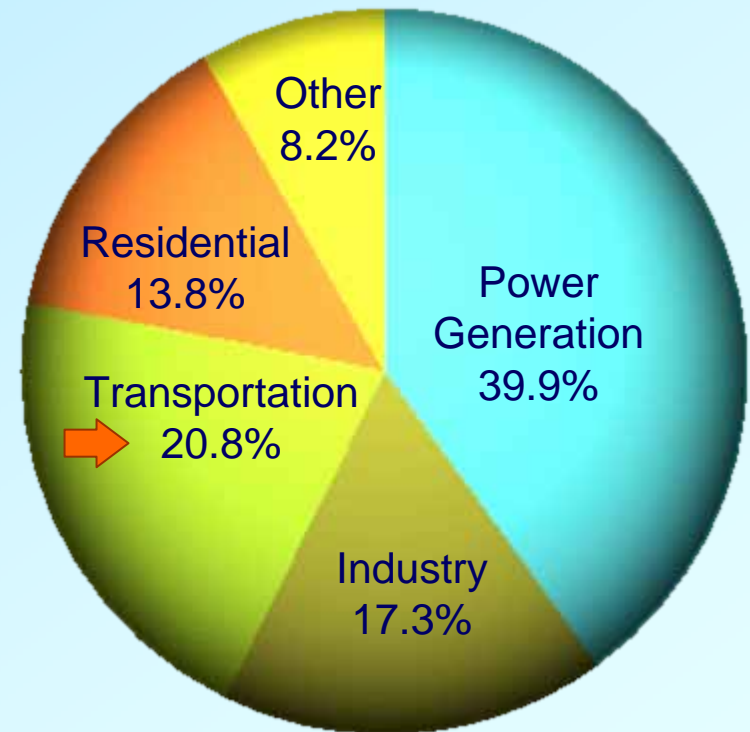


CO₂ Emissions: Past, present, and...?

Changes in Atmospheric CO₂ Concentration



Total World CO₂ Emissions: 23.6 billion tons

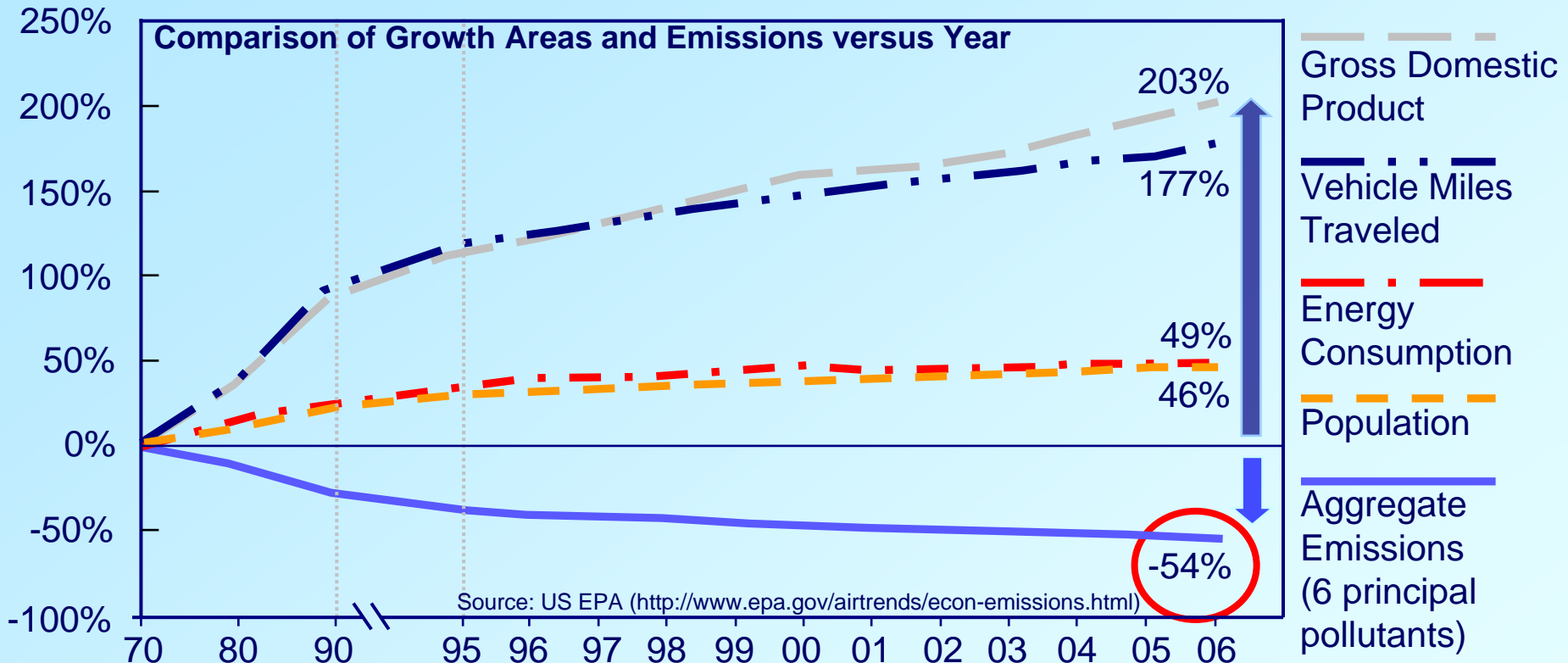


SOURCE: "IEA CO₂ Emissions from Fuel Combustion" (2004 Edition)

Global initiatives across all sectors are needed to address CO₂ emissions



Air Quality Trend in US



“Despite great progress in air quality improvement, over 100 million people nationwide lived in counties with pollution levels above the primary NAAQS in 2006.” – US EPA



