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Advanced Technologies at Toyota

Mobile Sources Technical Review Subcommittee

September 17, 2008

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Toyota Motor North America

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The "Big 4" Issues Driving Change in Business

Global development of industry and technology in the 21st century

Population growth

Growing number of motor vehicles

Accelerated consumption of fossil fuels

All affect Auto Industry

1. **Energy & Fuel Diversification**
2. **CO_2 Reduction**
3. **Air Quality**
4. **Urban Congestion**

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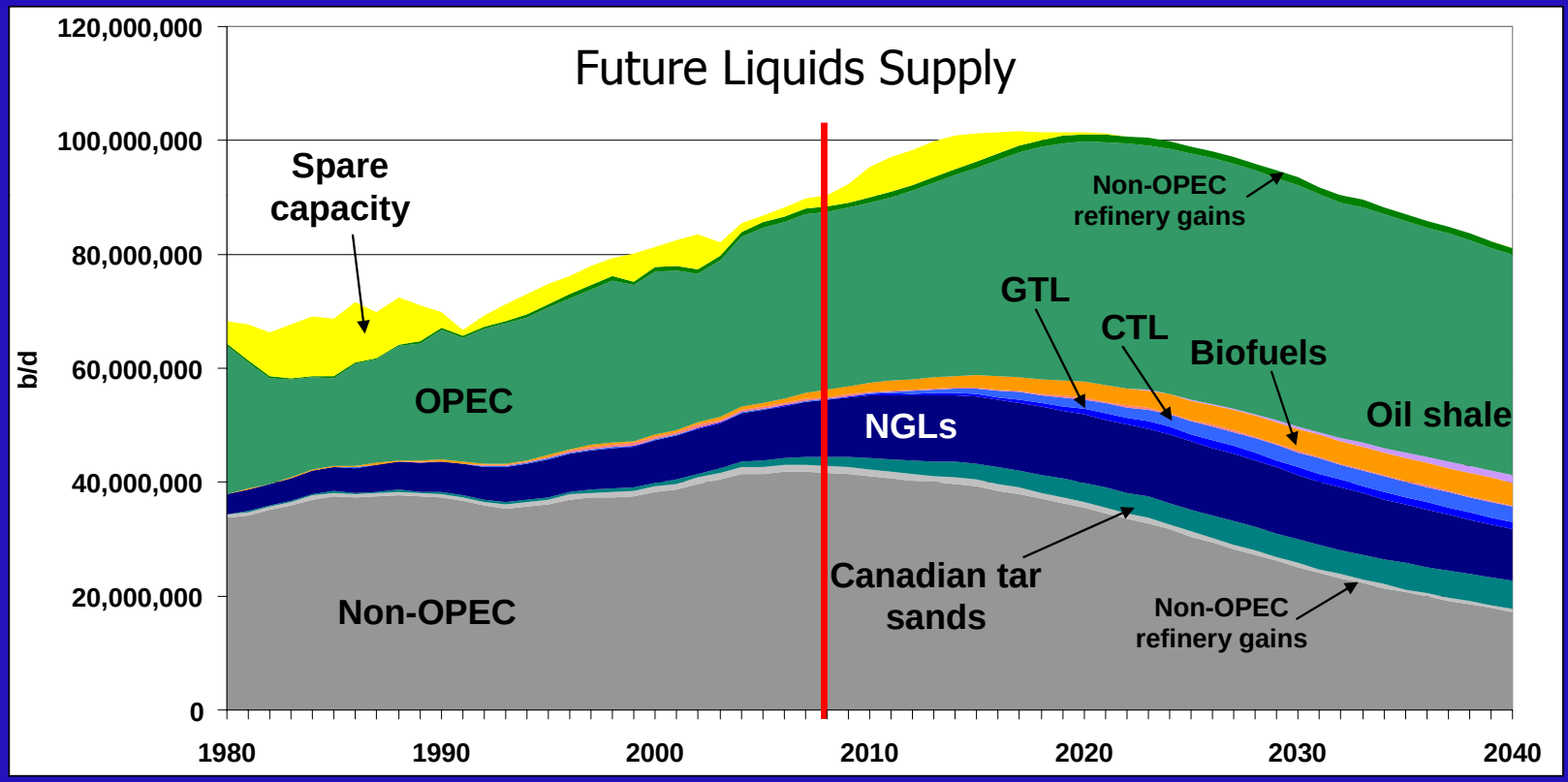
Why Energy & Fuel Diversity?



