GHG Emissions Reduction From Mobile Sources

A Light Duty Vehicle Manufacturer's Perspective

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David Raney
Senior Manager
Environmental and Energy Affairs
American Honda Motor Company, Inc.

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Critical Assumptions

Opportunities and Challenges

Technology Possibilities and Pathways

Policy Mechanisms

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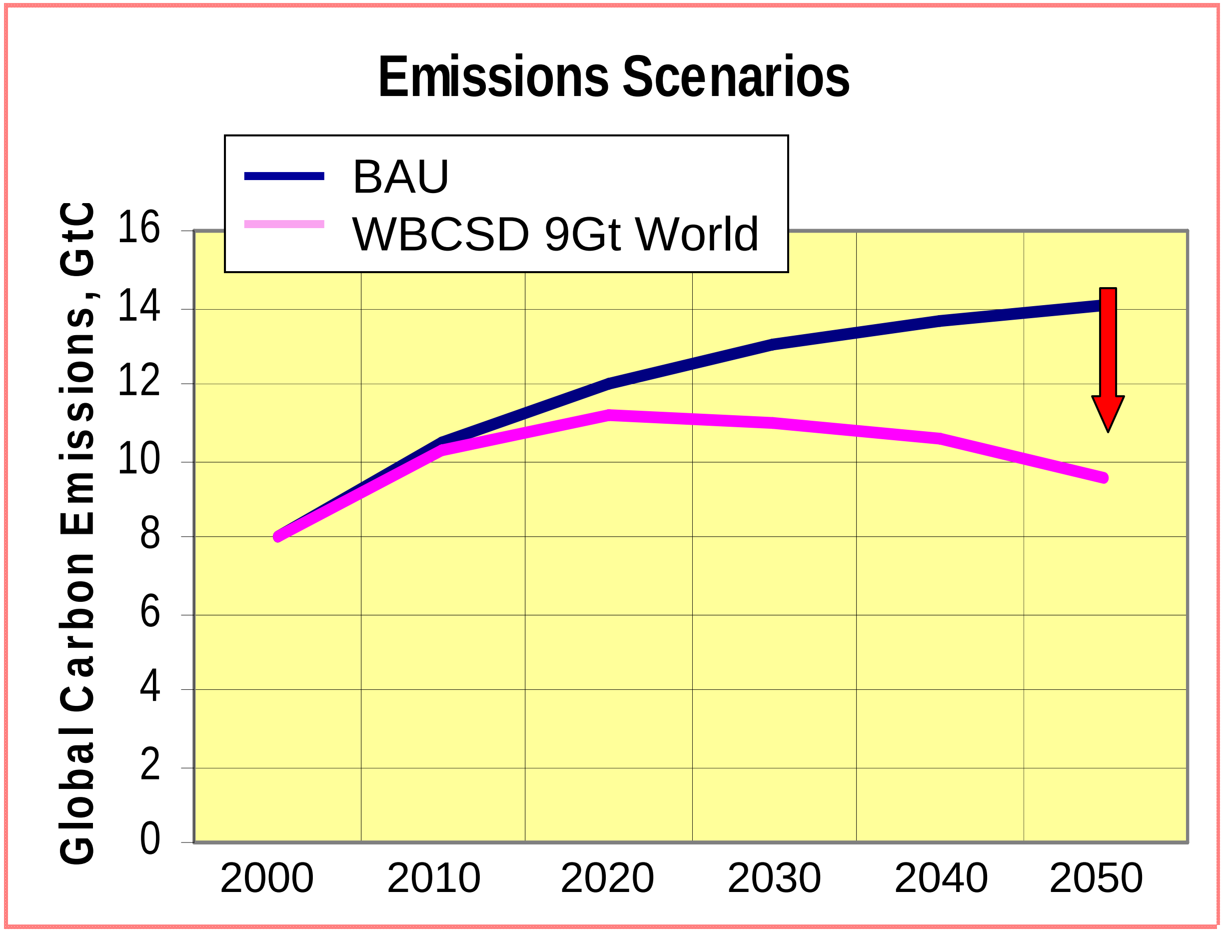
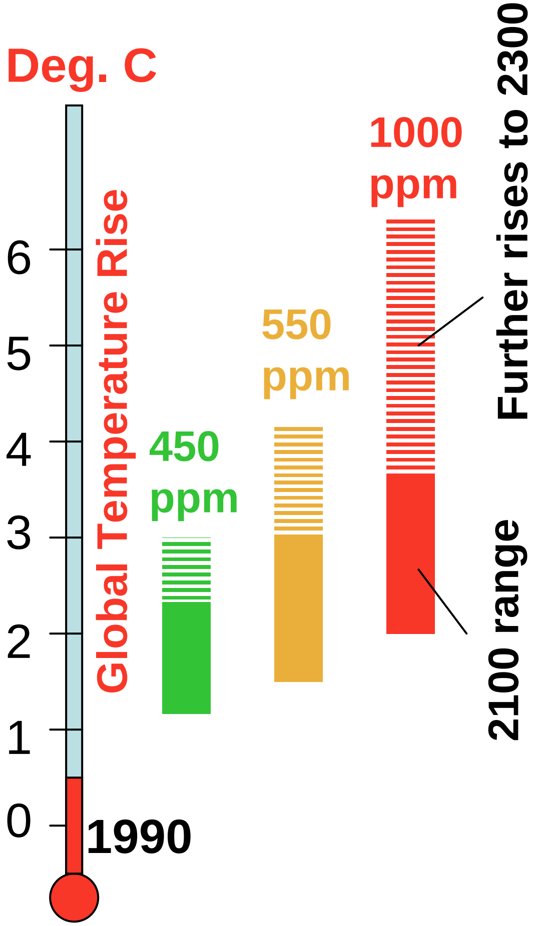
Critical Assumptions

Limiting atmospheric concentrations of CO_2 to around 550-ppm while still allowing carbon emissions to increase in the medium term requires a global downturn in emissions no later than 2030, followed by a continuing decline. By 2050, in contrast to a sharply rising demand for energy (at least 2X) over the same period, emissions must approximate today's levels. Transport sector policies adopted today must yield actual reductions based on stimulation of production of reliable, affordable, fuel efficient vehicles that customers want to buy.

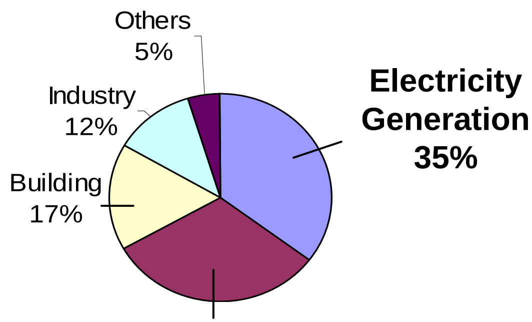




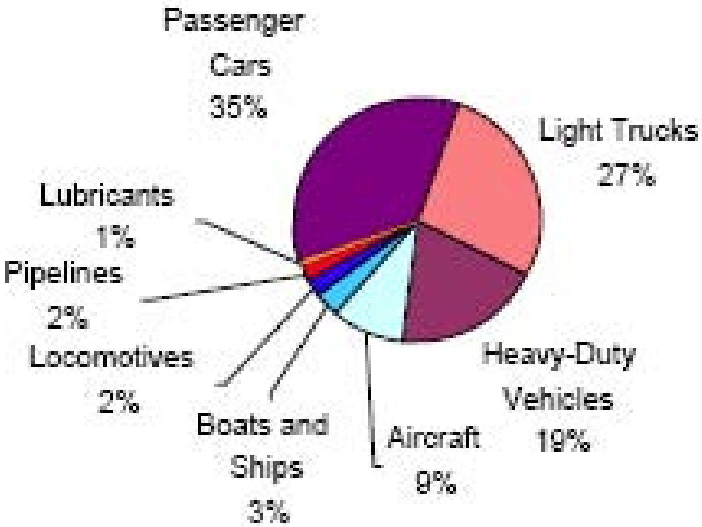
Sources: IEA 2004, WRE, IPCC

Critical Assumptions

North America CO2 Inventory@2003
(Total 6805 Mt CO2)



Transport CO2 emissions are projected to increase
1.6 - 1.7% per year through 2025.



