EV Policy Landscape in the US

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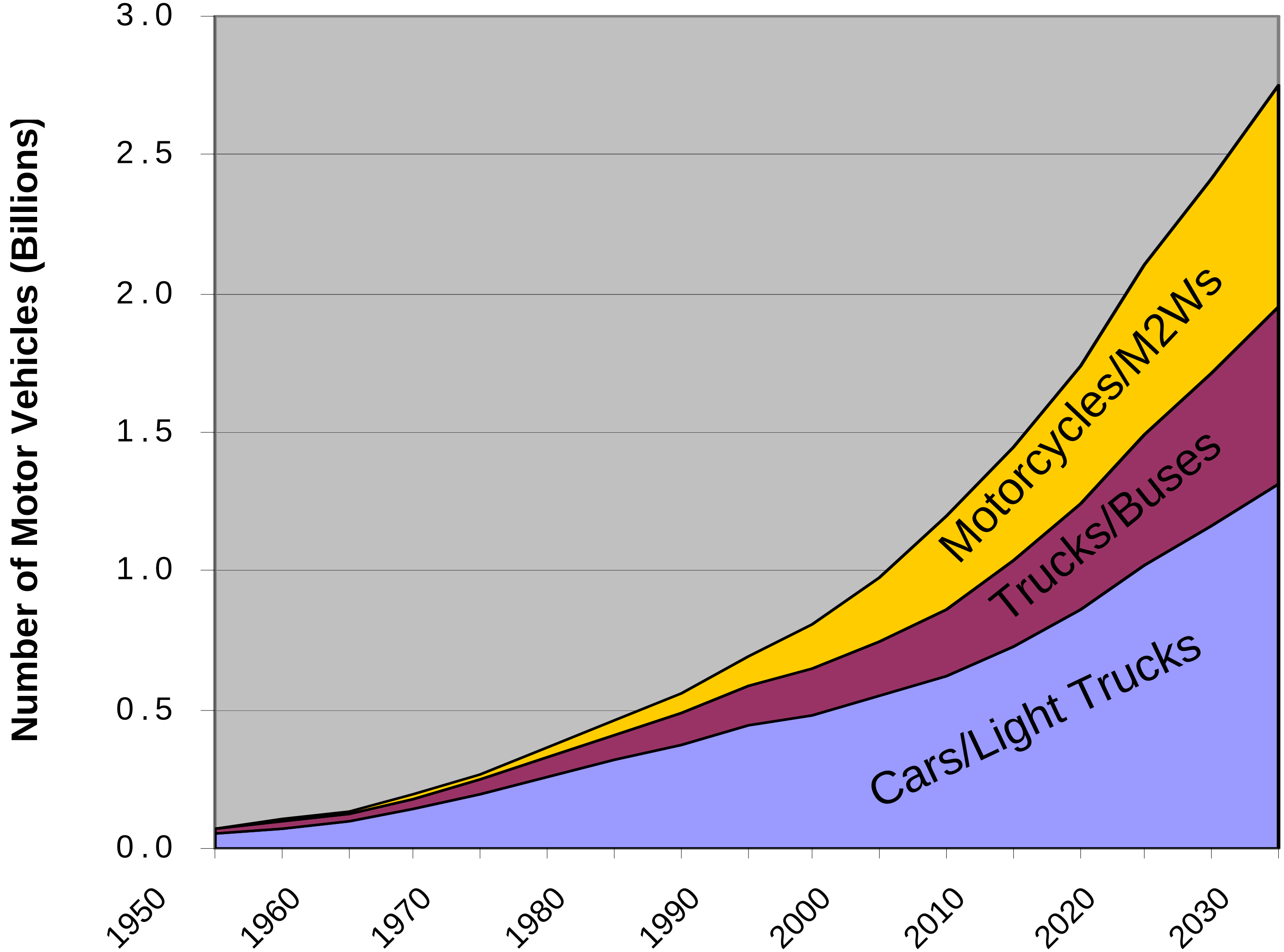
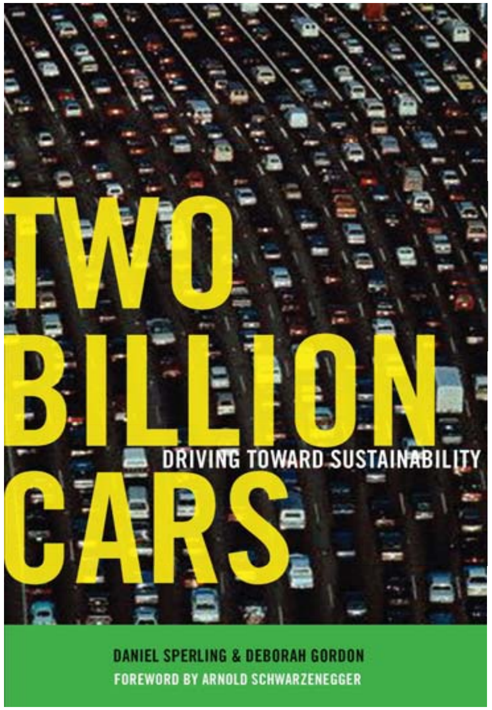
Beijing, China