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

Data:
P. Wells

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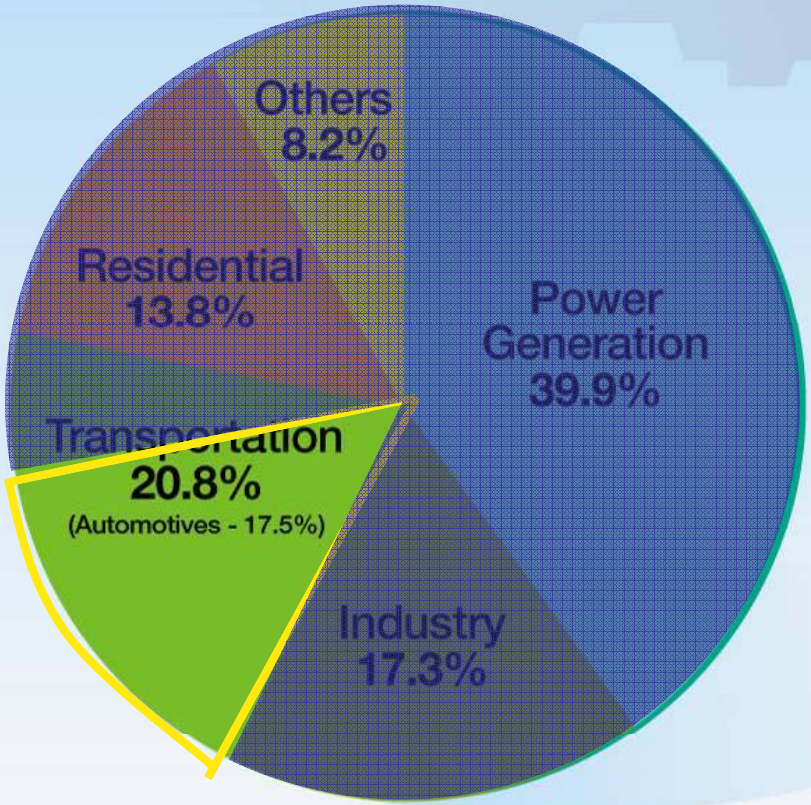
Sources of CO_2 Emissions