Source: U.S. EPA

Stabilization won't occur without significant reduction measures: advanced mobility technology and low carbon fuels

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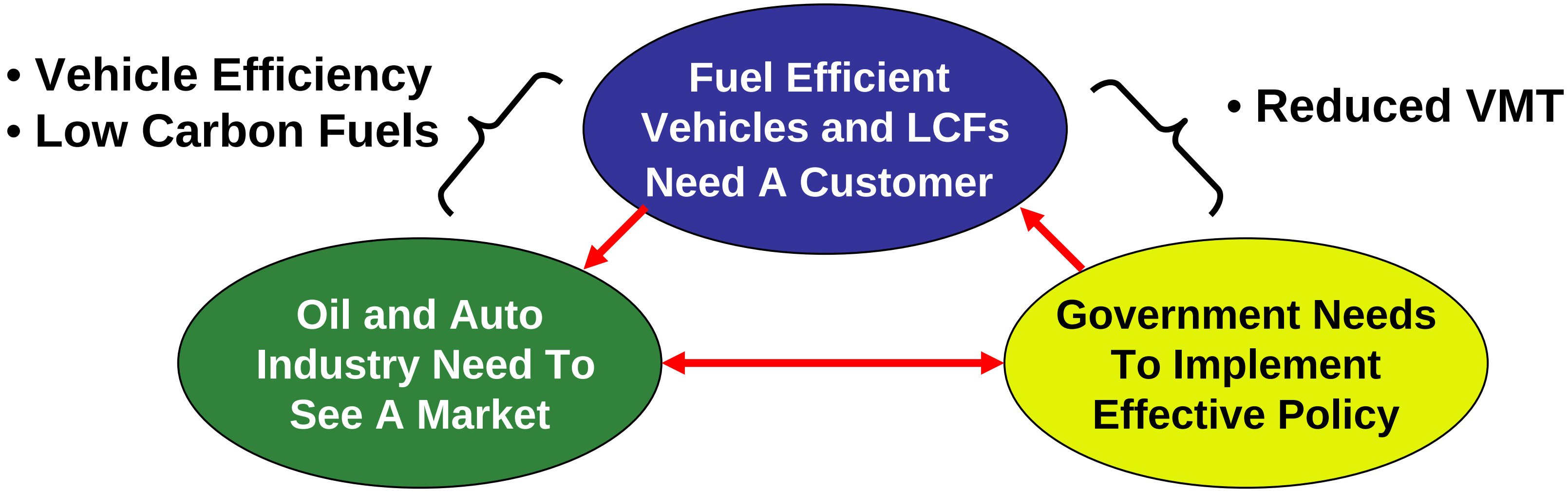
Opportunities and Challenges

- Reduction of GHG emissions from the transportation sector must begin in the near term if we have any hope of “turning the corner” in the 2020-2030 timeframe.
- Efficiency improvement is essential and can provide near term benefit.
- Efficiency improvement alone will not be sufficient to provide reductions needed for stabilization in 2050. New unproven low carbon technologies must begin to displace current transportation power sources: liquid fuels from biomass (e.g., cellulosic alcohols), advanced batteries for hybrids, and hydrogen.

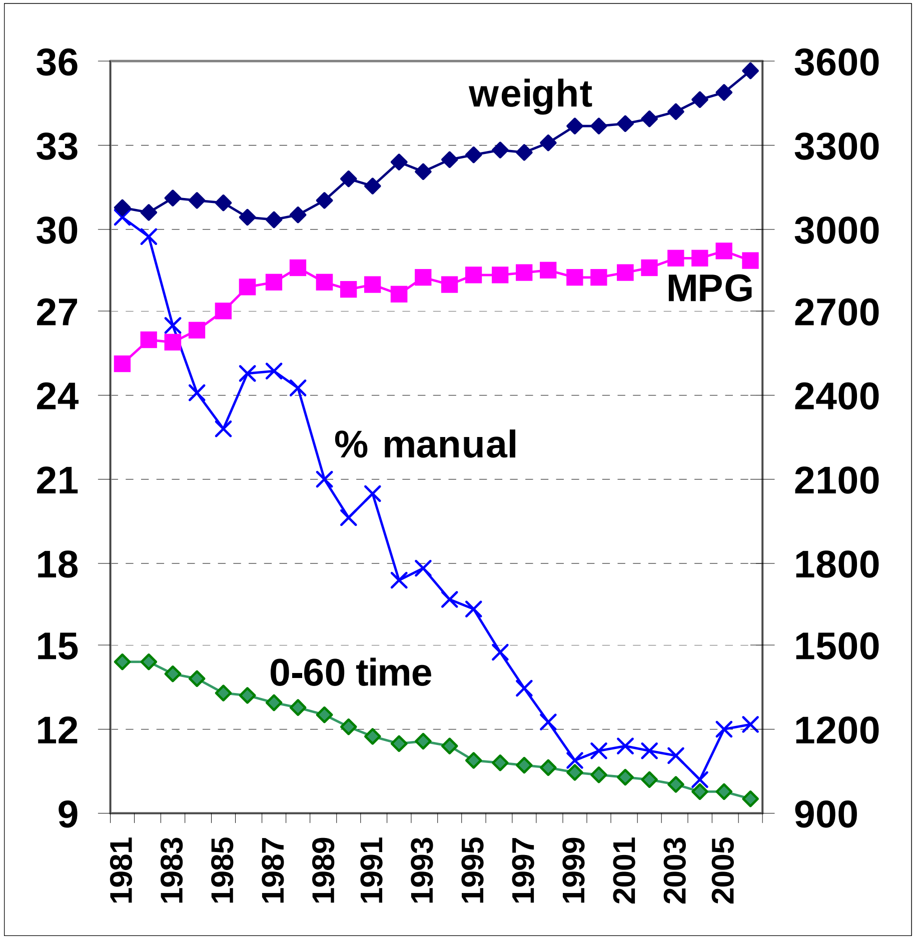
- **Technology alone cannot solve our problems; must be complimented with strong market signals.**