Status of Hybrid Vehicles Today



Hybrid Vehicles Available in the US Market



Highlander



Prius



Camry



RX400h



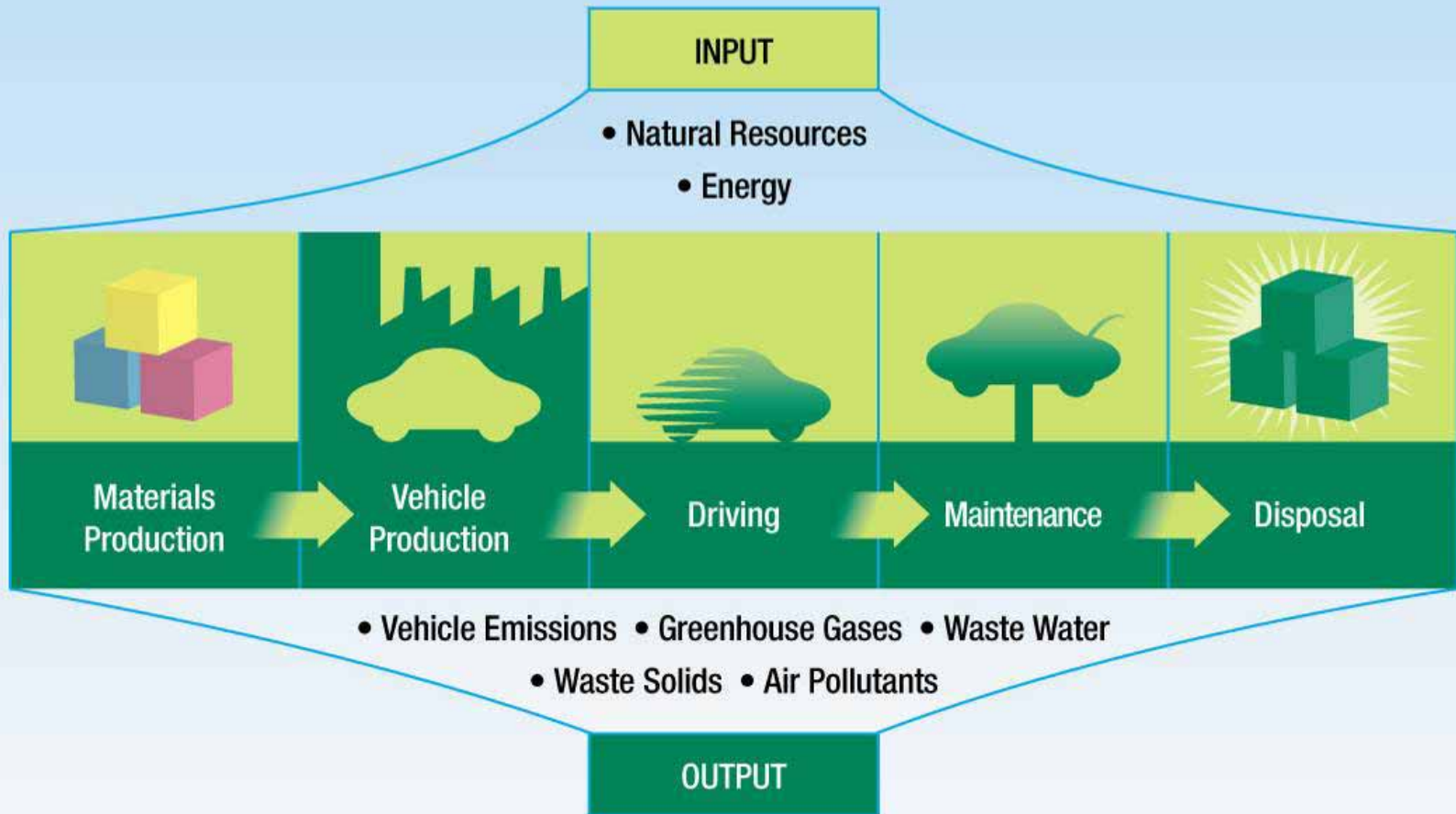
LS600hL
(introduced in 2007)



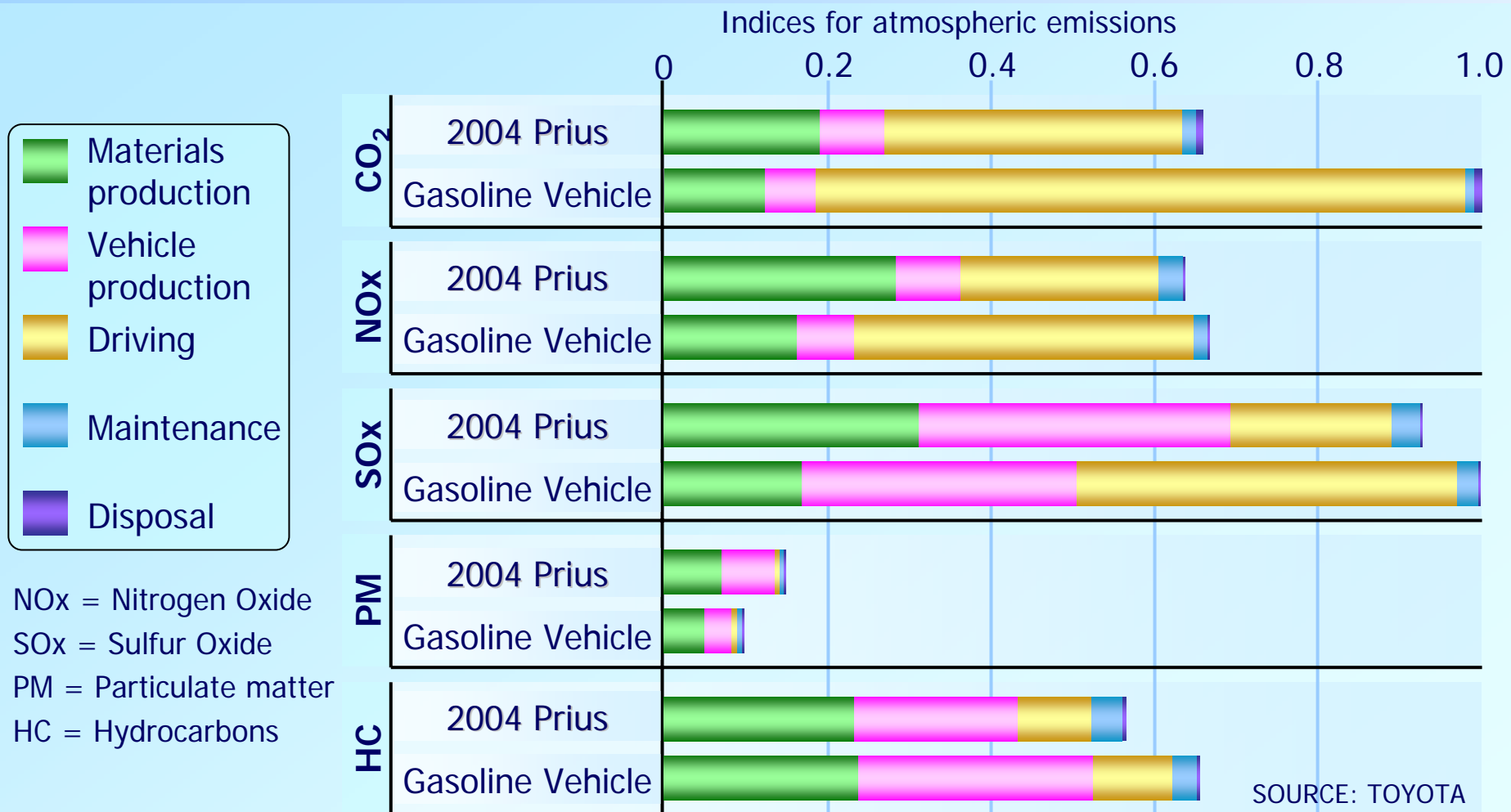
GS450h



Measuring Sustainability through the Life Cycle Assessment



Life Cycle Assessment for the Prius



SOURCE: TOYOTA

* CO₂ comparison assuming gasoline vehicle index 1 (other items based on a gasoline vehicle SO_x index of 1).