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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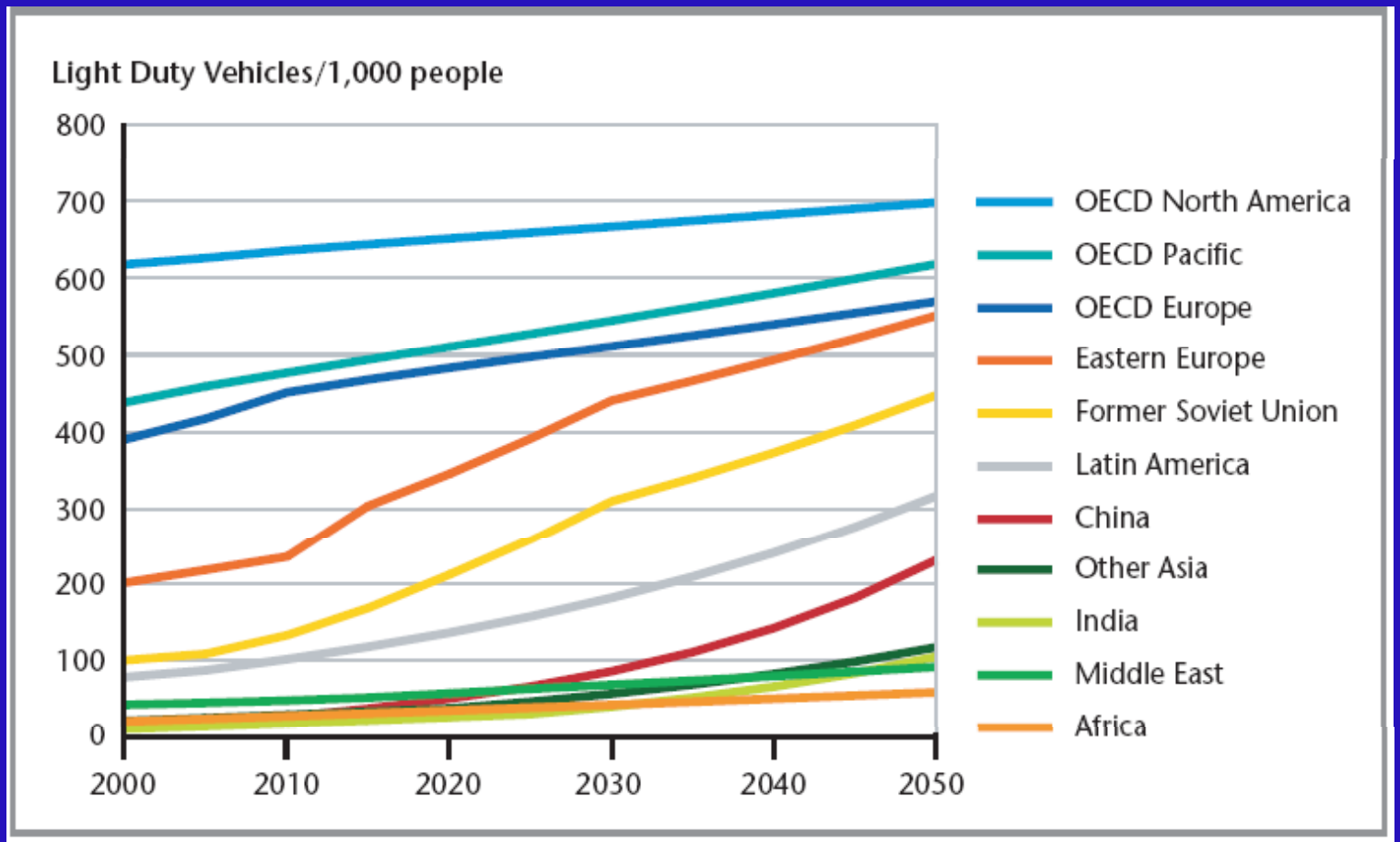
Growth in Vehicle Ownership Resulting in Pollution & Congestion



Source: Sustainable Mobility Project calculations.


The Automobile Challenge

1. Balance reduction of environmental impact with meeting consumer wants
   - ***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***


Regulations Complicate Vehicle Development

CAFÉ
Safety Standards
Carbon Legislation
Fuel Mandates

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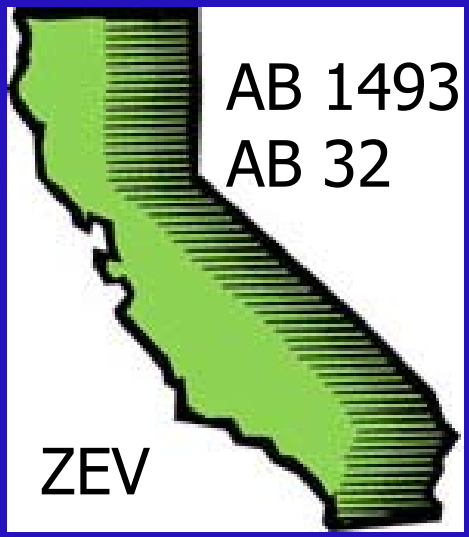

Differing timeframes, measurement techniques and legislative uncertainties greatly increase compliance costs and may conflict with market demand