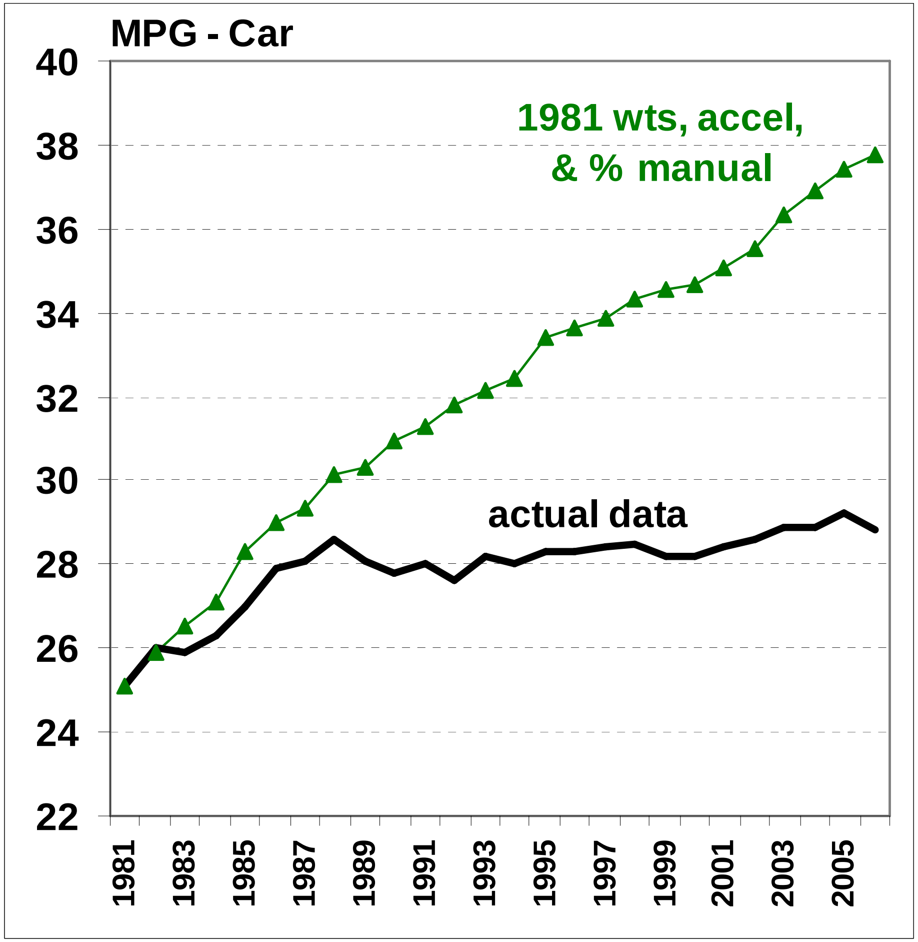


Opportunities and Challenges

Effect of Attribute Tradeoffs - Cars

Car Data from EPA’s 2006 FE Trends Report





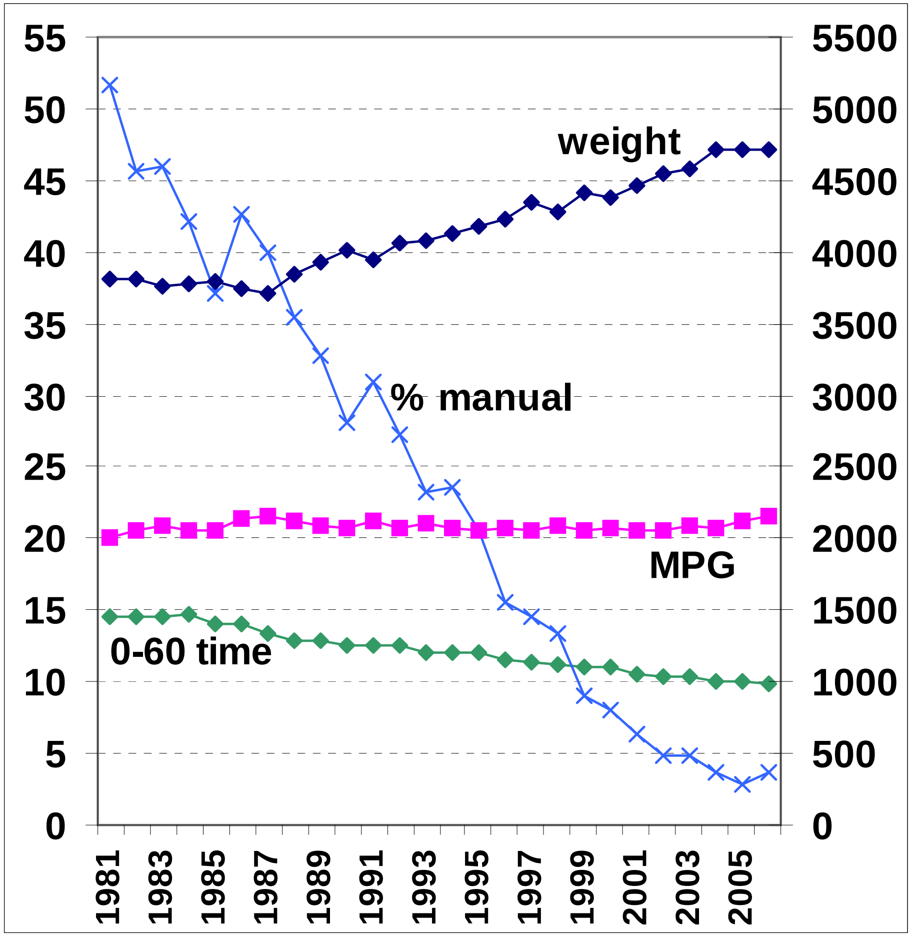
Fuel efficiency has increased by about 1.3% per year since 1987

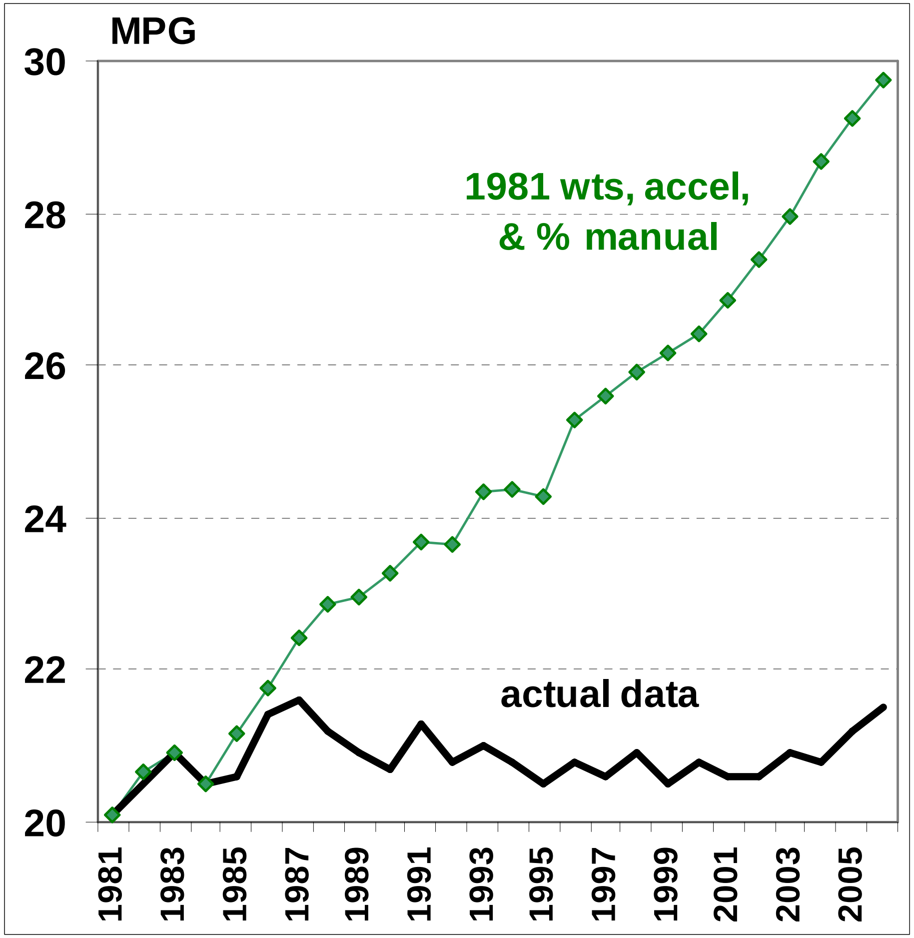
However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety

Opportunities and Challenges

Effect of Attribute Tradeoffs - LDT

Light Truck Data from EPA's 2006 FE Trends Report





Fuel efficiency has increased by about 1.5% per year since 1987

However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety

Technology Possibilities and Pathways

Near Term

- Continued Improvement of Standard ICE Powertrain Efficiency
- Light Duty Diesel
- Hybrid Electric Vehicles (not Plug-ins)

Longer Term

- Plug-in Hybrids
- Next generation biofuels
- Hydrogen Fuel Cells
  - Natural gas derived Hydrogen Initially
  - Low-carbon Hydrogen Source in Longer Term

Technology Possibilities and Pathways

Incremental FE Technology

- **Engine technology**
  - High specific output (including 4 valve/cylinder)
  - Variable valve timing/lift
  - Cylinder deactivation
  - Direct injection
  - Precise air/fuel metering
  - Lower engine friction
  - Turbocharging
- **Transmission efficiency**
  - 5/6/7/8 speed
  - CVT
  - Dual-clutch automated MT
- **Reduced losses**
  - Lightweight materials
  - Low drag coefficient
  - Low resistance tires
  - Lower accessory losses

Cost and value issue

- These technologies are continuously being incorporated into vehicles.
- However, consumers value other attributes more highly, such as performance, safety, utility, and luxury.
- Putting in technologies just to improve fuel economy may not be valued by customers.