September 29, 2009

Good news and bad news

Soaring Global Demand for Vehicles (and Oil)

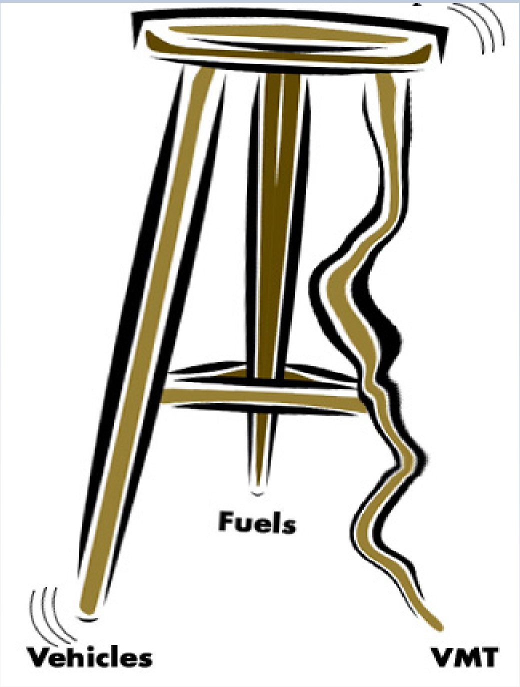




Sperling and Gordon (2009), based on DOE, JAMA, other

Need to Transform Transportation

to reduce oil use, GHGs, and road costs, and improve urban livability



- Transforming vehicles *("easiest")*
- Transforming fuels *(hard)*
- Transforming mobility *(hardest)*

First Leg
Transforming Vehicles

- **Large potential to reduce oil use and GHGs with conventional (ICE) vehicles.**
- **Much larger potential with advanced *electric-drive* vehicles.**
  - Gasoline (and diesel) hybrid electric vehicles (HEVs) (eg, Prius)
  - Plug-in hybrid vehicles (PHEVs)
  - Battery electric vehicles (BEVs)
  - Fuel cell electric vehicles (FCVs)

Failed Search for Petroleum Alternatives … Resulted in Fuel *du jour* Phenomenon (in US and elsewhere)