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Toyota's Multi-Path Approch

Issues

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

Sustainable Products

Alternative fuel HV
Diesel HV
FCHV
Plug-in HV
HSD
Hybrid Technology
Biofuels
DPNR
Synthetic fuels
CNG
Common rail DI
D-4
Lean burn
VVT-i
EV

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

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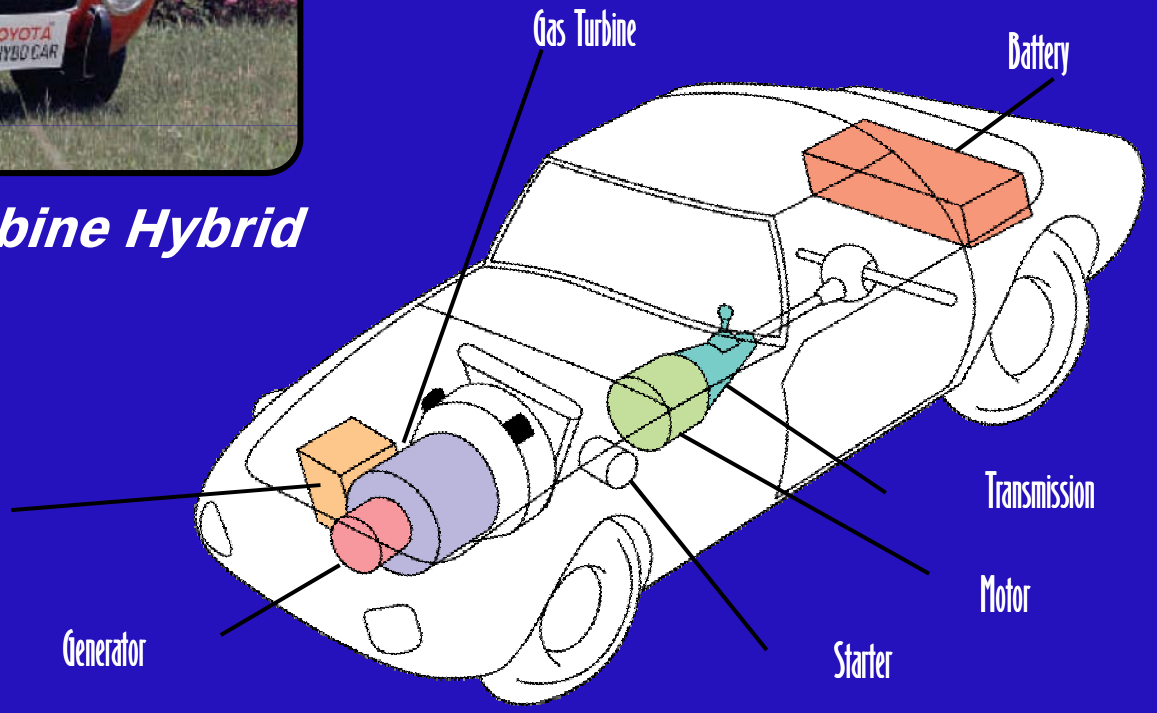
Toyota's First Hybrid