Fuel Economy Improvement - ???

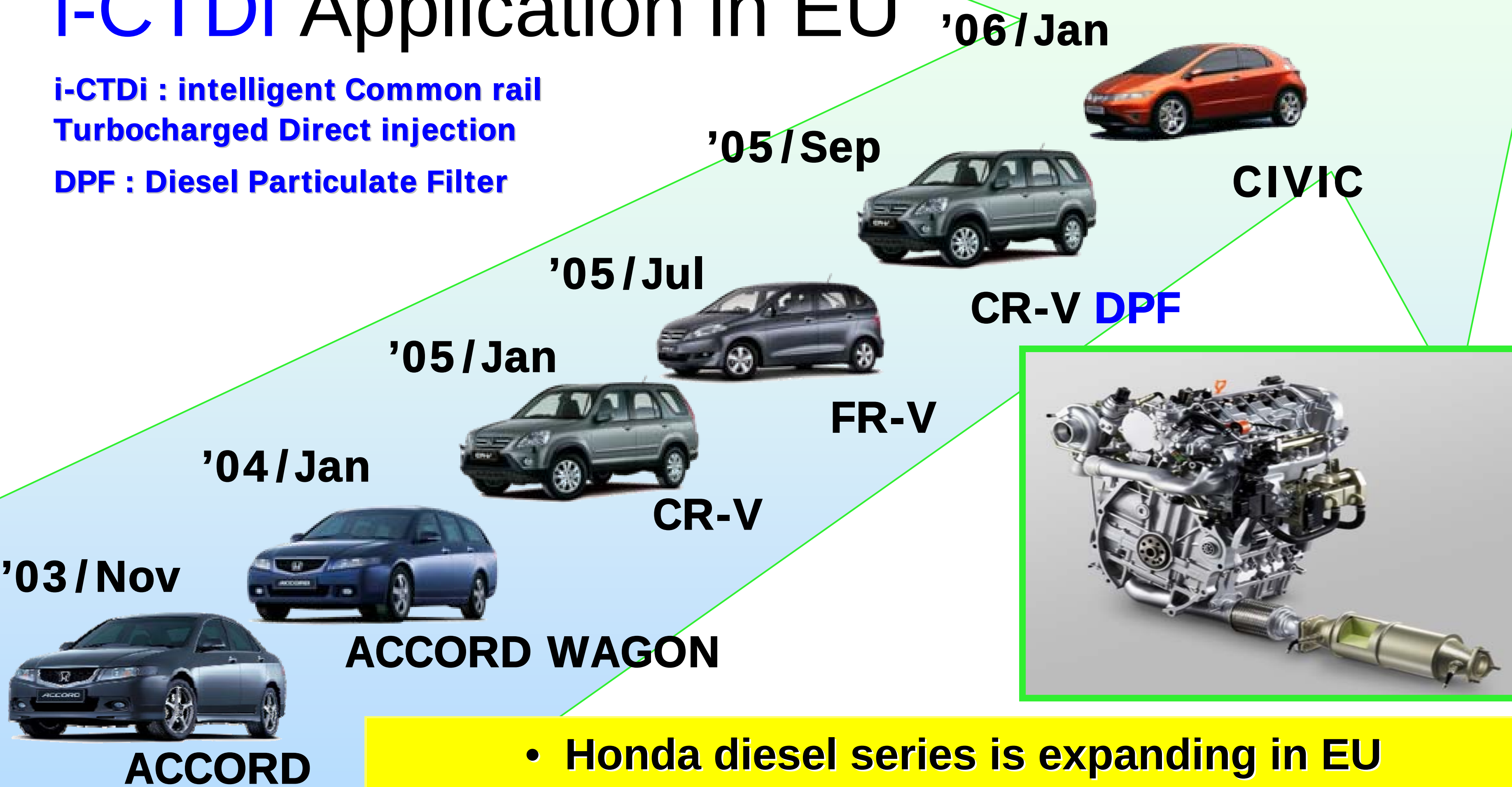
Depends on how much is already incorporated into fleet and synergies (or lack of synergy) between technologies

Technology Possibilities and Pathways

i-CTDi Application in EU

i-CTDi : intelligent Common rail Turbocharged Direct injection

DPF : Diesel Particulate Filter



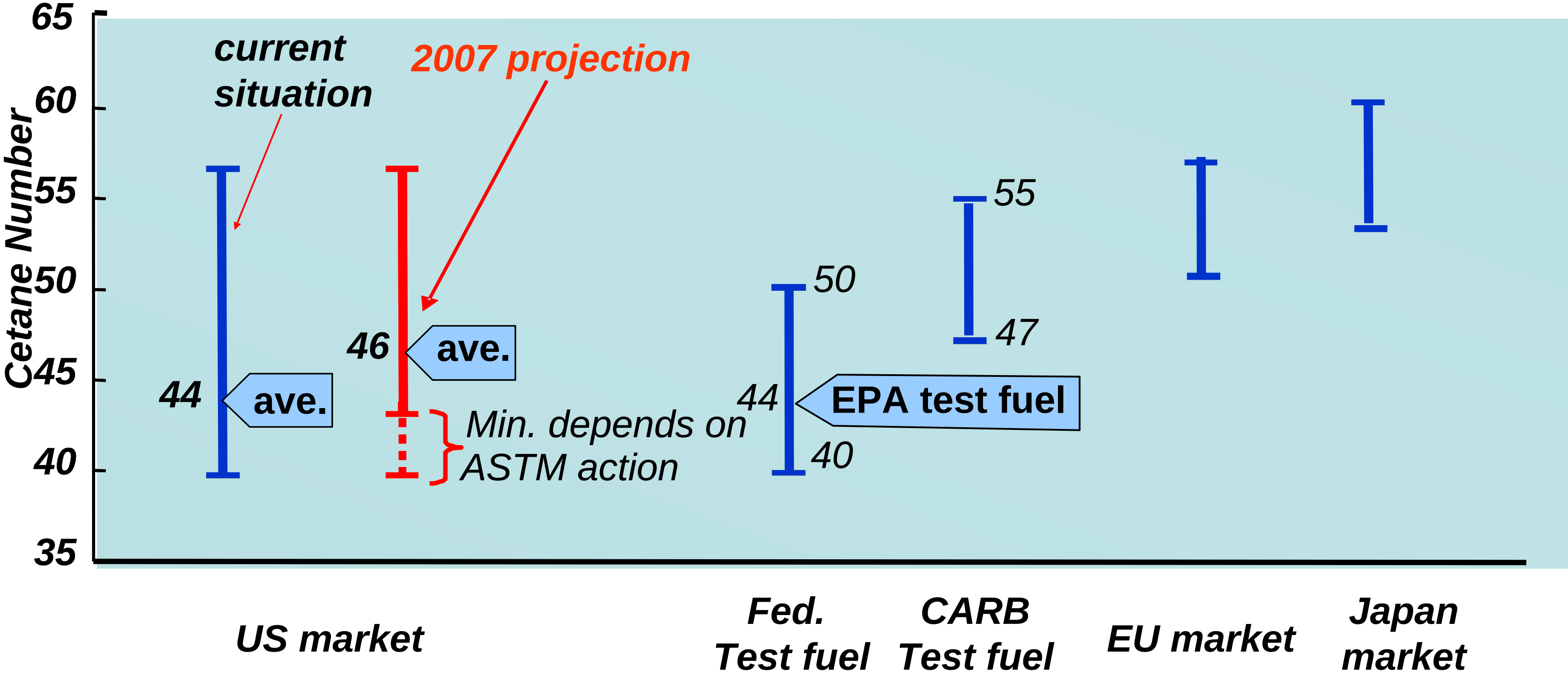
- **Honda diesel series is expanding in EU**
- **Virtually same powerplant in all models; DPF in '05**
- **US version must have lean NOx catalyst plus DPF**