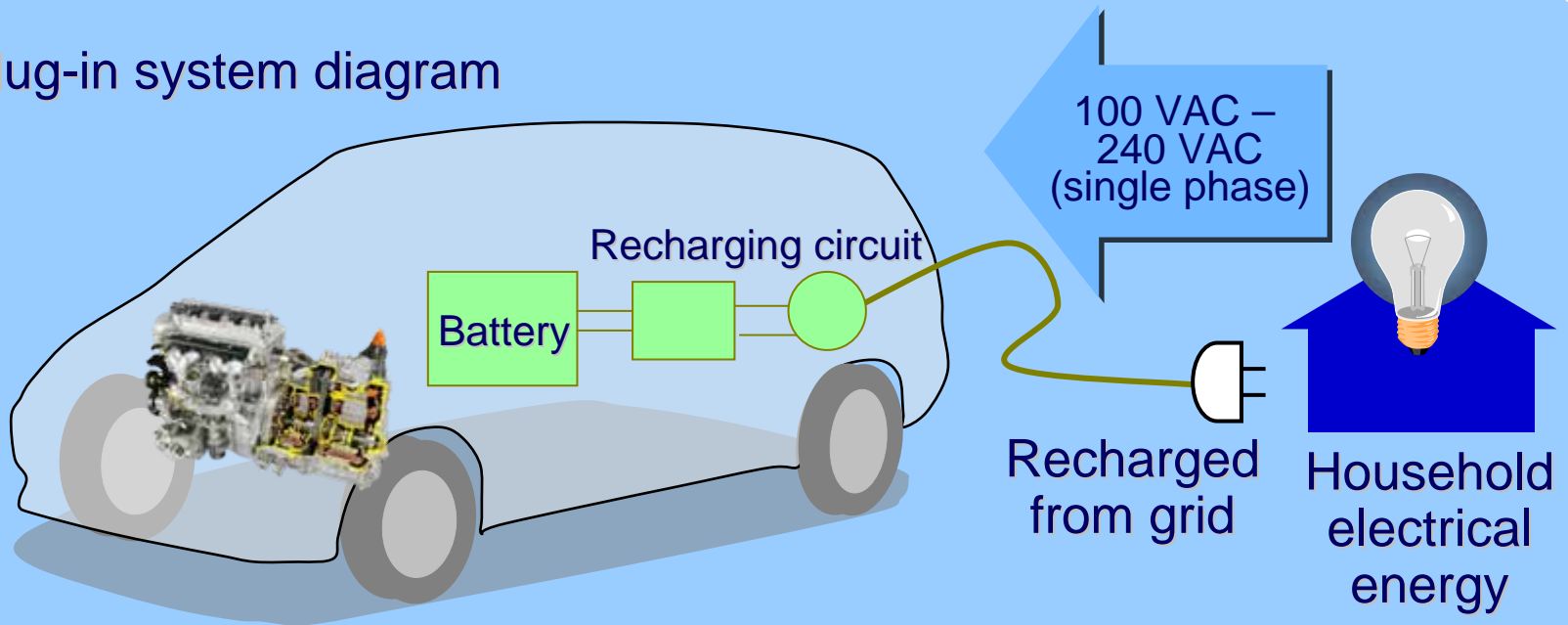
Status of Plug-In Hybrid Technology



Plug-In Hybrid Vehicle (PHEV) Benefits

Battery can be recharged from an external source to extend the electric motor-enabled driving range

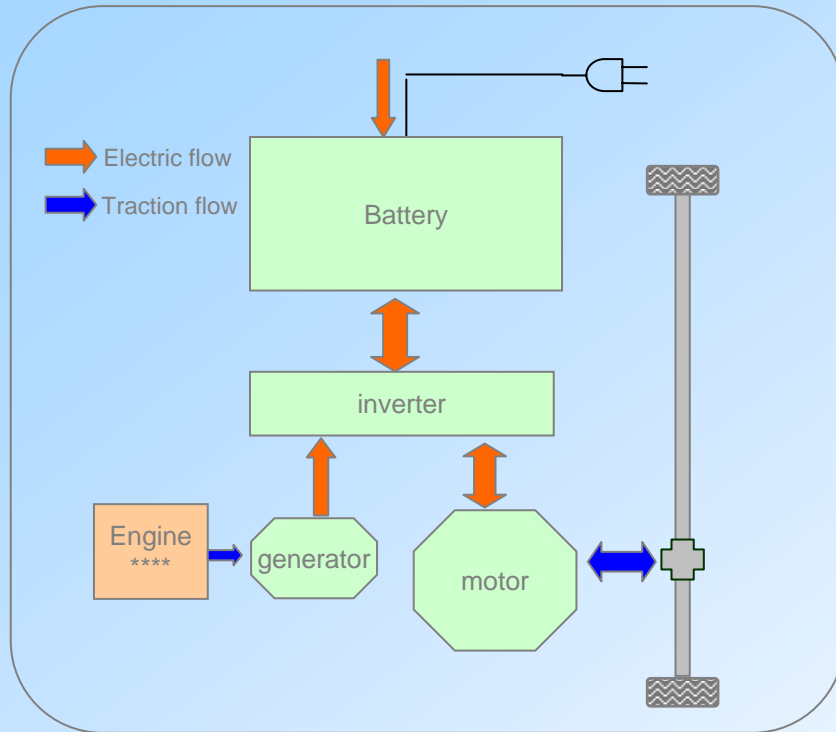
Plug-in system diagram



Benefits: Reduction in CO₂ emissions, fuel savings, quiet operation in EV mode, and able to recharge from home.