1967 S800 Gasoline Turbine Hybrid





Toyota's Line of Hybrids in America

TOYOTA MODELS

Prius
Midsize 5 Door

Camry Hybrid
Midsize 5 Door

Highlander Hybrid
Midsize SUV

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

LEXUS MODELS

RX400h
Luxury SUV

GS450h
Premium Sport Sedan

LS600h
Flagship

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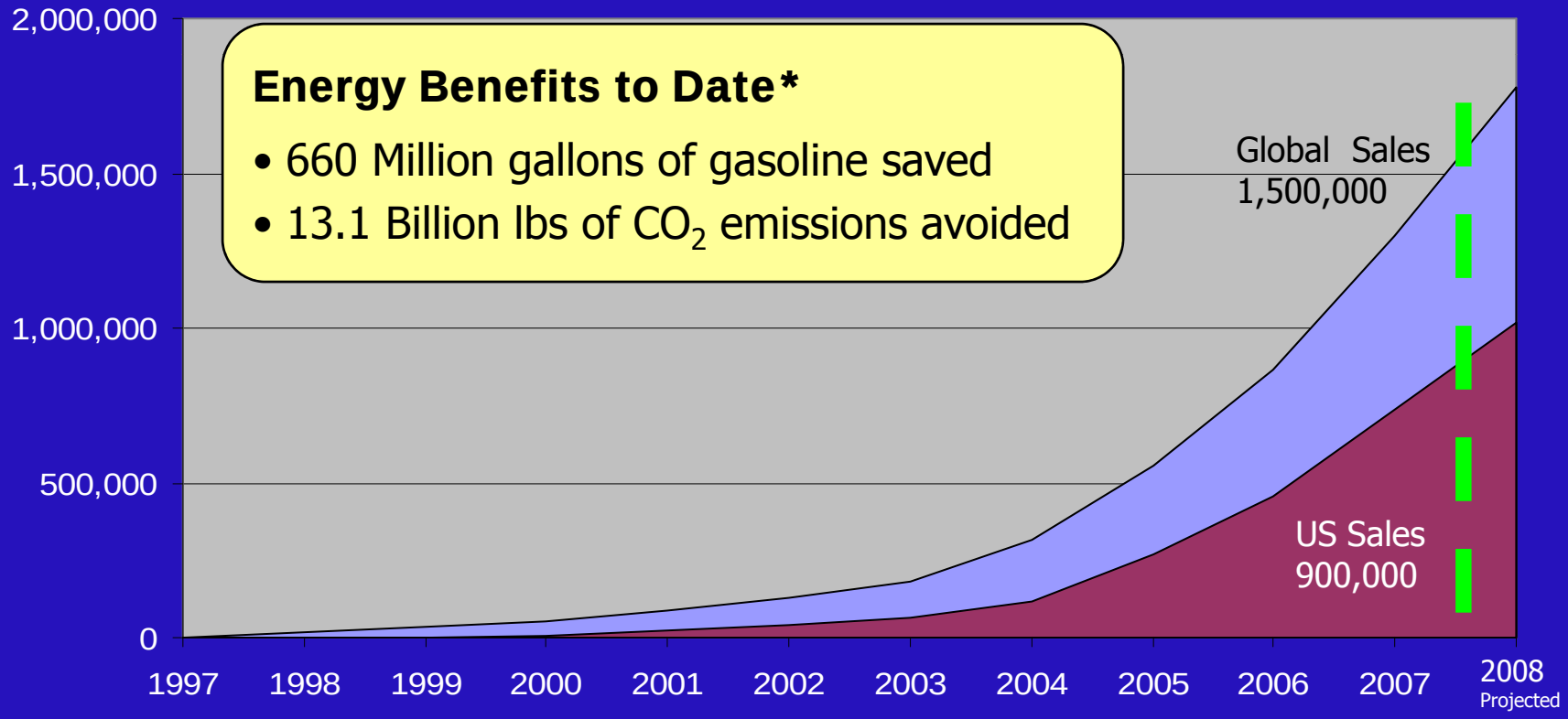
A Million & Half Hybrids Sold & Growing