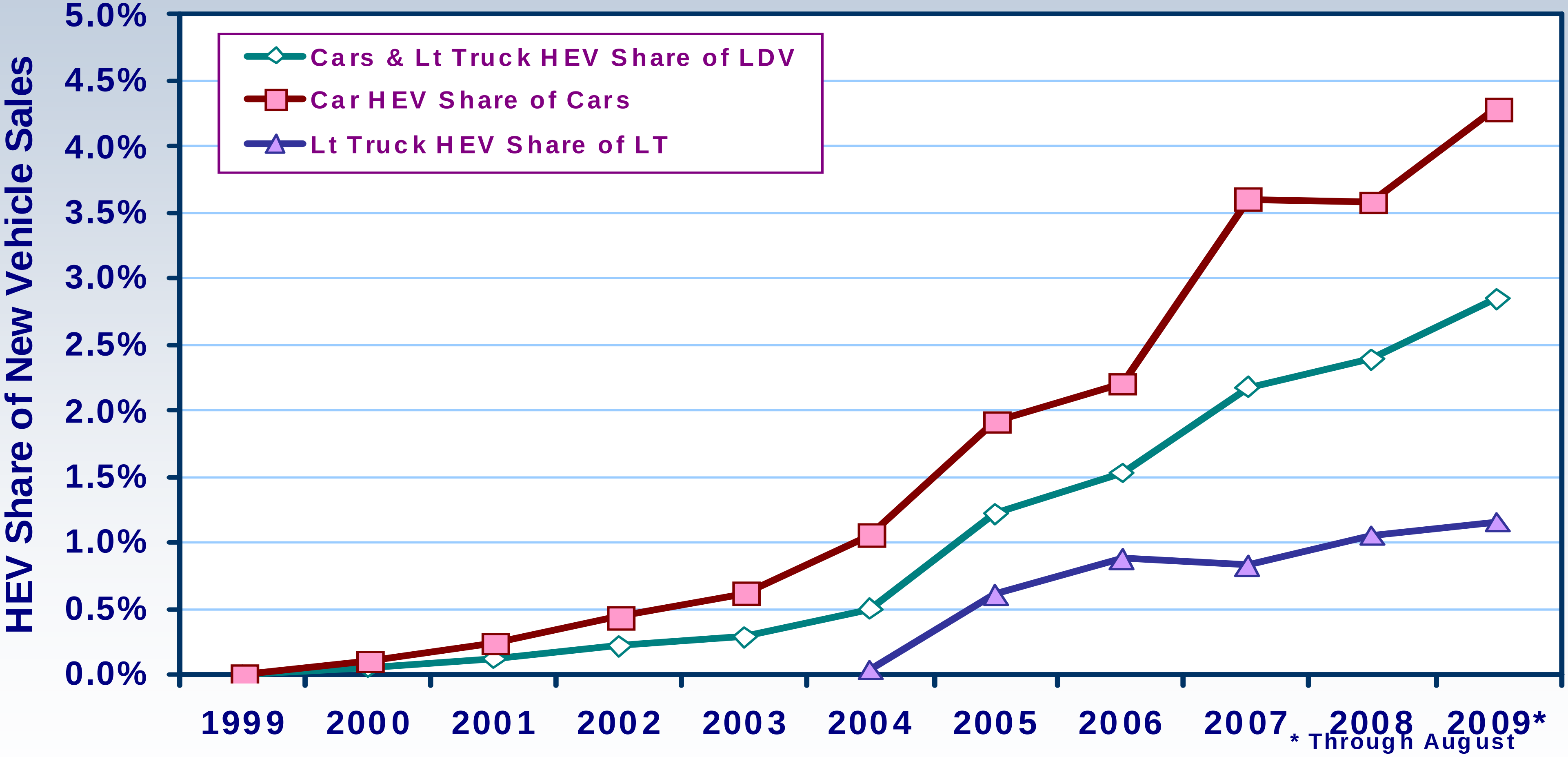
Disruptive and wasteful

- **30 years ago – Synfuels (oil shale, coal)**
- **20 years ago – Methanol**
- **15 years ago – Electricity (Battery EVs)**
- **5 years ago – Hydrogen (Fuel cells)**
- **2 years ago – Ethanol**
- **Today – Electricity (Plug-in hybrid vehicles)**
- ***What's next?***

