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Advanced Technologies at Toyota

Mobile Sources Technical Review Subcommittee

September 17, 2008

Robert Wimmer
Toyota Motor North America

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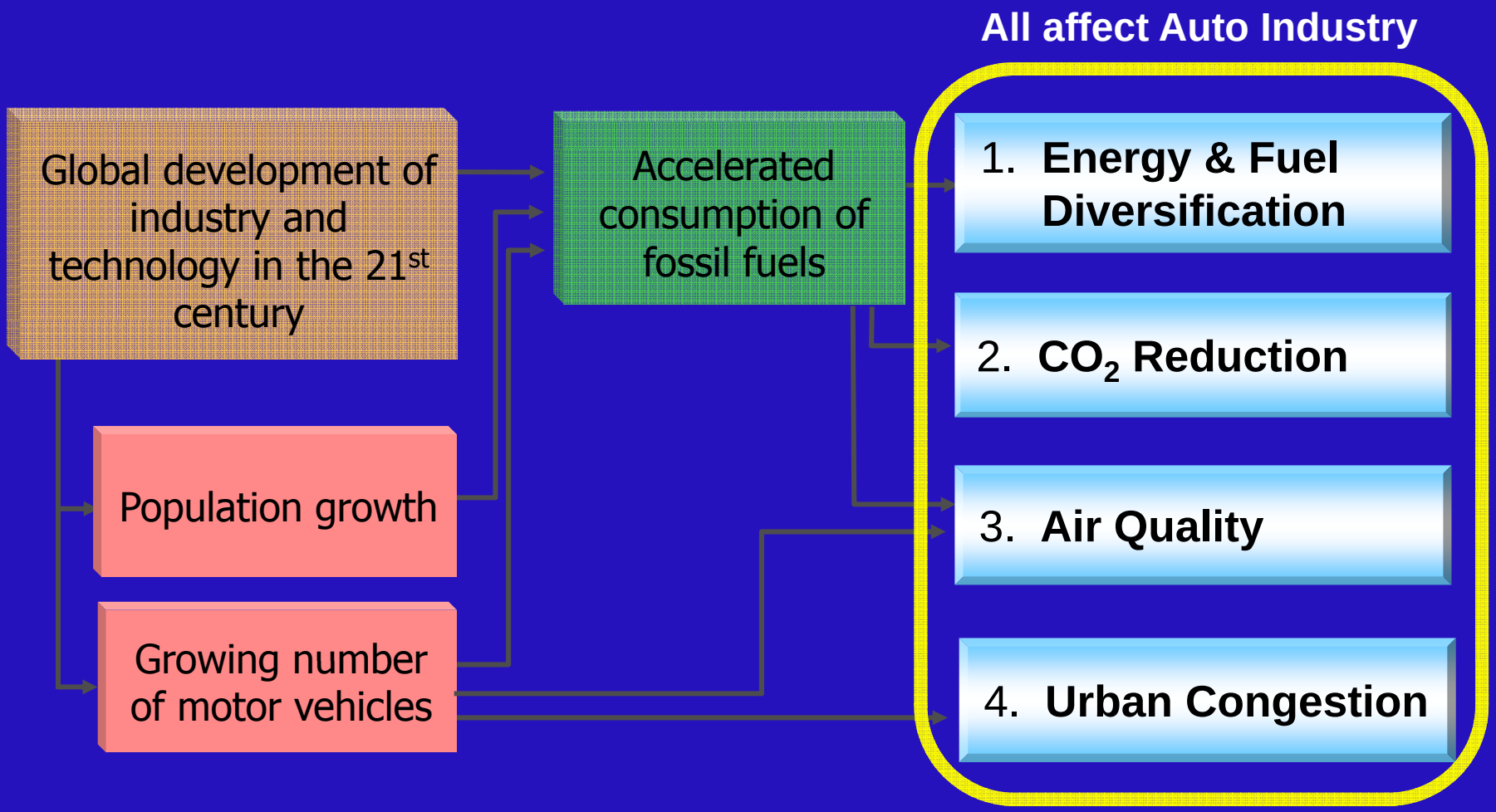
The "Big 4" Issues Driving Change in Business