Cumalative Hybrid Sales thru July 2008



*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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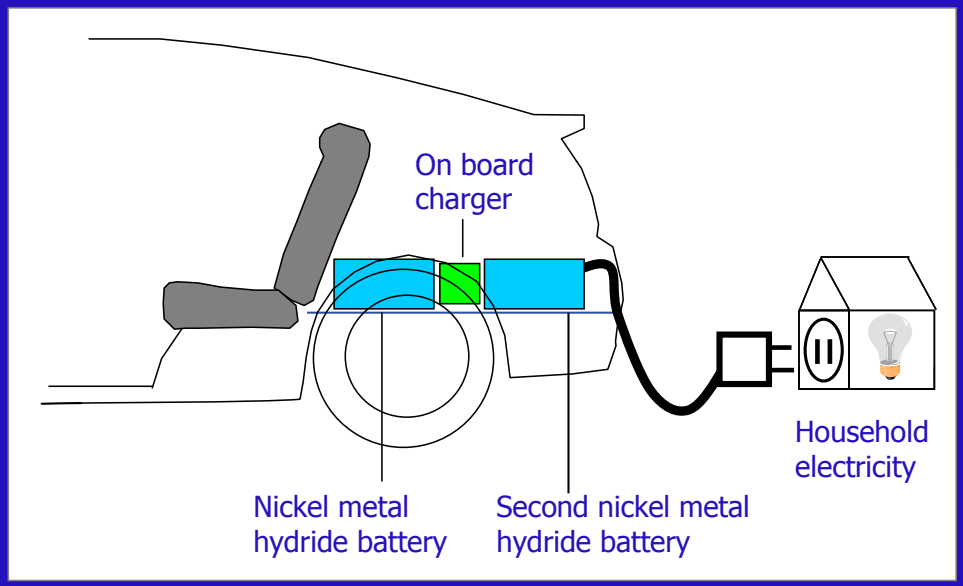
Toyota's Current PHV Prototype



VEHICLE BENEFITS

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

PROTOTYPE OBJECTIVES

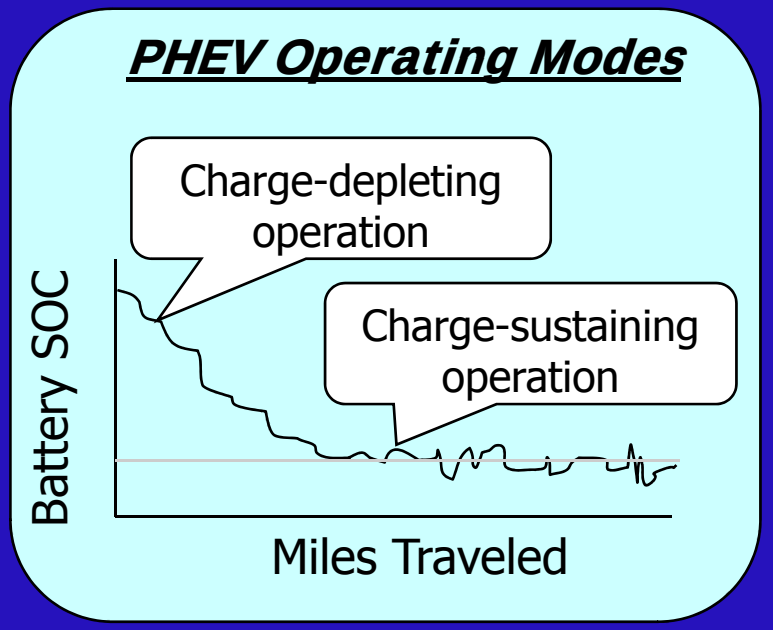
- Study consumer behavior (US)
- Study public charging (Europe)
- Demonstrate system, not battery capability

CHALLENGES

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


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)




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

Power control unit (PCU)
Controls precisely the distribution of electric power of the fuel cell and secondary battery.

Secondary battery
Stores the regenerative electric power and assists output of the fuel cell at acceleration.

Toyota FC Stack
Unit (fuel cell) that generates electric power from the hydrogen and oxygen in the air.

High-pressure hydrogen tank
Stores the hydrogen supplied to the Toyota FC Stack.

Motor
Generates the driving force of the vehicle.