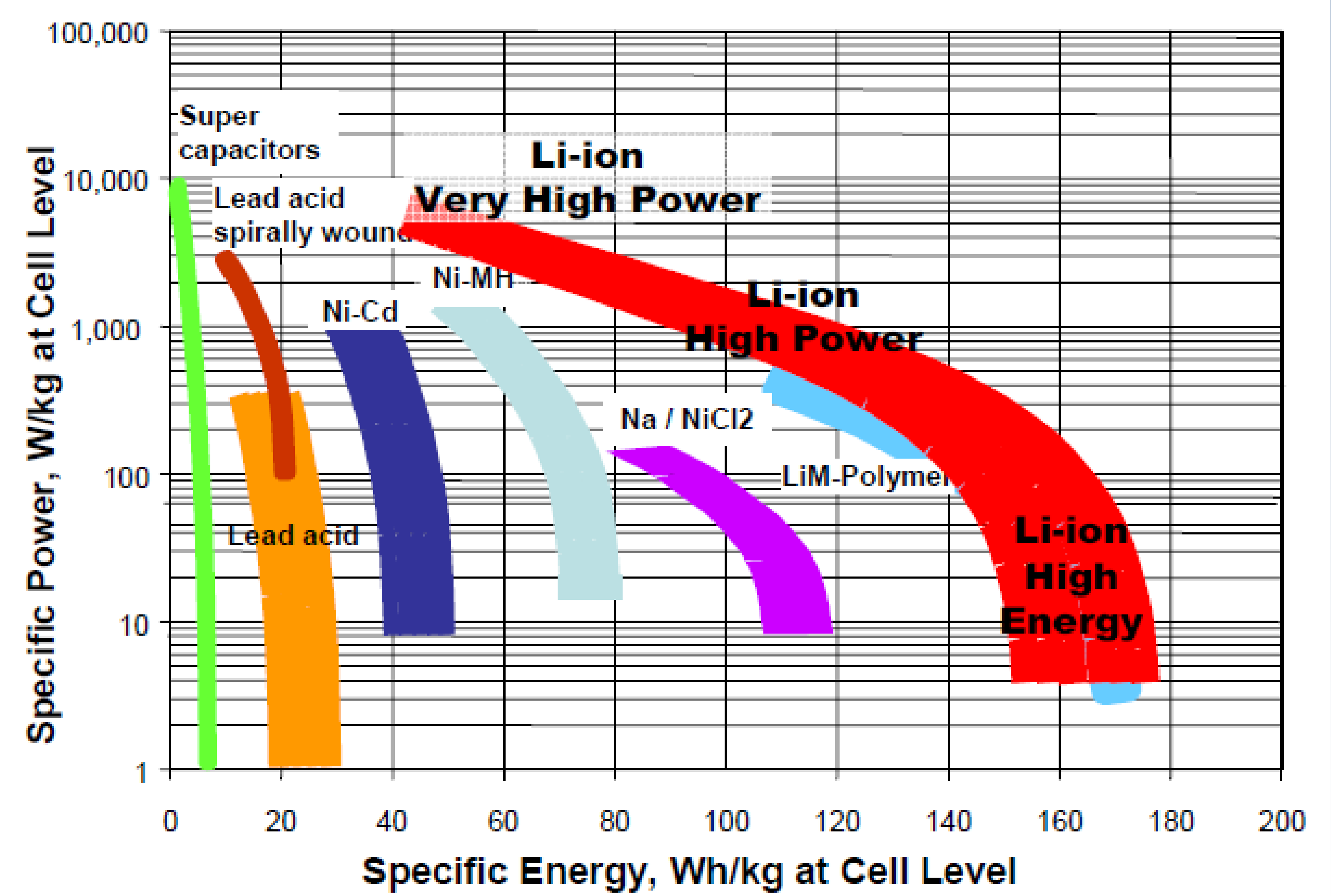
BEV experiment of 1990s largely failed … but led to improved batteries and electric drivetrains which are now making comebacks in hybrids, fuel cell vehicles... and next-generation BEVs!

Forerunner Technology for BEVs, PHEVs, and FCVs

HEVs Slowly Gaining Market Share in USA (now 2.9%)



Batteries are Expensive But Steadily Improving
(~8% improvement/yr)



Source: Johnson Control–SAFT, 2005 and 2007 (from IEA, 2009)

Incremental Cost of Electric-Drive Vehicles Relative to Baseline 2005 Gasoline Vehicle over Next 25 years (2005$)

	Car
Current gasoline	0
Current diesel	+$1,500
Current HEV	+$4,400
Advanced gasoline	+$1,800
Advanced diesel	+$3,000
Future Gasoline HEV	+$2,500
PHEV	+$3,900
BEV	+$8,000
FCV	+$4,500