Diesel Market Potential in US

- Diesels good for towing, low rpm power, and highway efficiency
  - Hybrids get better fuel economy in city driving
- Diesels are currently cheaper than hybrids, but are not cheap
  - $1500 for 4-cyl., $2000-$3000 for V-8
  - Tier 2 emission standards will add cost; OBD-II still a challenge too._
  - Hybrid costs will come down in the future
- Will public recognize improvements in noise, vibration, smell, starting, and emissions?
- Pickup customers want a “tough” diesel; image may “come into play”
- Must compete with improved gasoline engines and hybrids
- Europe refineries already shipping unwanted gasoline to US
  - Can refineries adjust output if US also shifts to diesels?
- U.S. fuel producers need clear signal
  - Has North American market accepted the products? Evaluation metric?
  - When should they make capital investments in refineries to supply demand?

Technology Possibilities and Pathways

US diesel fuel cetane

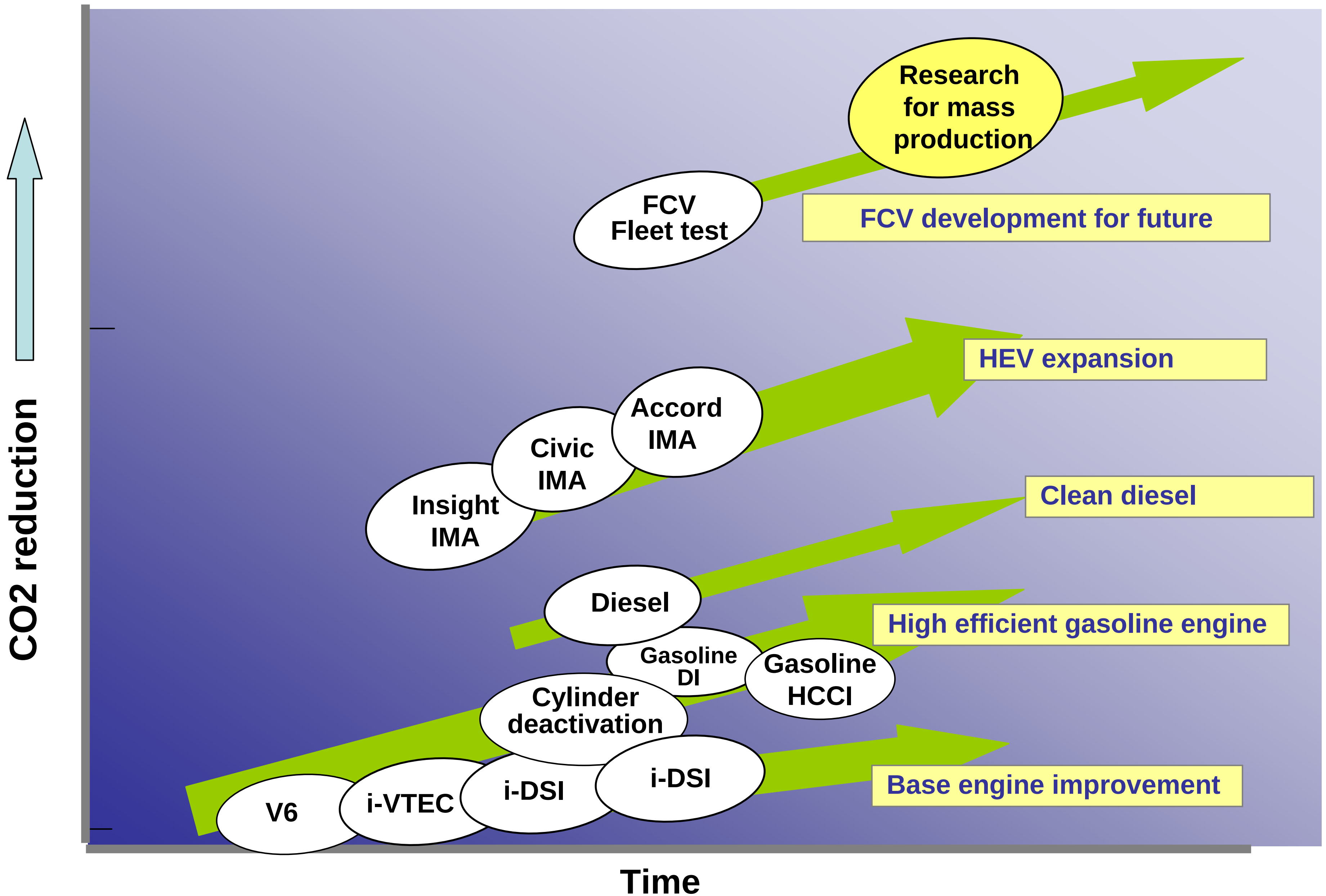


Low and wide variation of Cetane number compared to other market.

Challenge:

- **Calibrating for 57 cetane can lead to misfire when fueled with 47 cetane**
- **Calibrating for 47 cetane can lead to soot and DPF failure when fueled on 57 cetane**

Honda Powertrain Progress for CO2 Reduction



Technology Possibilities and Pathways

Plug-In Hybrid Payback

Table 8, Plug-In Hybrids, ACEEE, Sep 2006			Calculated
	Hybrid	**Plug-In, 40-Mile range**	**Plug-In vs. Hybrid**
Near-term Incremental costs			
Battery	$2,000	$17,500	$15,500
Other incremental costs	$1,500	$1,500	0
Annual fuel savings	$480	$705	$225
Payback (years)	**7.3**	27.0	**68.9**
Long-term Incremental costs			
Battery	$600	$3,500	$2,900
Other incremental costs	$1,000	$1,000	0
Annual fuel savings	$480	$705	$225
Payback (years)	2.9	**6.4**	**12.9**

Assumptions include:
12,000 miles per year, hybrid FE of 50 mpg, conventional vehicle FE of 30 mpg, 50% of plug-in miles on electricity, $3.00/gal, no discounting of fuel savings, **no FE penalty for additional weight of plug-in batteries, no battery replacement for plug-in**

Technology Possibilities and Pathways

Biodiesel (fatty acid methyl esters)

- Need national (global?) standards for fuels.
  - There are currently no standards in place for biodiesel blends in the US.
  - Customer must be protected from poor-quality fuels.
- Imported biodiesel may come from regions with poor land management practices.
  - Must consider local and global implications and unintended consequences.

    Environmental “costs” could far outweigh benefits.

