The Energy Efficiency Potential of Global Transport to 2050

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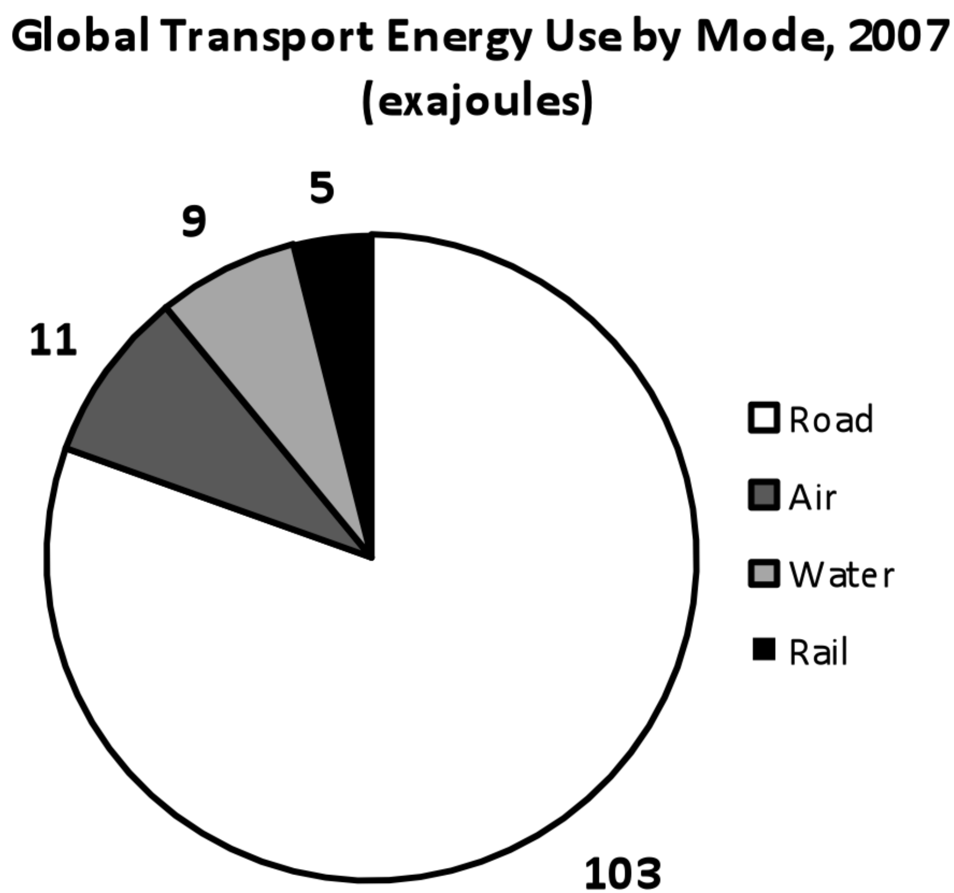
Directions in Engine-Efficiency and Emissions Research
Detroit, Michigan
October 3-6, 2011

Increased energy efficiency is crucial to the sustainability of global transportation.

- It should be possible to more than double transportation energy efficiency by 2050.
- This should be sufficient to hold transportation energy use at today's level.
- Threats to energy efficiency improvement?
  - The Energy Paradox:
    - Markets tend to undervalue energy efficiency
    - Underinvestment in technology and R&D
  - Rebound: "emergent" property of energy systems?
    - Direct effect of lower energy cost/km
    - Indirect effect on economic growth and energy prices

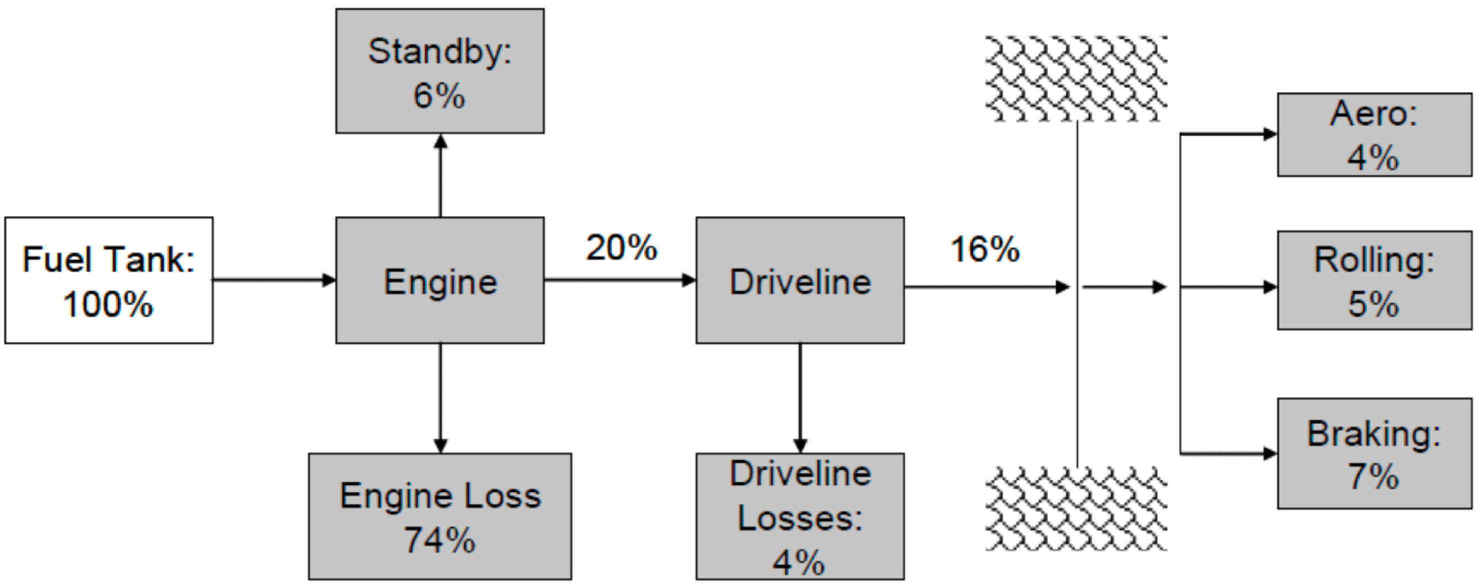
Petroleum provides 95% of the energy for global transport, which accounts for 27% of global final energy use.