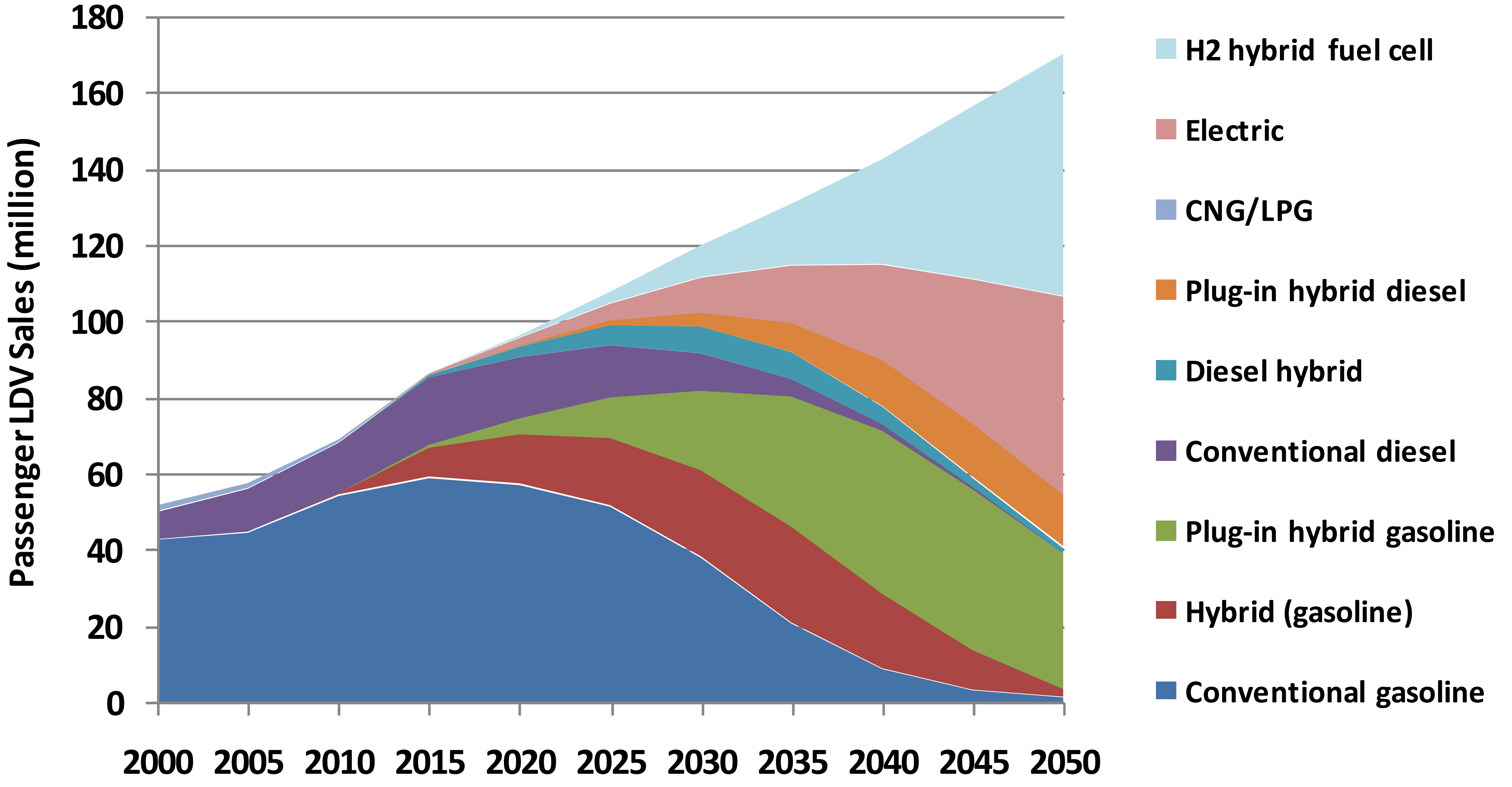
Source: Adapted from US National Academies, 2009; Bandivadekar et al., 2008; Kalhammer et al, 2007; Kromer and Heywood, 2007; NAS, 2008.

Plausible Market Shares of Advanced Light Duty Vehicles by 2020 and 2035 (by model year) (USA)

	2020	2035
Turbo Gasoline SI	10-15%	25-35%
Diesels	8-12%	15-30%
Gasoline HEV	10-14%	15-40%
PHEV	**1-3%**	**7-15%**
FCV	**0-1%**	**3-6%**
BEV	**0-2%**	**3-10%**

Source: National Academies, 2009 (AEF energy efficiency chapter)

IEA Aggressive CO_2 Scenario… Almost All Cars are Electric-Drive in 2050



IEA, 2009 (blue map scenario: 50% reduction in CO2-e emissions by 2050)