Renewable Diesel (hydrotreated fats and oils)

- Chemically identical to petroleum-based diesel.
- Entering production in US, EU, and Japan. (various producers)

Next-Generation Biofuels

- Cellulosic alcohols
- BTL

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Technology Possibilities and Pathways

Honda's Next Generation Fuel Cell Electric Vehicle – Advances in…

Range
Freezing Temp Performance
Packaging

Weight Optimization
Dynamic Performance

Range
Efficiency

Next Generation FCX Vehicle Launch in 2008 –
Current FCX is First Fuel Cell Vehicle to be approved by IRS for Federal Qualified Fuel Cell Motor Vehicle Tax Credit - $12,000 credit

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Technology Possibilities and Pathways

Crystal Ball is Not Very Clear

- **Improved conventional engines keep raising the bar**
  - Ultimate goal….fuel cells, but timing unclear (**not near term**)
  - Plug-in hybrids attractive
    - Might prolong fossil fuel era. No battery in sight (**not near term**)
  - Hybrid technology is progressing rapidly
    - Costs coming down
    - Synergies with other technologies developing … Consumer features will develop
  - Home refueling is highly desirable by owners of CNG vehicles
  - Light diesel market growth uncertain but could yield significant benefits
- **Challenge is customer's low value of fuel economy**
  - Real cost of driving today is very low
  - Performance, utility, comfort, safety valued more highly
  - Most only consider fuel savings during first 2-3 year ownership period
- **Policy makers and industry have a dilemma**
  - Significant standards being considered but must consider technology costs
  - Very difficult to estimate cost and benefit beyond 5-6 years

Technology Possibilities and Pathways

We can make some predictions with confidence:

1) Transport sector GHG reductions of any significance will occur in the near term solely from improvements in the efficiency of existing vehicle technology (diesel and gasoline ICE)

2) Pushing for production of current-generation biofuels and alternative fuel vehicles to run on them could actually result in increases in GHG emissions

3) If hoped-for breakthroughs occur in large scale production of cellulosic alcohols or the direct production of synthetic gasoline or diesel from biomass, **AND** these fuels actually become commercially available in the 2015 – 2020 timeframe, we can predict significant reductions in GHG emissions relative to the gains in near term efficiency mentioned above.

4) Research and development on advanced vehicle technology and fuels will continue and these technologies will find their way into the mass market once customer acceptance seems apparent.

To support this pathway, we need to create a more robust analytical and decision process that recognizes the accurate, life-cycle GHG attributes of mobility technologies, regardless of the fuel used in the system. Must reward performance and avoid specific technology mandates.

Technology Possibilities and Pathways

Long-known fact: Leadtime Is A Critical Issue For New Efficiency Regulations

National Academy of Sciences

2002 NAS Study - EFFECTIVENESS AND IMPACT OF CAFE STDS

Finding 15. Technology changes require very long lead times to be introduced into the manufacturers' product lines. Any policy that is implemented too aggressively (that is, in too short a period of time) has the potential to adversely affect manufacturers, their suppliers, their employees, and consumers. Little can be done to improve the fuel economy of the new vehicle fleet for several years because production plans already are in place. The widespread penetration of even existing technologies will likely require 4 to 8 years (highlight added). For emerging technologies that require additional research and development, this time lag can be considerably longer.

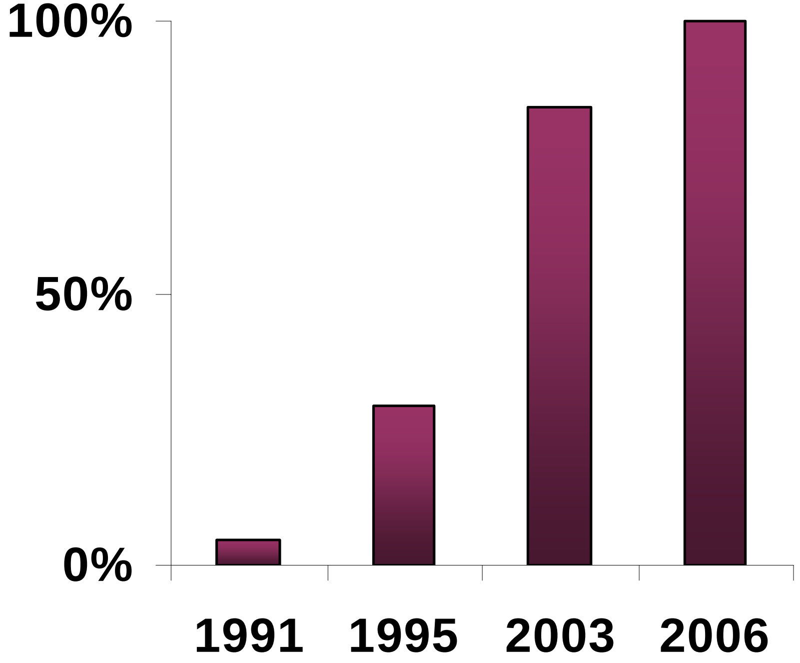
CASE STUDY

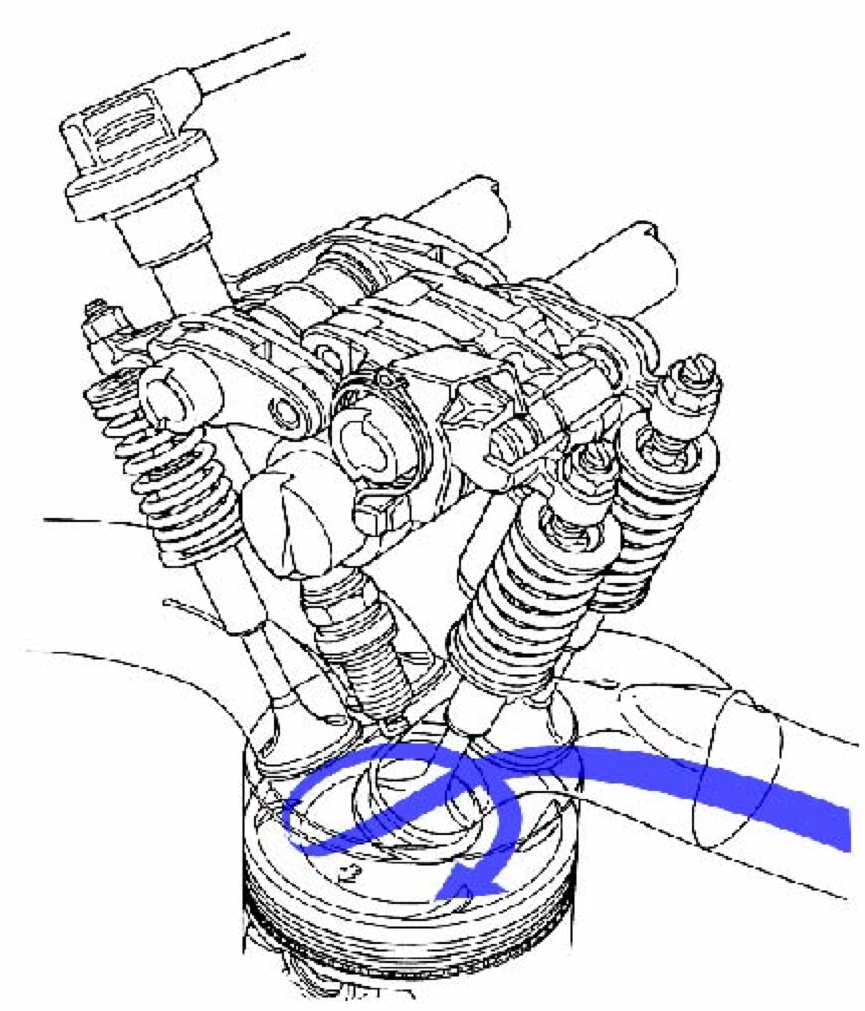
- Acura NSX introduced in 1988; first application of VTEC
- 2006 Honda Civic full model change; VTEC finally in 100 percent of Honda's fleet
- 24 years after R&D initiated; 19 years after first market introduction in NAmerica.