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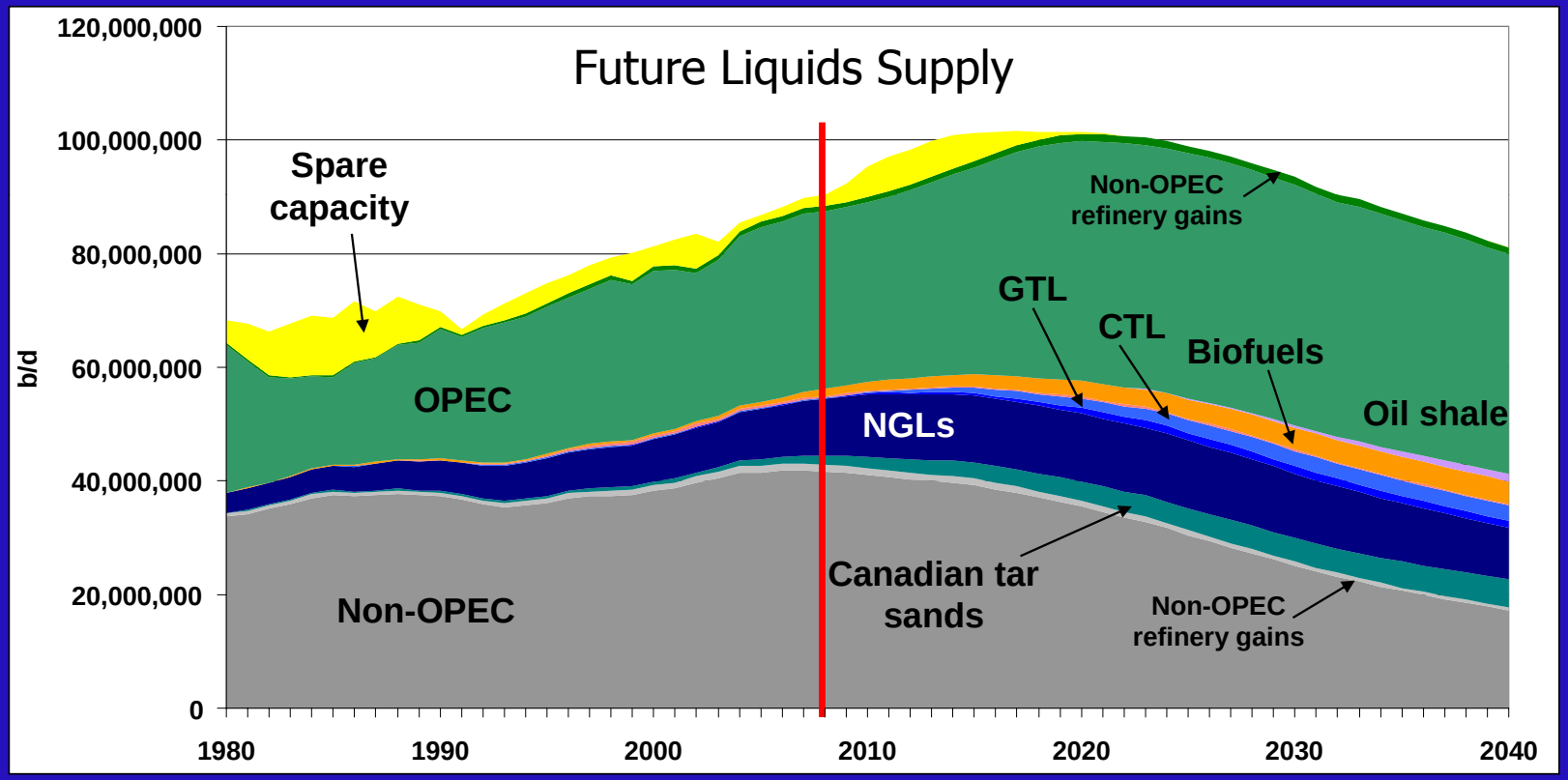
Why Energy & Fuel Diversity?



Continued growth in liquid fuels is not sustainable.
Diversification will be necessary.