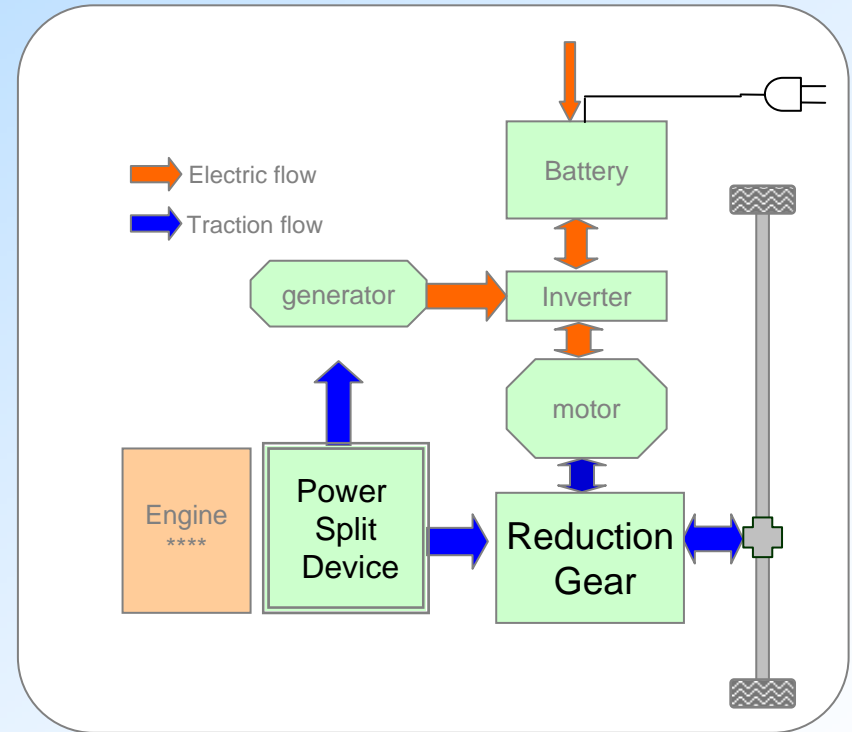
AER vs. Blended PHEV Comparison

All Electric Range (AER) type PHEV



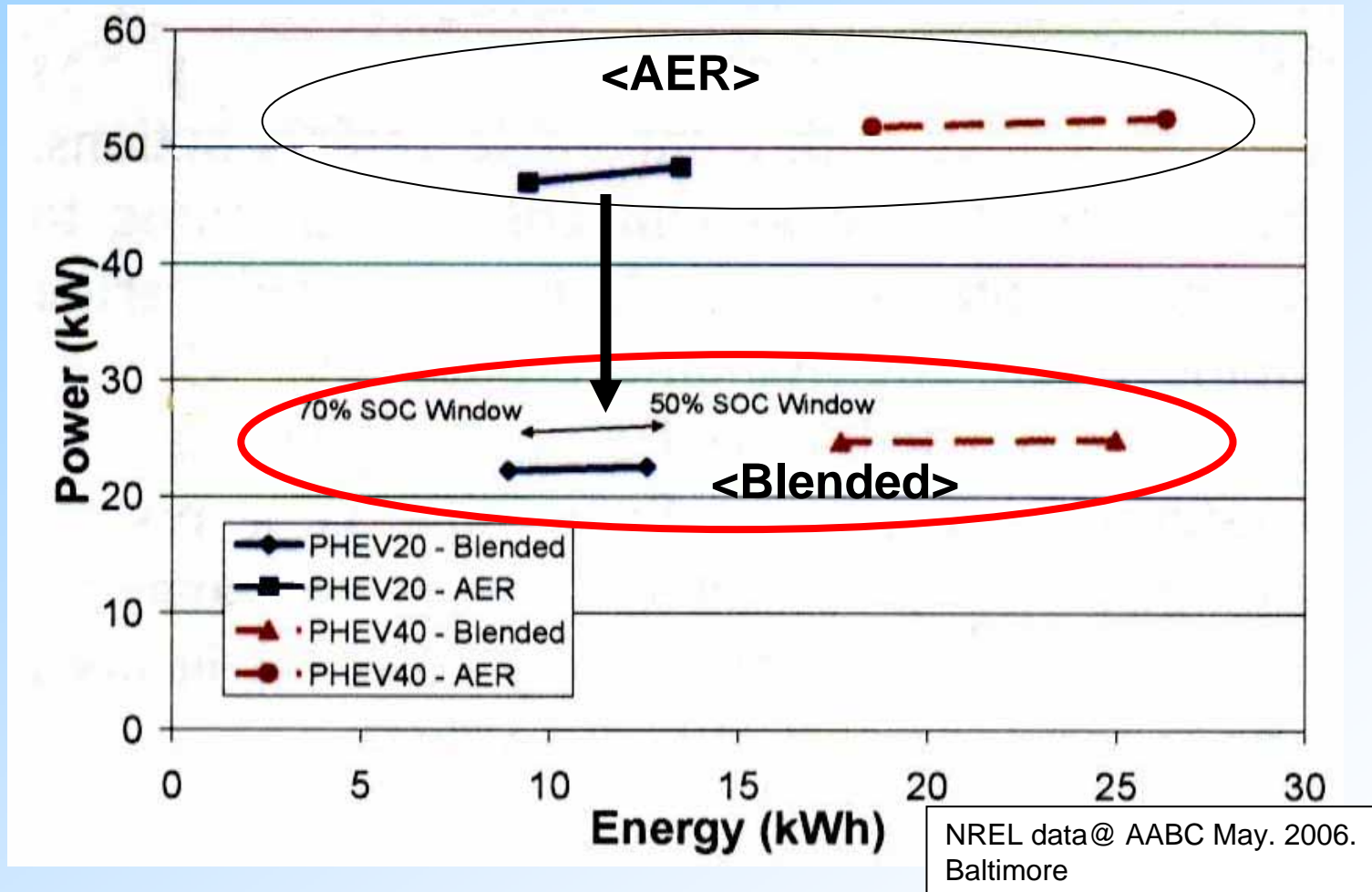
A BEV with a small engine that acts as a range extender when the battery is depleted

Blended type PHEV



A series/parallel hybrid with a larger battery to allow greater all electric operation

AER vs. Blended System Comparison

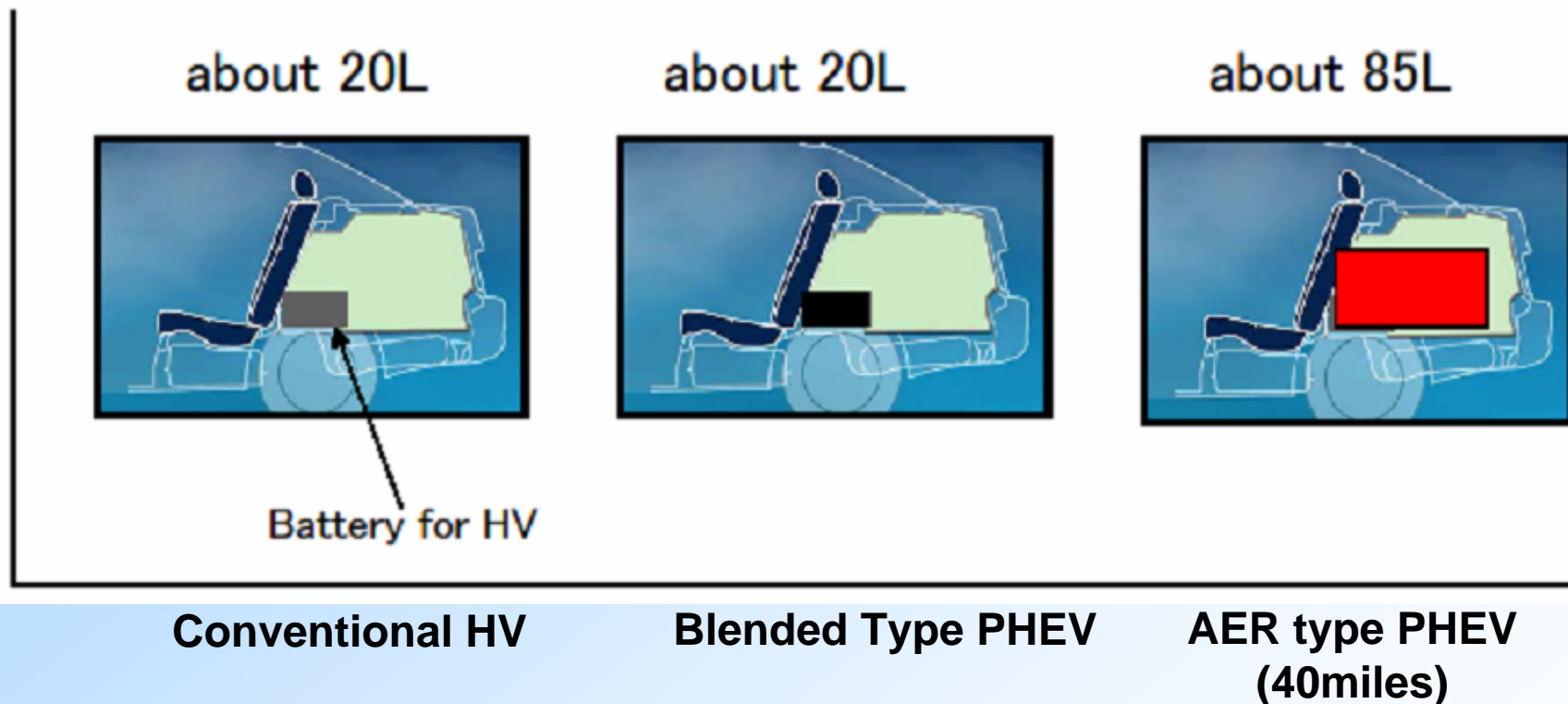


A "Blended" PHEV can reduce maximum battery and motor power significantly.