Honda VTEC Combustion:

(**V**ariable valve **T**iming and lift, **E**lectronically **C**ontrolled)

- **HIGHER EFFICIENCY**
- **LOWER EMISSIONS**
- **GREATER PERFORMANCE**

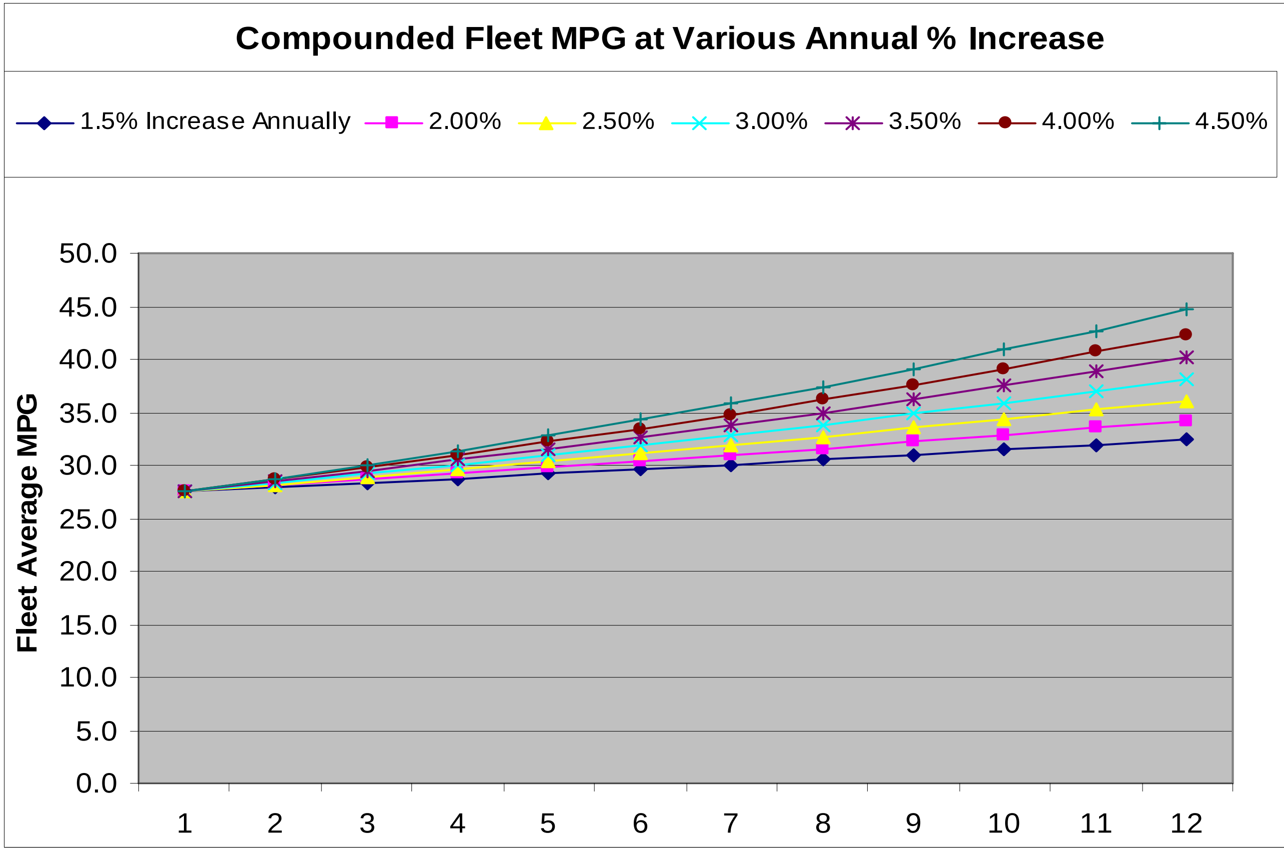




FE Mandates in Japan and Europe

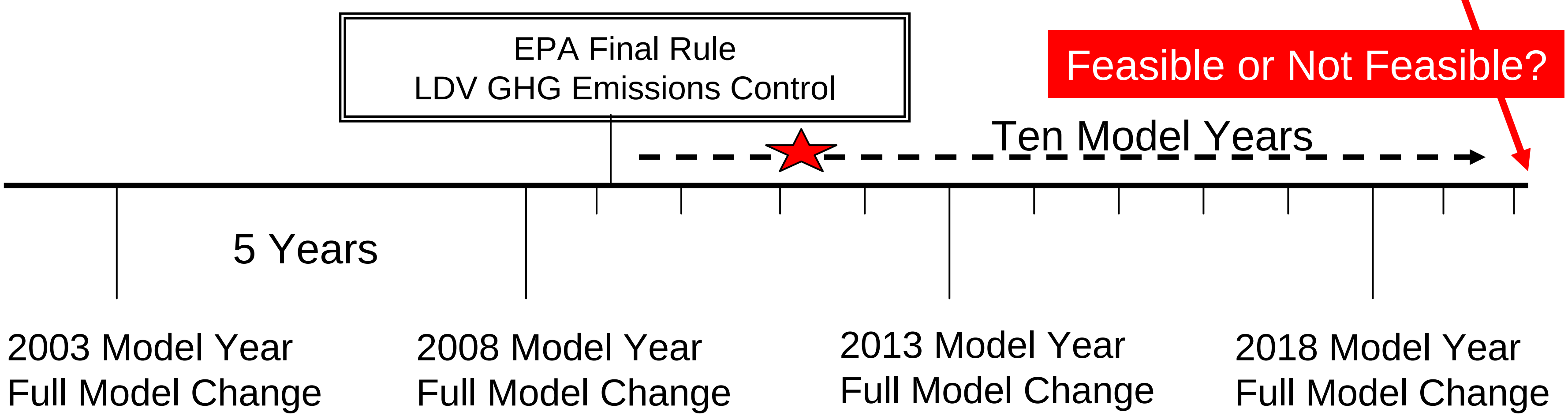
- Europe 1995-2008:
  - CO_2 reduced from 185 gCO_2/km in 1995 to 140 in 2008
  - Annual FE improvement rate: **2.2% per year**
- Europe 2008-2012:
  - Further reduce CO_2 emissions to 130 grams/km by 2012
  - Annual FE improvement rate: **1.9% per year**
- Japan 2005-2016:
  - Increase economy from 13.6 km/l in 2005 to 16.8 km/l in 2016
  - Annual FE improvement rate: **1.9% per year**

Pushing beyond the 2% per year threshold for improvements without adequate leadtime given to producing firms, introduces significant risk of market disruption.



Car baseline

2.5%	3.0%	3.5%	4.0%	4.5%
27.5	27.5	27.5	27.5	27.5
28.2	28.3	28.5	28.6	28.7
28.9	29.2	29.5	29.7	30.0
29.6	30.0	30.5	30.9	31.4
30.4	31.0	31.6	32.2	32.8
31.1	31.9	32.7	33.5	34.3
31.9	32.8	33.8	34.8	35.8
32.7	33.8	35.0	36.2	37.4
33.5	34.8	36.2	37.6	39.1
34.3	35.9	37.5	39.1	40.9
35.2	37.0	38.8	40.7	42.7
36.1	38.1	40.1	42.3	44.6



Policy Mechanisms

- Individual Policy Assessments
- Specific Comments on a Few Prospective Policies
  - Feebates
  - Fuel Efficiency Standards

Policy Mechanisms

Strategies for stabilizing mobile source GHG emissions:

1. **Improving vehicle fuel efficiency**
2. **Reducing carbon in fuel**
3. **Reducing VMT**

Observations

- No single policy can address all three strategies simultaneously.
- No single policy can work directly on producers and consumers at the same time
- Multiple policies must be pursued in parallel that compliment each other
  - Synergy is needed
- Every policy, before adoption, should include an accurate assessment of its:
  - life-cycle greenhouse gas emissions and environmental consequences;
  - economic costs and benefits; and,
  - impact on the global energy trade on which the U.S. and all other industrial economies will continue to depend.