Data:
P. Wells

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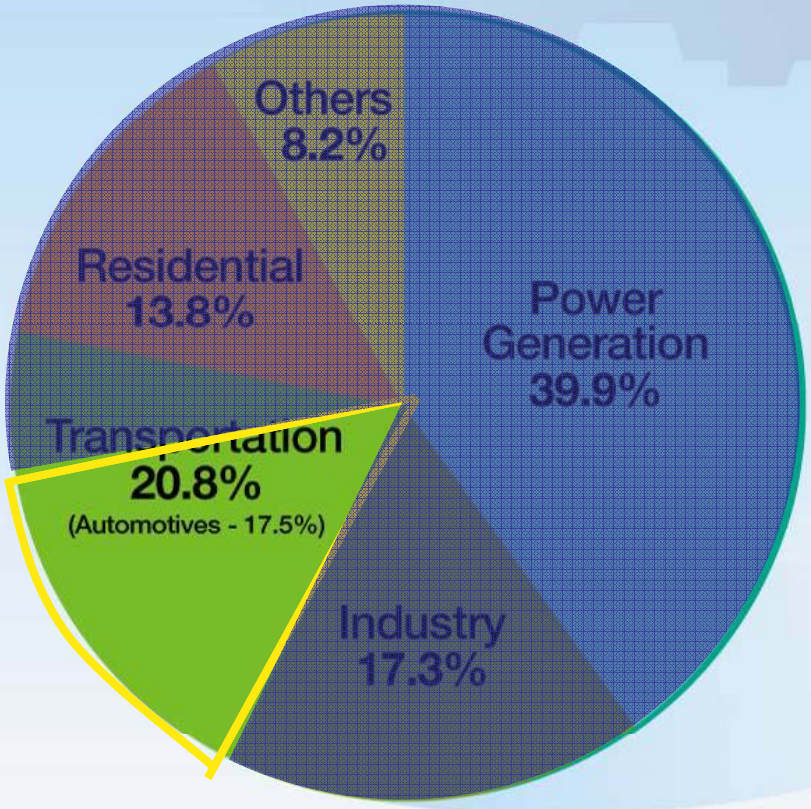
Sources of CO_2 Emissions



World CO_2 emissions arising from fuel combustion by sector

excludes animal husbandry

Total CO_2 Emissions:

23.6 billion tons

SOURCE: "IEA CO_2 Emissions From Fuel Combustion" (2004 Edition)

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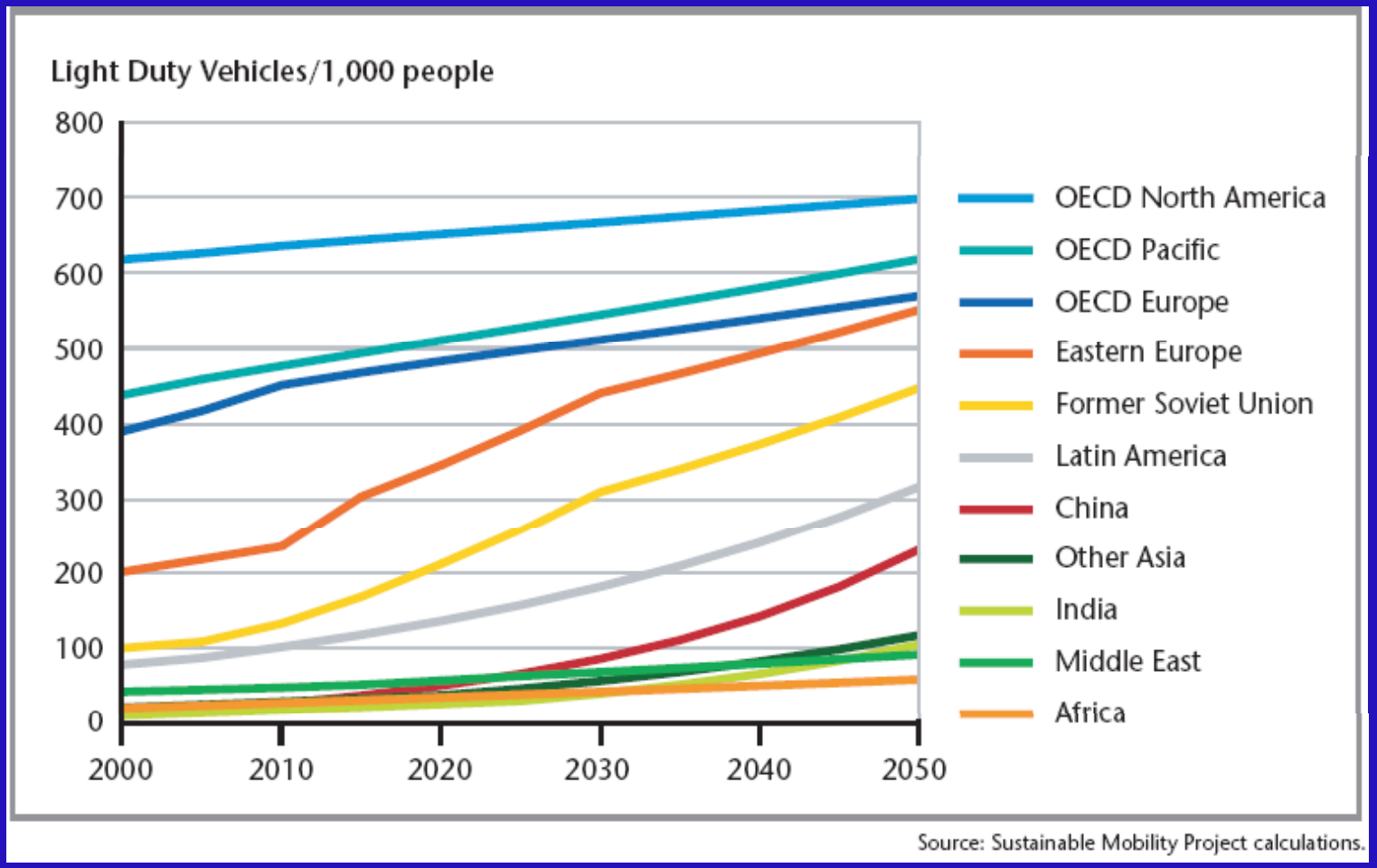
Growth in Vehicle Ownership Resulting in Pollution & Congestion