Technology Strategy for Electric-Drive Vehicles

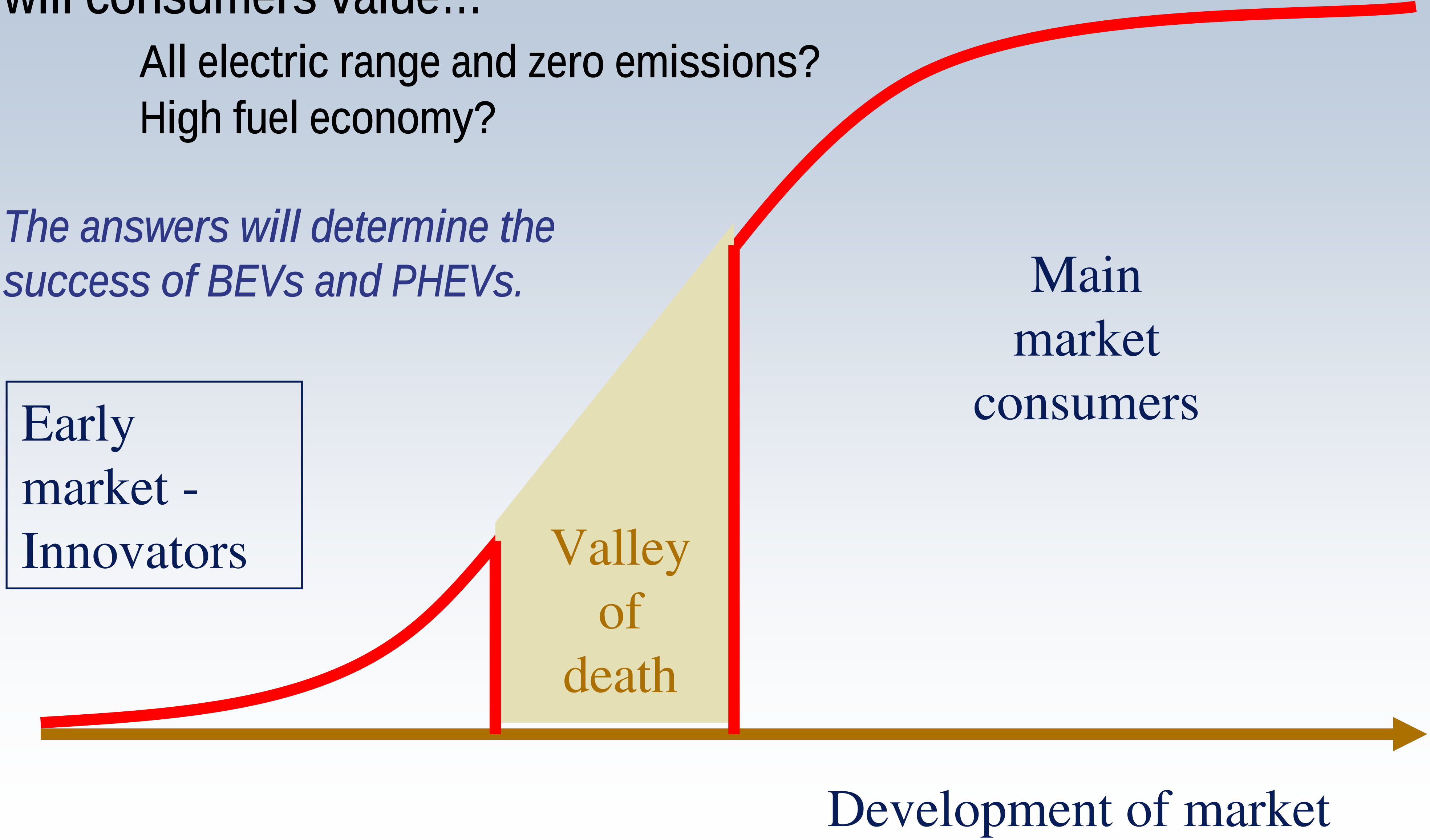
- BEVs for city cars and small vehicles with limited performance req’ts (10-30% of market)
- PHEVs and FCVs for larger cars and light trucks
- FCVs and biodiesel for large trucks

But great uncertainty about how market will evolve. How will consumers value…

All electric range and zero emissions?

High fuel economy?

The answers will determine the success of BEVs and PHEVs.