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Policy Mechanisms

Policy	To improve total fleet efficiency		To reduce carbon intensity of fuel used		To reduce VMT
	Producers	Customers	Producers	Customers	
General policies					
CAFÉ standard	++				
Feebate incentive	++				
Cap and Trade (Upstream)		+			+
Cap and Trade (middle / downstream)		+			++
Vehicle technology mandate	+				
Vehicle technology incentive		+			
Vehicle Tax (Registration)		+			
Insurance depend on VMT					+
Pay at the pump insurance		+			+

Policy Mechanisms

Policy	To improve total fleet efficiency		To reduce carbon intensity of fuel used		To reduce VMT
	Producers	Customers	Producers	Customers	
General policies					
Fuel Tax		+			+
Carbon Tax		+		+ (if fuel is easily accessible)	+
Low Carbon Fuel Standard			++		
Tax Differentiation on different fuel				+ (If fuel is easily accessible)	
Retirement incentive	+				
Specific fuel mandate (including Alternative fuel mandate)			+		
Land-use policy					0 to ++

Continuous Efficiency Incentive Programs (aka Feebates)

- Feebates have similar effects as CAFE
  - CAFE fixes amount of fuel reduction
  - Feebates fix cost of fuel reduction
- 90% of feebate response is from the manufacturer, not the customer
- Class-based standards provide flexibility

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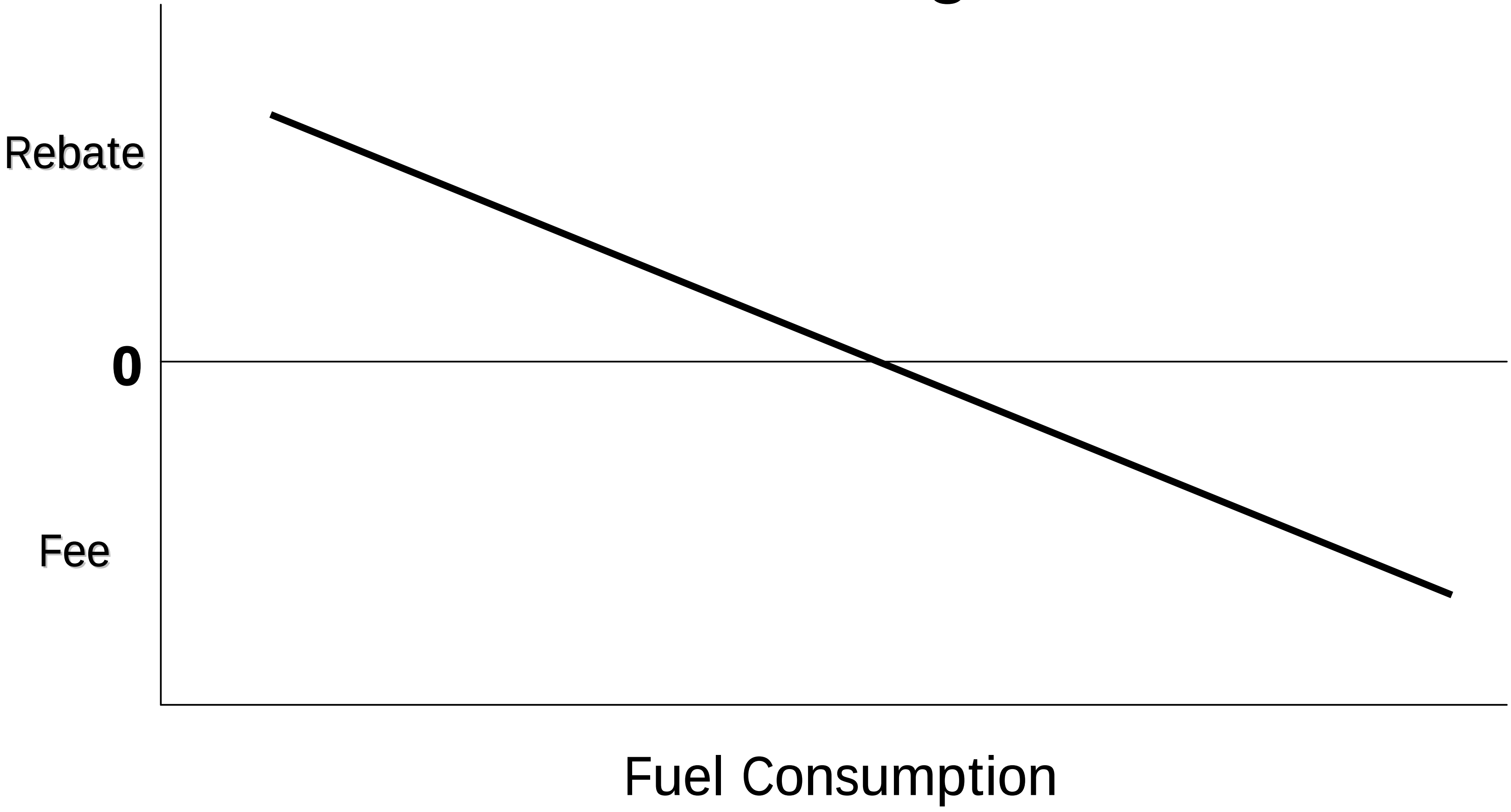
What is a “Feebate” System?

- “Feebate” simply means higher efficiency vehicles receive rebates, lower efficiency pay fees
- Generic structure – specifics can vary widely:
  - Revenue neutral, net proceeds, or net payments
  - Floating or fixed midpoint
  - Linear or discontinuous changes in fees/rebates
  - Single or multiple classes
  - Gallons or GHG can be used as metric
  - Value assigned to gallons or CO2
- U.S. gas guzzler tax is half of a feebate system
- Feebate system – means different things to different people.
  - Need to expand understanding of benefits

Policy Mechanisms

Feebate Program



Incentives/Mandates are Needed

- Fuel price is a good lever for vehicle choice and VMT
  - Gas taxes “should” be raised
- Fuel price is NOT a good lever to “push” technology
  - Technology cost and fuel savings balance
  - Little influence on highly complex and emotional purchase decisions
- Role of Federal government is to reflect full fuel savings and externalities in performance-based requirements or incentives

Policy Mechanisms

Carbon Credits Trading Schemes

- Interest in flexible mechanisms such as cap and trade continues to grow.
- Can the auto sector be included in a multi-sector cap and trade program?
  - Not a bad idea, but unlikely to yield much benefit
  - While inclusion may be envisioned as granting flexibility to offset standard stringency; this is only a facade´
  - Credits may not exist to trade
  - Even if credits did exist to trade…..
    - Highly unlikely auto makers will trade among each other
      - Competitive issue
      - May want to preserve credits for themselves
  - Individual auto makers may trade with fuel providers, but:
    - Credit price determination a challenge between two industries
    - Double-counting a significant issue
  - Introduces a possible disincentive for trading firms to improve
  - Must be designed appropriately to avoid disincentives to improve

Feebates may be the best approach and much more effective than a cross-sector carbon credits trading program between fuel providers and the auto makers.

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Closing Thoughts…..

- Technology can and will play a significant role in achieving GHG emissions stabilization, but…without consistent market incentives and signals, we will not succeed.

- The customer must be part of the equation.
  - Individual awareness is growing; but there may be a feeling of helplessness if left to act alone.
  - How can we address consumer awareness / response at-large and also stimulate individual and grassroots community response?

- Effective policy needs to address the leadtime issue.
  - Moderate ramp-ups in the early years of standards are important.

- Don't forget the need for policy synergy.

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