Source: Sustainable Mobility Project calculations.

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The Automobile Challenge

1. Balance reduction of environmental impact with meeting <u>consumer wants</u>
   - ***It doesn't matter how "green" a product is if no one will buy it***
2. Mass market appeal
   - ***Must sell millions to make real impact***
3. Life Cycle Assessment
   - ***Must look beyond "tailpipe" for true environmental impact***

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Regulations Complicate Vehicle Development

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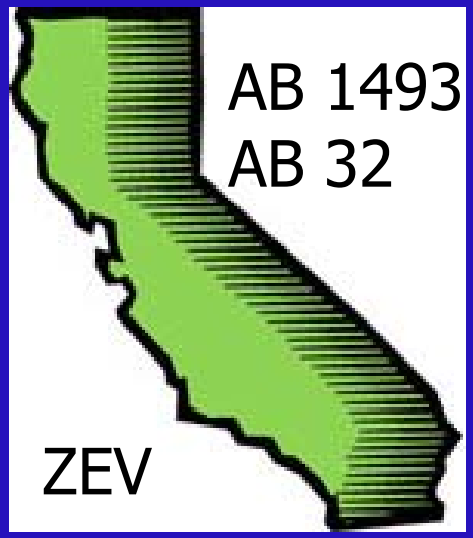

Differing timeframes, measurement techniques and legislative uncertainties greatly increase compliance costs and may conflict with market demand

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Toyota's Multi-Path Approch

Issues

- CO_2 Reduction
- Energy Diversification
- Reduced Emissions
- Urban Congestion

Sustainable Products

Hybrid Technology

Alternative fuel HV
Diesel HV
FCHV
Plug-in HV
HSD

Biofuels
Synthetic fuels
CNG

DPNR
Common rail DI

D-4
Lean burn
VVT-i

EV

Alternative fuel engines | **Diesel engines** | **Gasoline engines** | **Electrical energy**

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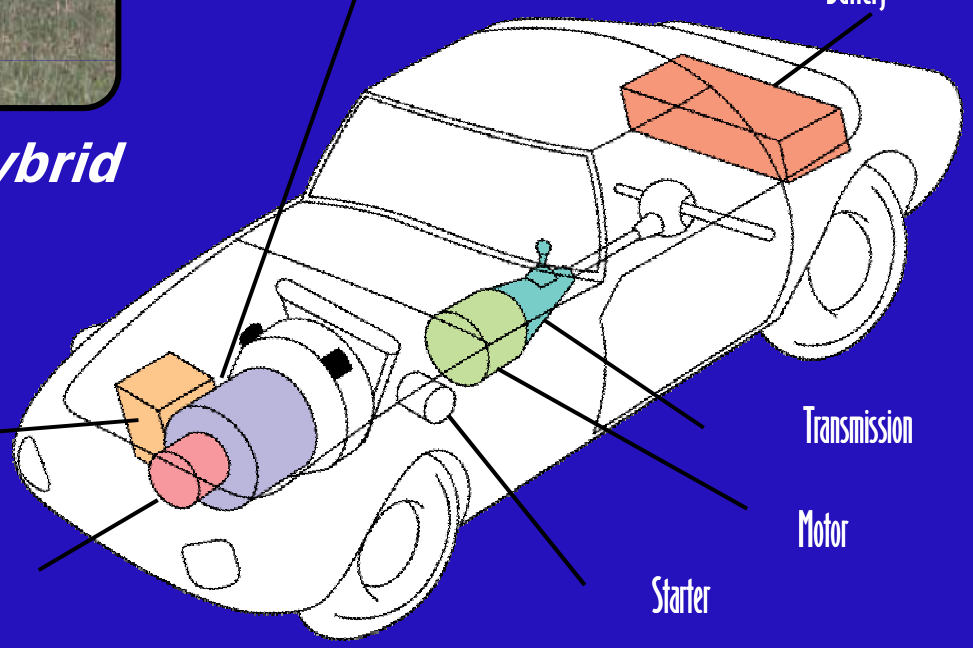
Toyota's First Hybrid