Transport energy use is expected to more than double by 2050 under BAU.



IEA, Energy Technology Perspectives 2010.

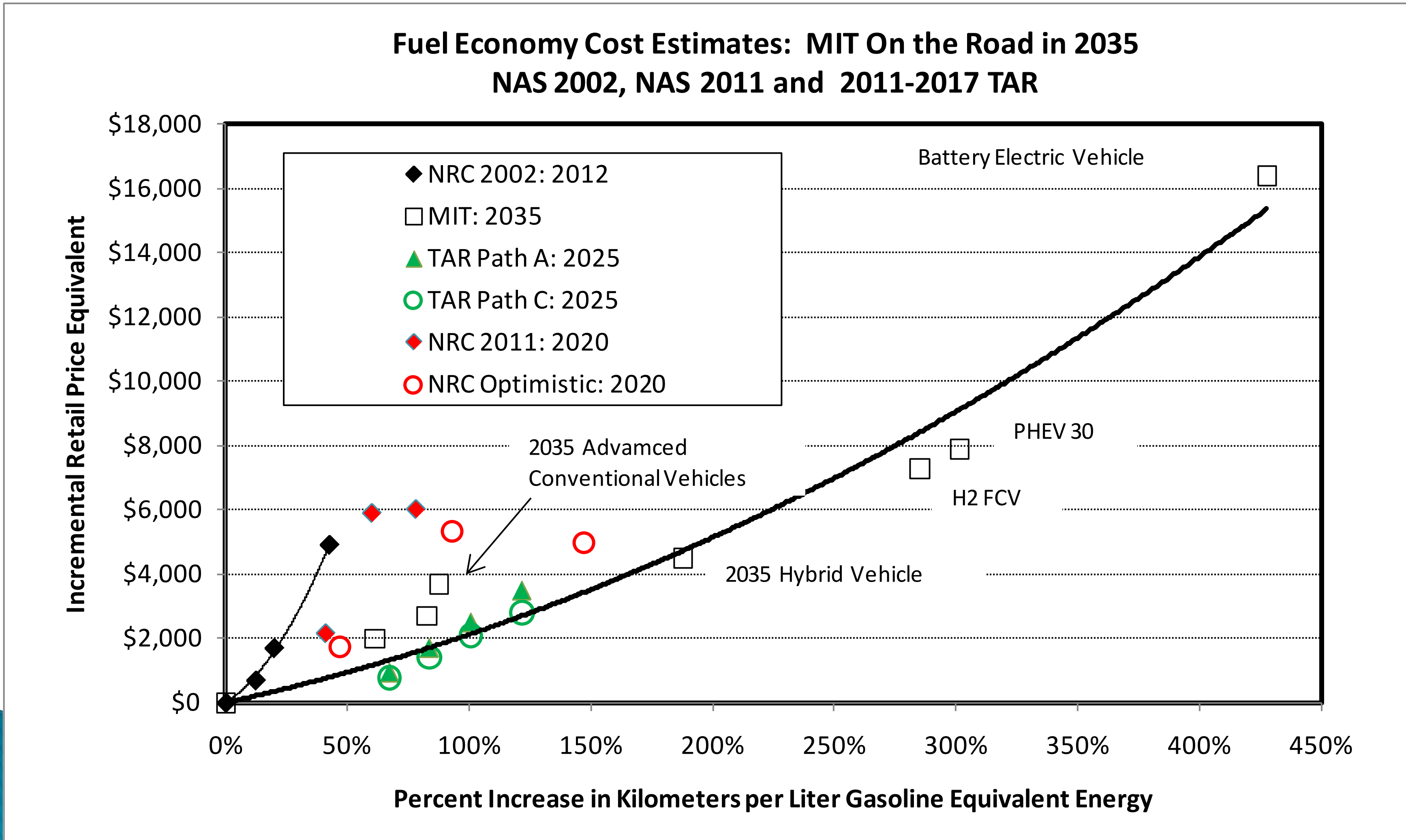
The overall energy efficiency of U.S. passenger vehicles is on the order of 1%.
Though an extreme example, it is reasonable to infer potential for major improvement.