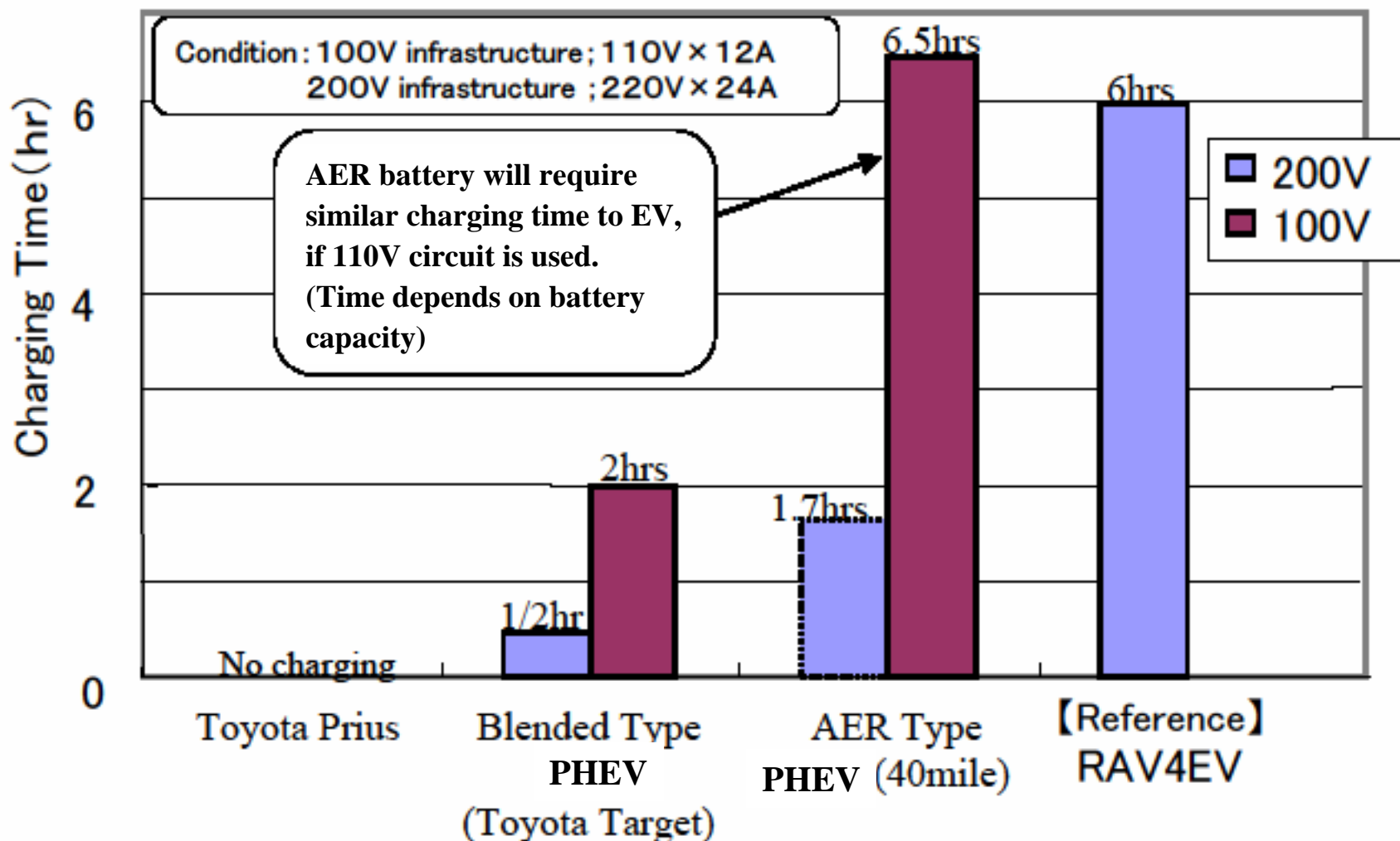
PHEV Challenges

Battery Installation Space



**AER PHEV will require a large capacity battery even with advanced battery technology expected by 2015
→ difficulty in ensuring practical trunk space**

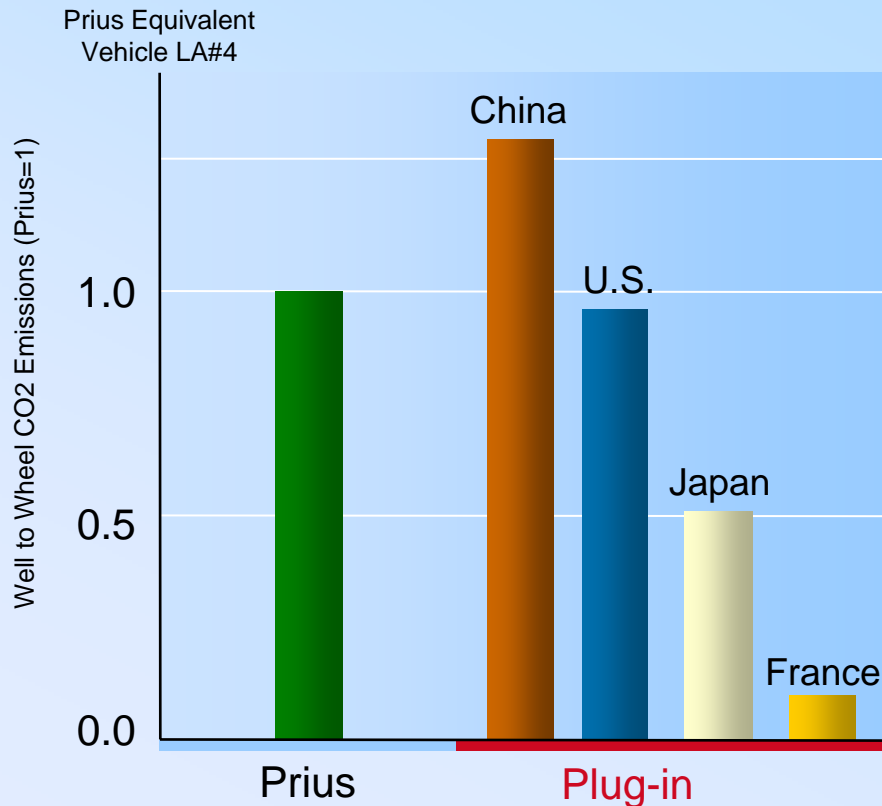
Battery Issues : Charging Time



AER PHEV battery requires same charging time as EV !



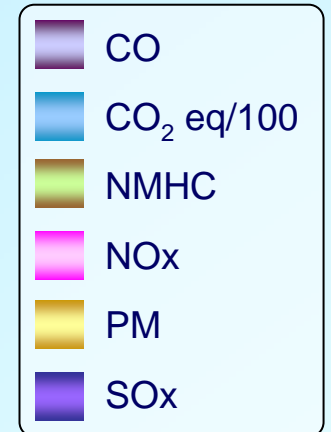
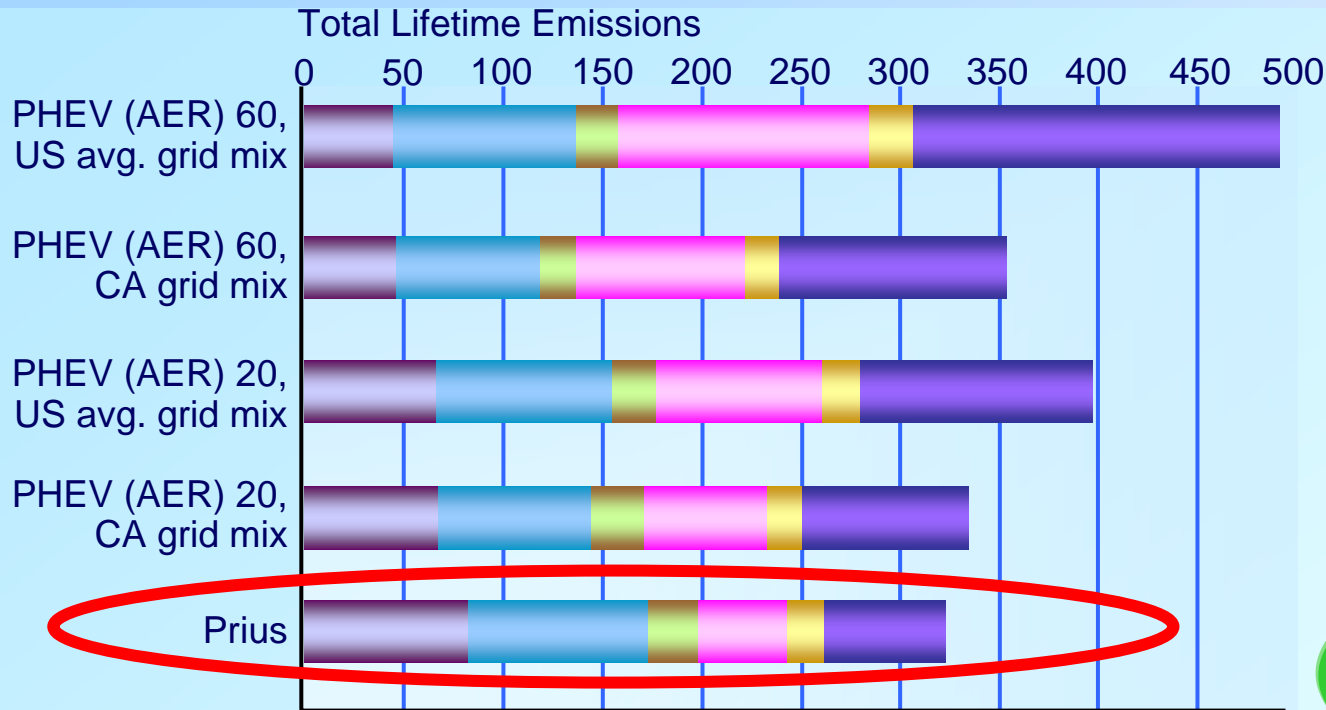
CO2 Reduction