1967 S800 Gasoline Turbine Hybrid



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Toyota's Line of Hybrids in America

TOYOTA MODELS

Prius
Midsize 5 Door

Camry Hybrid
Midsize 5 Door

Highlander Hybrid
Midsize SUV

LEXUS MODELS

RX400h
Luxury SUV

GS450h
Premium Sport Sedan

LS600h
Flagship

Combined US sales averaging over 23,000 / month in 2008

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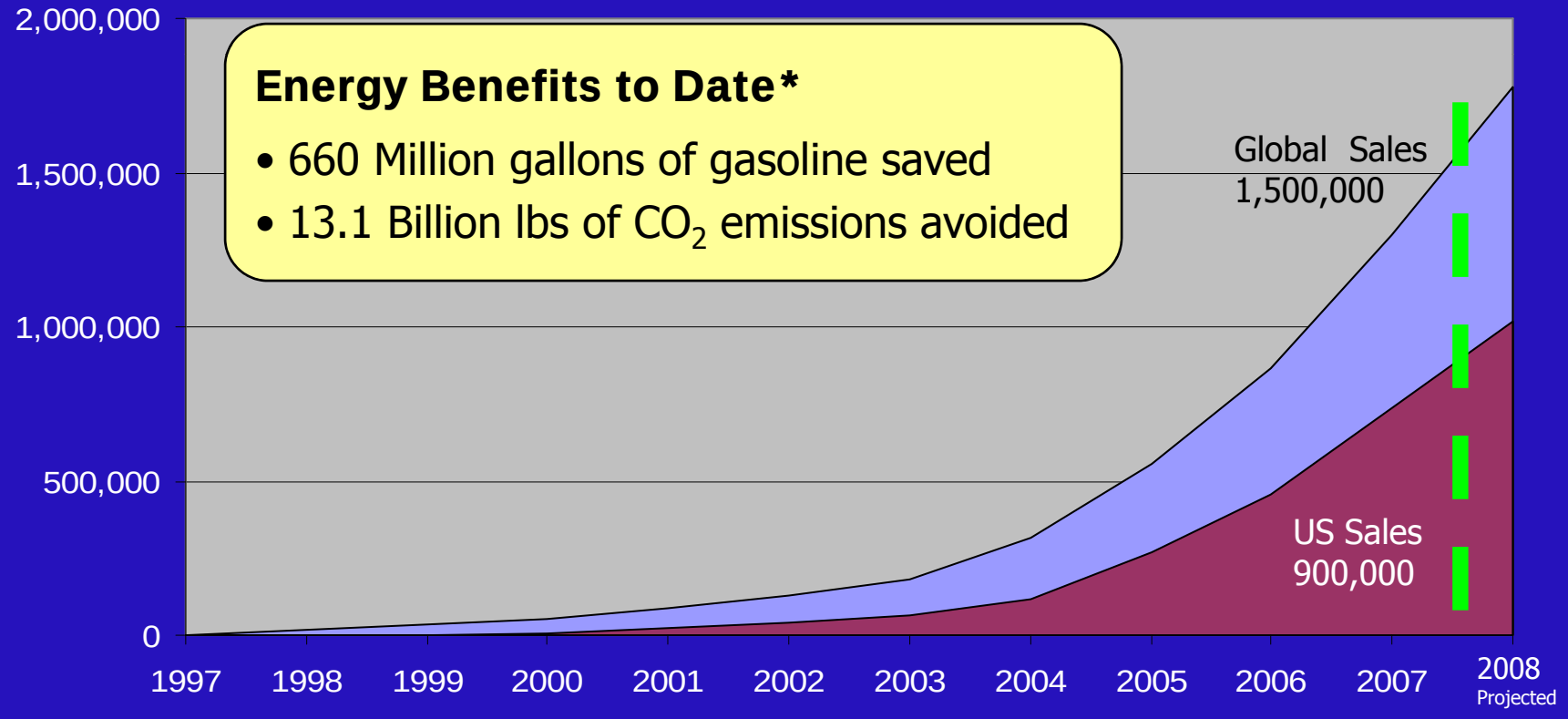
A Million & Half Hybrids Sold & Growing