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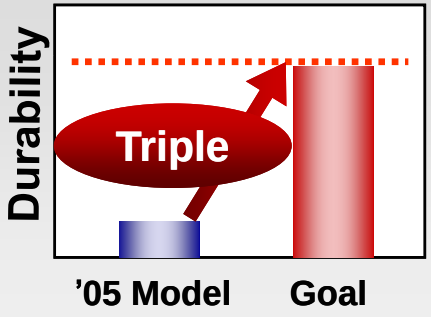
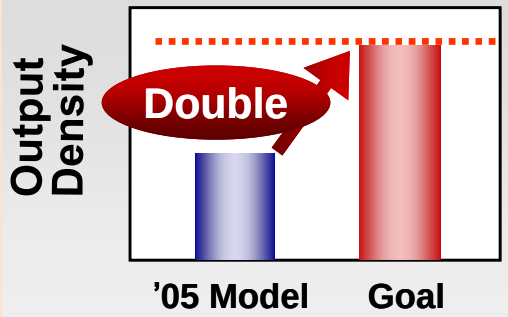
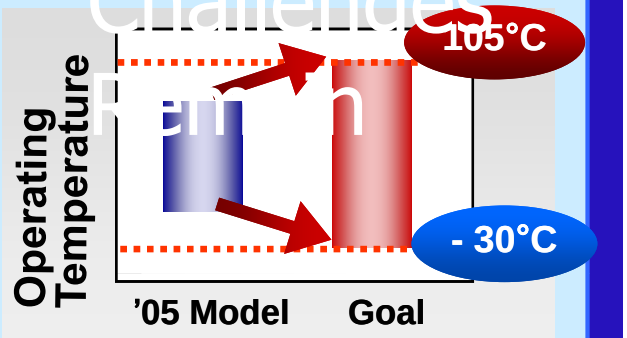
Stack Durability



Compactness / High Power Density



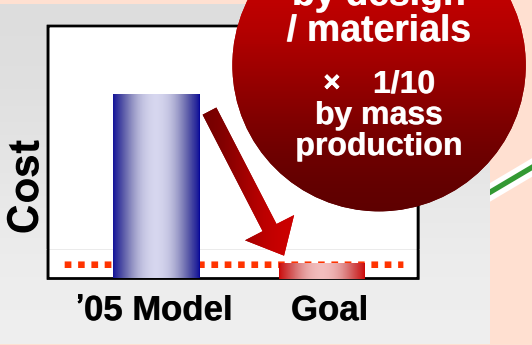
High & Low Temperature



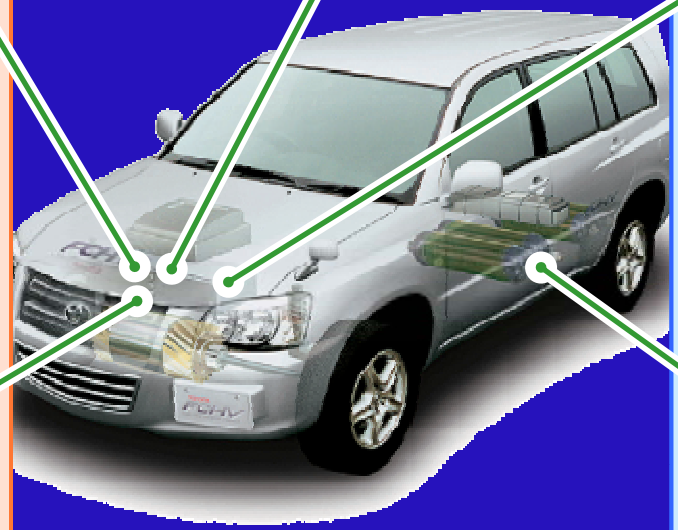
Next targets

Significant Progress

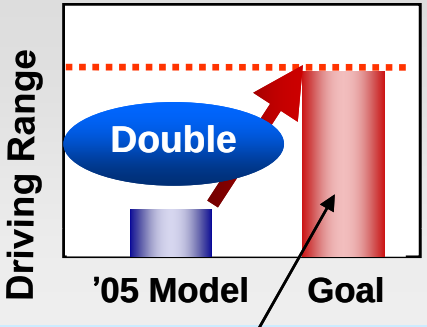
Cost



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



Driving Range



Over 500 miles demonstrated


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?