The advantage is big in France where **nuclear power generation** is common. There is no advantage in China, which mainly uses **coal-fired power plants**.

When electricity is generated from low-carbon sources, the CO2 emissions of a PHEV are lower than an HV

Hybrid and PHEV Total Emissions



SOURCE: Kreider & Associates



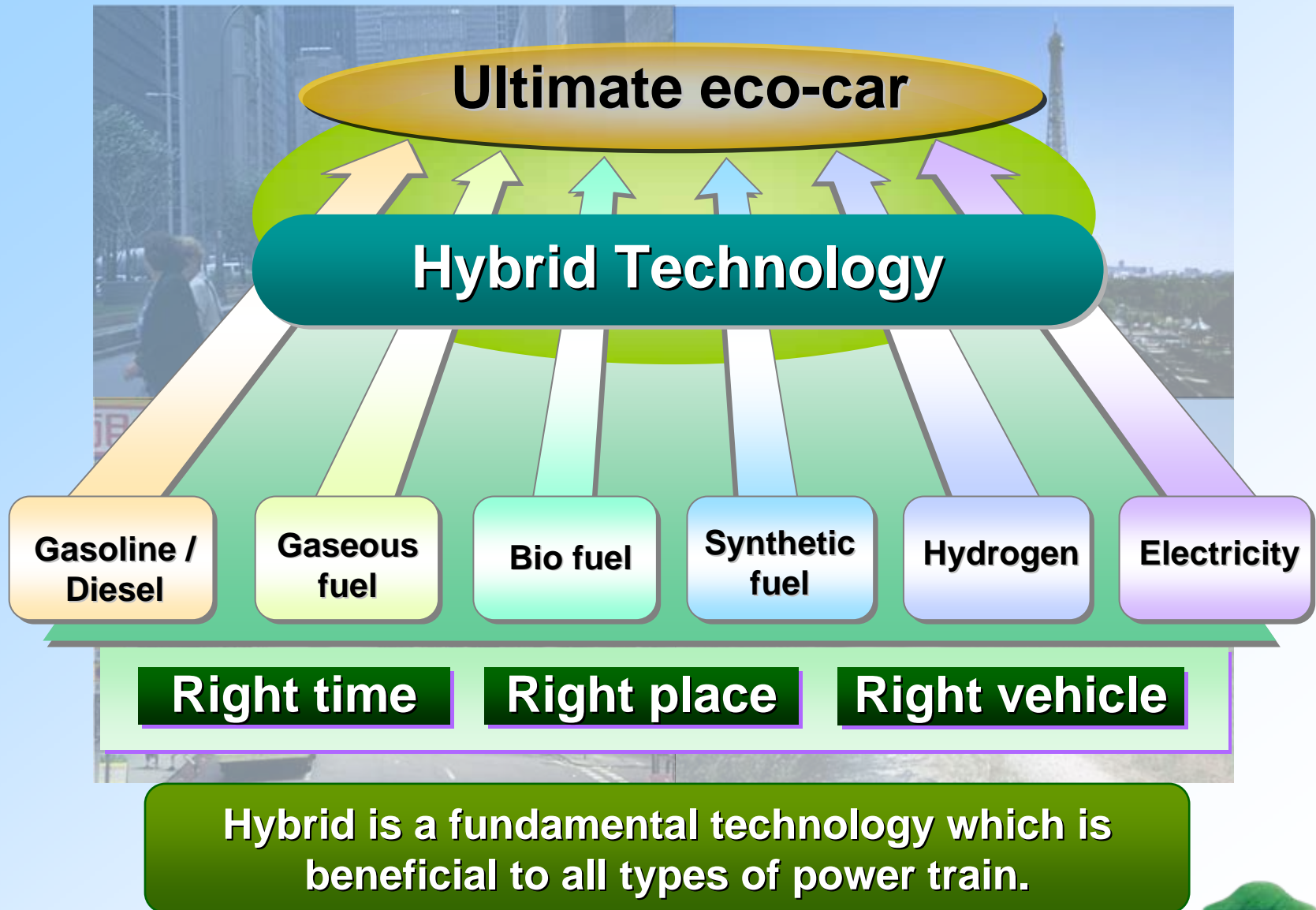
Total lbs. of emissions over lifetime of vehicle
(126K miles; 7 yr. battery life; PHEV 20: 39% of total VMT in EV-only; PHEV 60: 74%)

In addition to controlling CO₂ emissions it is important to manage the other critical emissions components.