Cumalative Hybrid Sales thru July 2008



Energy Benefits to Date*

- 660 Million gallons of gasoline saved
- 13.1 Billion lbs of CO_2 emissions avoided

*Toyota Estimate

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Hybrid as a Foundation

- Toyota's Hybrid Synergy Drive is the powertrain foundation for next generation technologies
  - Flexibility
  - Reduced development time & cost
  - Lower cost higher volume potential

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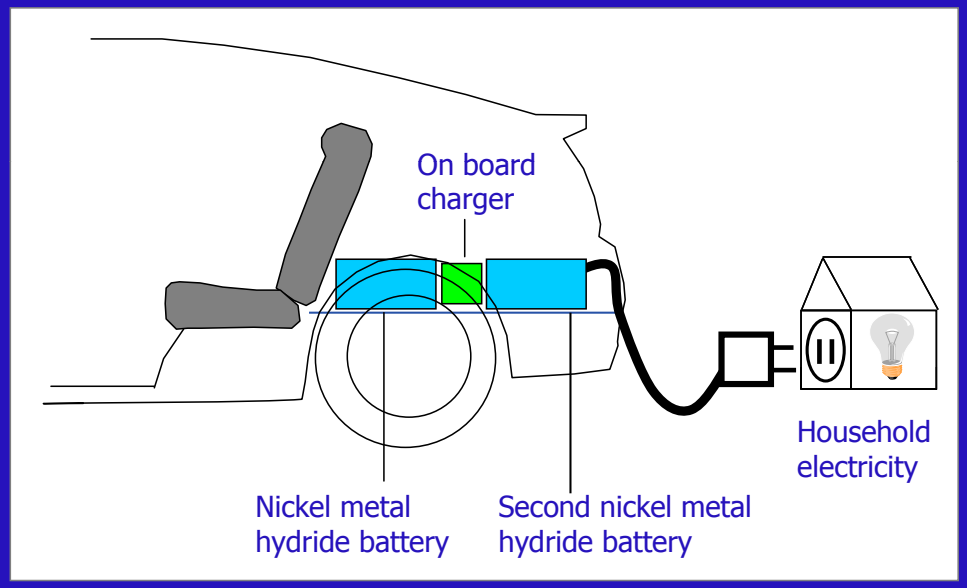
Toyota's Current PHV Prototype



VEHICLE BENEFITS

- Fuel diversification (energy security)
- Potential greenhouse gas reduction
- Reduced fuel cost

PROTOTYPE OBJECTIVES

- Study consumer behavior (US)
- Study public charging (Europe)
- Demonstrate system, not battery capability

CHALLENGES

- Battery cost & life – key for commercial introduction
- Packaging
- Need for cleaner electricity

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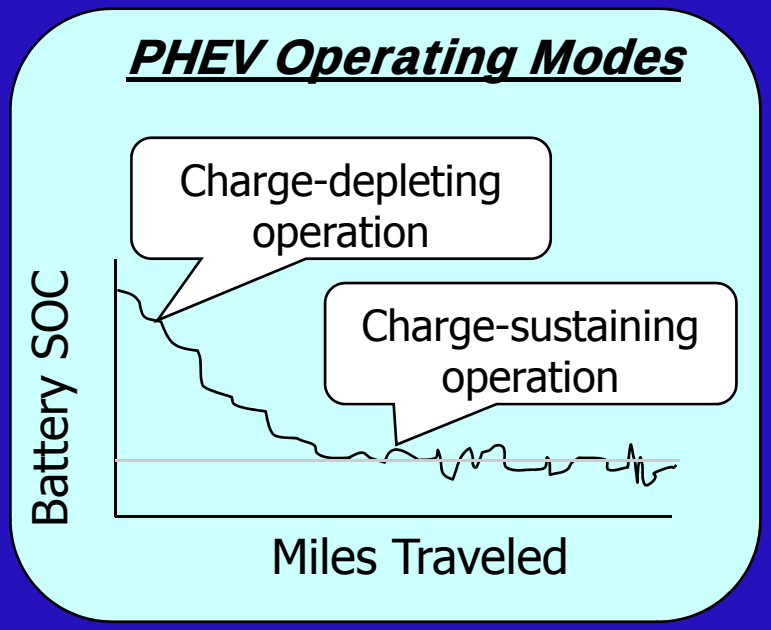
Toyota PHEV Performance Specifications