Governments Worldwide Providing "Start-Up" Incentives for PHEVs and EVs (*fuel du jour?)*

- Germany: Goal of 1 million PHEV/EVs by 2020
  - Many incentives for consumers and automakers. Large incentives.
- United Kingdom: Goal of 750,000 PHEVs/BEVs by 2020
  - Large incentives for consumers and automakers (Nissan building BEV and battery factories)

- China:
  - Goal of 150,000 PHEVs and 100,000 BEVs by 2012
  - Goal of 5.4 million PHEVs and 4 million BEVs by 2020
  - 18 million e-bikes/year

Governments Worldwide Providing "Start-Up" Incentives for PHEVs and EVs (cont'd)

- USA: Goal of 1 million PHEVs by 2015
  - Tax credits of $2500-$7500/vehicle (at least 4kWh batteries, with additional $417 per additional kWh). Up to 200,000 PHEVs/BEVs per automaker
    - NEVs receive tax credits up to $2500/vehicle
    - Converted vehicles receive 10% tax credit through 2011 (up to $4000/veh)
  - Tax credits for refueling facilities: 50% (up to $50,000 for electricity stations and $2000 for residences, and $200,000 for H2 stations).
  - ~$3 billion for advanced battery and electric-drive vehicle manufacturing (including $1 billion loans to startup EV companies: Fisker PHEV and Tesla BEV)
  - California ZEV mandate

Controversial History of California ZEV Mandate

Year	
1990	ZEV mandate adopted: 2% ZEVs in 1998, 5% in 2001, and 10% in 2003—measured as % of new car sales
1996	Eliminated 2% 1998 requirement and replaced with much softer requirement of 3750 BEVs
1998	% ZEV requirement further reduced by allowing very clean gasoline (and other alt fuel) vehicles as partial substitute (“PZEV”)
2001	% ZEV requirement further reduced by allowing small numbers of FCVs to satisfy requirement
2008	New requirement: 12,500 BEVs or 5000 FCVs, plus 58,000 PHEVs by 2014
2010	Large increase for post-2015?!

Too aggressive too soon?

Stimulated investment in electric-drive technology!

What next for ZEV mandate?

But Also Need Broader and More Robust Policy Approach (to avert fuel du jour phenomenon)—Especially Performance Standards?!

Treatment of ZEVs and near-ZEVs in new US vehicle standards??

- Assign zero CO_2 g/mile for automaker compliance with GHG stds??
- Give double weighting to BEVs in calculations??
- PHEVs?

Regulatory issues that need to be addressed

- How to reward automakers for BEVs that have different emissions depending on electricity source?
- How to deal with dual-fuel vehicles (eg, PHEVs), since uncertain how much of each fuel they will use?

Policy Model Template for Electric-Drive Vehicles

1. R&D for advanced batteries, fuel cells, hydrogen storage, and electric-drive propulsion technology
2. *Temporary* mandates and incentives to overcome initial barriers, such as:
    - Vehicle production requirements
    - Subsidies/mandates for initial recharging and refueling stations (home and public)
    - Large incentives for "early adopter" consumers
    - Place-based requirements (such as banning combustion vehicles in urban centers)
3. *Permanent* performance-based and market-based policies, such as:
    - GHG standards for vehicles and fuels
    - Carbon taxes
    - Feebates based on oil use, air pollution, or GHGs
    - Taxes and fees that favor low GHGs, air pollution, and oil use (eg, fuel taxes, vehicle registration fees)

Opportunities for International Corporation

- Development of models and tools to analyze policies and technology strategies for transition to electric-drive vehicles
  - lifecycle emissions analysis, cost forecasts, interactions of electricity and transport systems, infrastructure system design
- Joint development and testing of standards and protocols
  - Battery, vehicle testing that can facilitate imports and exports
- Joint research and development of electric-drive powertrain systems;
  - Basic science, systems design, specialized applications
- Joint research and development of smart grid technologies for the diffusion of electric-drive vehicles; and
- Demonstration projects with BEVs, PHEVs, and FCVs in selected cities.

(based in part on discussion with Professor Zhang Xiliang, Tsinghua Univ, August 2009)

Conclusions

- BEVs, PHEVs, and FCVs will all succeed, but at different times, in different places, in different ways
- BEVs will thrive in large cities (London, Paris), isolated markets (Israel, Hawaii), polluted regions (Kathmandu, Chinese cities), areas with abundant low-carbon electricity (France)
- PHEVs and FCVs have potential to fully replace petroleum-powered vehicles
  - Depends on progress of batteries, fuel cells, hydrogen supply, *and* policy
- Many opportunities for collaboration (across universities, companies, governments)

Transformation is a Question of Will and Vision, More Than Cost!

- Consider hydrogen and fuel cells, which many think is most expensive and difficult transition …
  - $4 billion per year over 15 years for vehicles and fuels, to get to 10% market penetration (NRC/NAS, 2008)
- Meanwhile, US spends ~$8 billion/year on subsidies for corn ethanol

Thank You