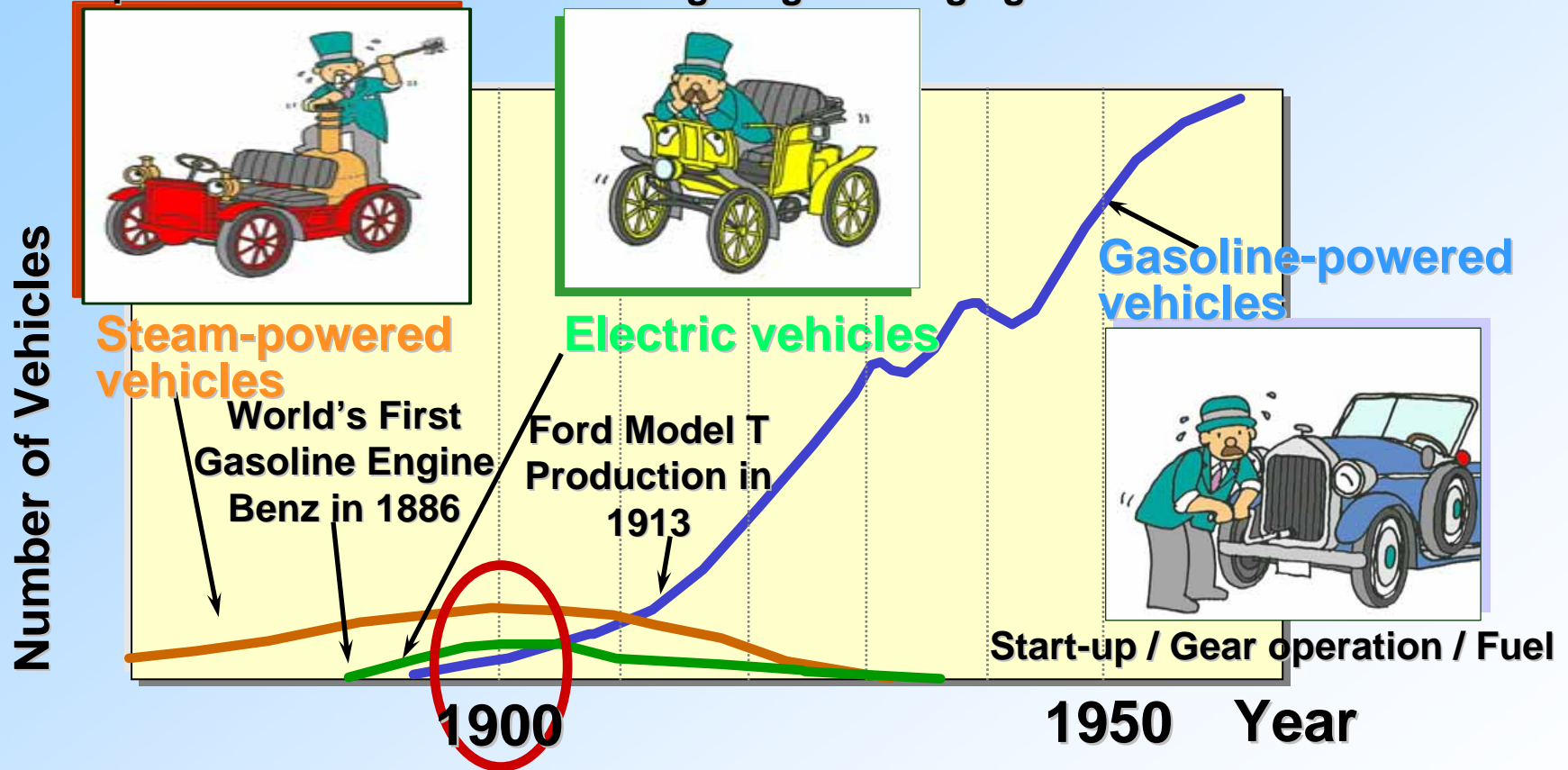
4. Conclusions

TOYOTA's Mission



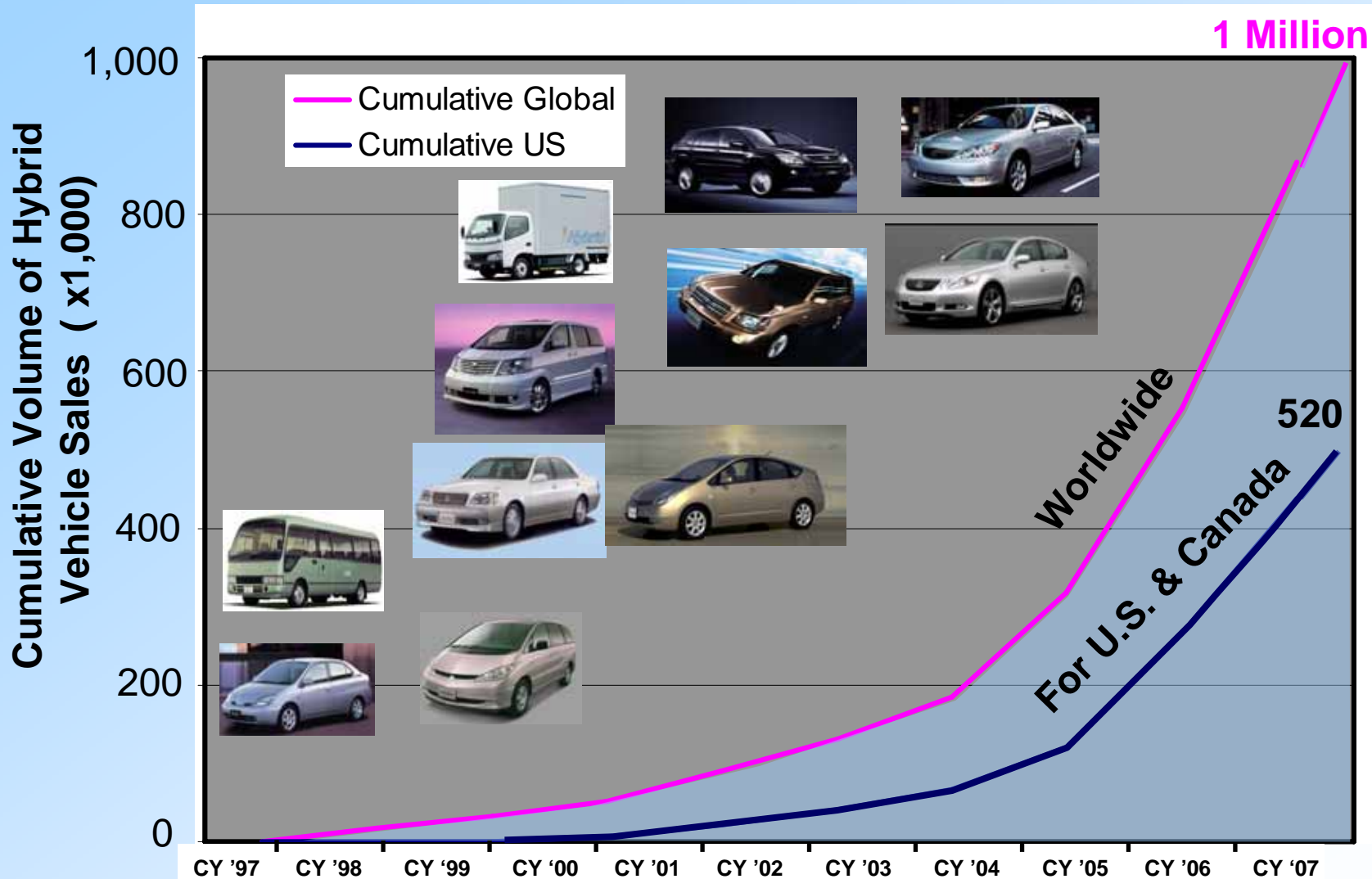
Automobile History

Start-up / Soft water for boiler Cruising range / Charging time / Electric sources



It took 27 years for gasoline-powered vehicles to become the mainstream in global markets.

Hybrid Vehicle Sales History



- 9 years have passed since Prius was introduced and global market share for hybrids is still around 0.2%.
- This demonstrates the slow penetration of new power train technologies.