- EV Performance (Charge-depleting)
  - Top speed in EV mode – 62 mph
  - Max EV power ~ 40 kW
  - EV range ~ 7 miles
- Battery (2 x NiMH)
  - 2 x 6.5 Ah (13Ah / 2.6kW-hr)
  - 202 V
- Charging Time
  - 1-1.5 hr on 220V
  - 3-4 hr on 120V
- Max system power 100kW (20kw more than Prius)



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2010 – The Next Step

- Toyota has announced our next generation PHEV:
  - Significant numbers beginning in 2010 model year
  - Global program
  - Commercial fleets
  - Li-Ion batteries
    - Manufactured by Panasonic EV (Joint venture with Toyota)
  - Results to help determine suitability for consumer market
- Re-evaluate suitability of battery electric vehicles for consumer market

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Toyota's Current Fuel Cell Prototype

VEHICLE BENEFITS

- Zero tailpipe emissions
- Potential non-petroleum, diversified fuel sources
- Low / zero carbon fuel

PROTOTYPE OBJECTIVES

- Public education on hydrogen
- Demonstrate technology
- Identify infrastructure issues

CHALLENGES

- Fuel cell system cost
- Fuel cell stack life
- Lack of infrastructure

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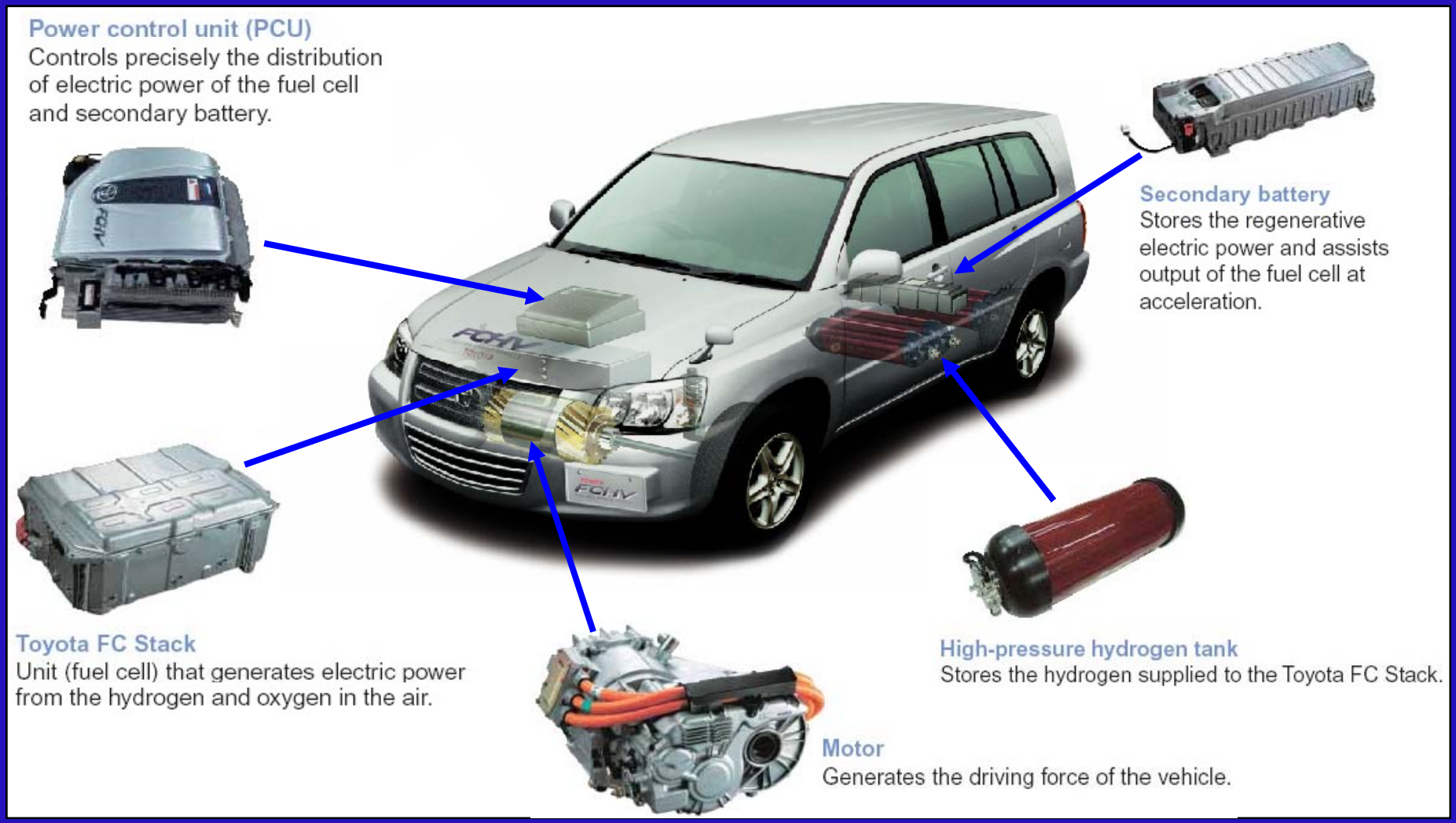
Key System Components



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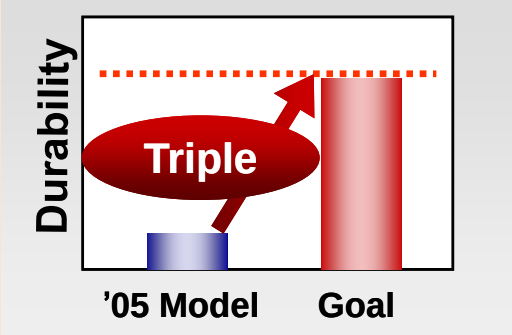
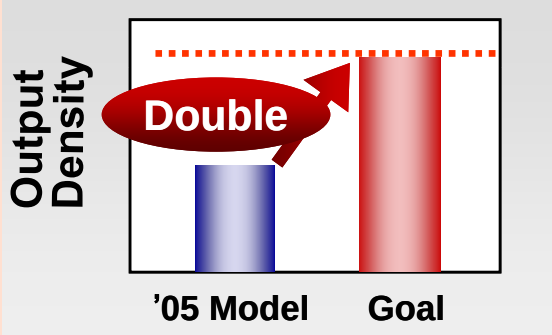
Challenges Remain

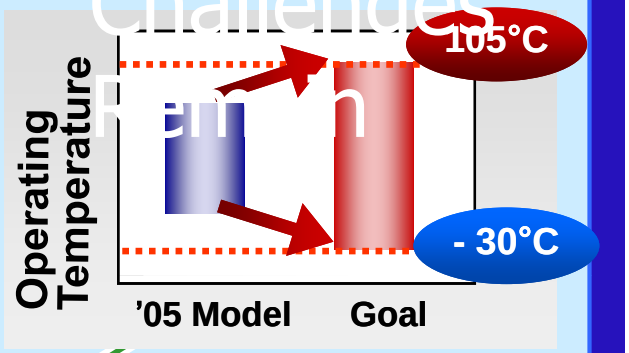
Stack Durability



Compactness / High Power Density



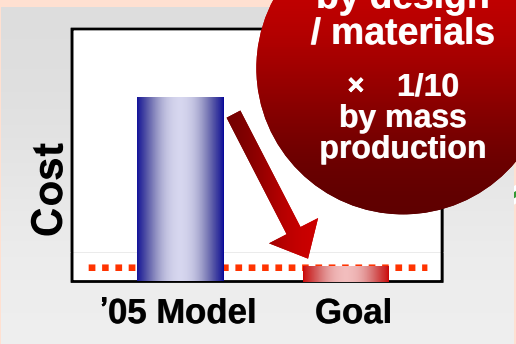
High & Low Temperature



Next targets

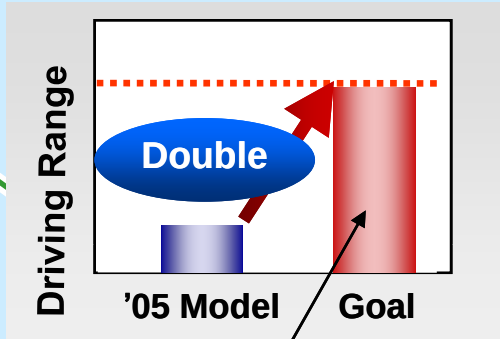
Significant Progress

Cost



1/10 by design / materials × 1/10 by mass production

Driving Range



Over 500 miles demonstrated

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Conclusions

- The auto industry must adapt to multiple energy and environmental issues and regulations
- Hybrid is the foundation for future vehicle technologies at Toyota – Fuel Cell & PHEV are evolutions
- Fuel Cells & PHEVs show environmental & energy security promise, but only if produced in large volumes
- Durability, cost and infrastructure are challenges for Fuel Cells & PHEVs.
- Without "green" fuels, the environmental benefit (GHG reduction) of these technologies will be modest at best

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Thank You!

Questions?