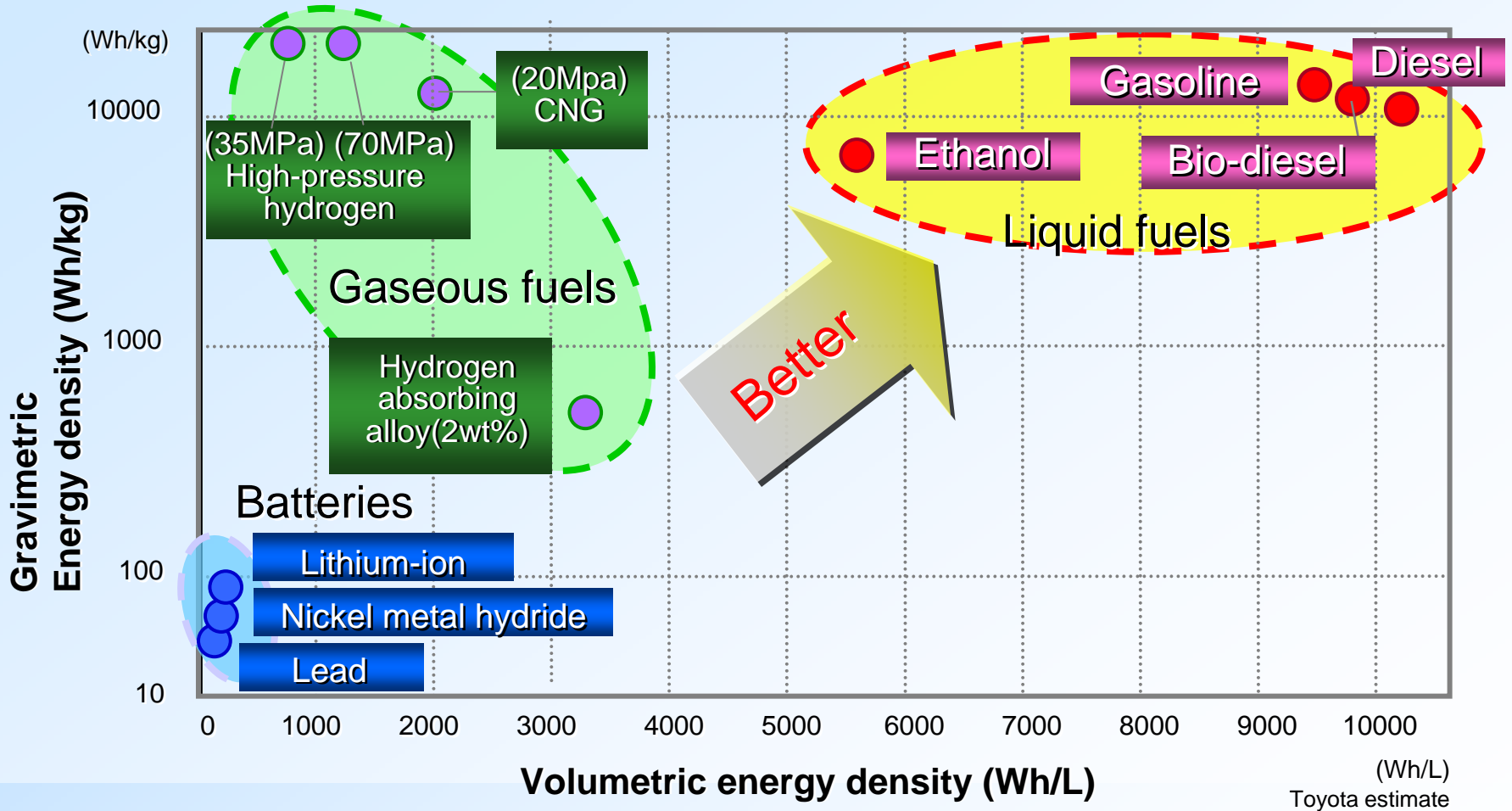
Thank you for
your attention



Back-up slides

Hydrogen and Batteries Challenges Remaining

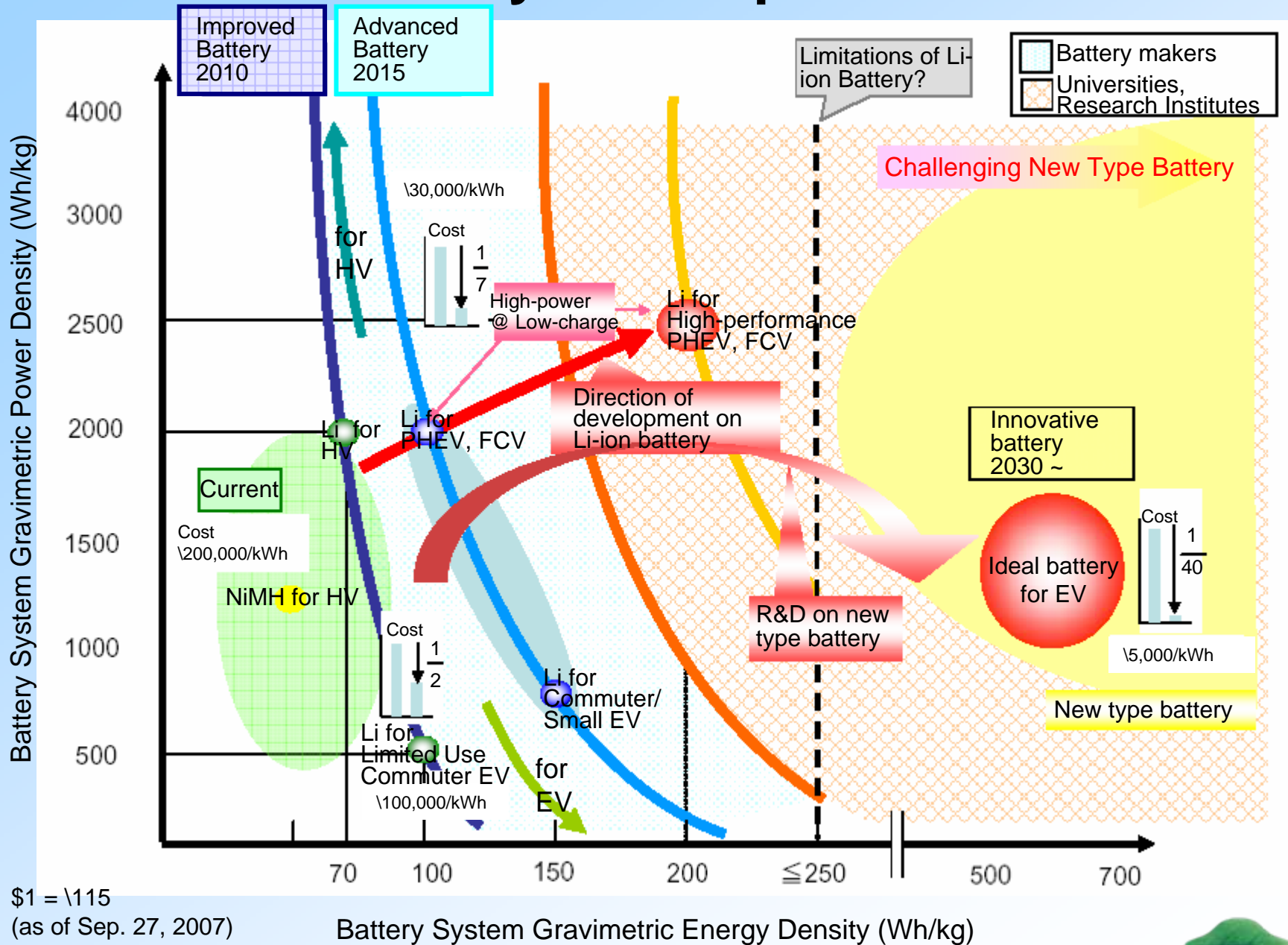
Alternative fuels and their density



Hydrogen and Batteries have poor energy density compared to liquid fuels



Direction of Battery Development for Vehicles



\$1 = ≈ 115

(as of Sep. 27, 2007)

Source: <http://www.meti.go.jp/policy/automobile/LEV/battery-report.pdf> (translated by TMC)



2007 Houston World Oil Conference

Proceedings



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