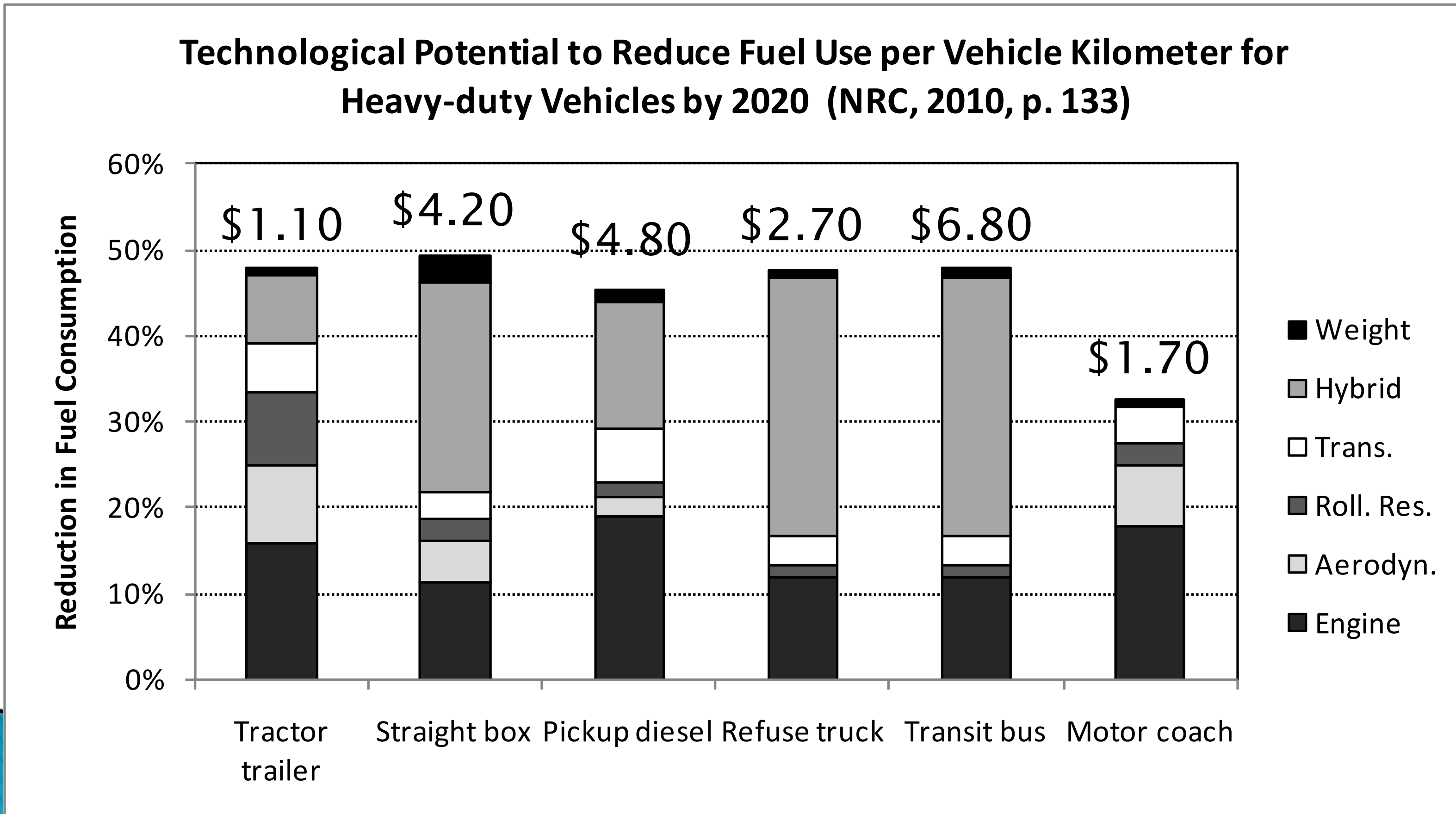
Bandivedekar et al., 2008, “On the Road in 2035”, MIT Sloane Automotive Res. Lab.

Proposed fuel economy standards require more than a doubling of miles per gallon by 2025.

Can it be done cost-effectively?



The "energy efficiency paradox" seems to apply to heavy-duty vehicles, as well, which would explain why Japan, the EU, the US and China are all implementing efficiency standards for heavy-duty vehicles. (US: 9-23% reduction in fuel consumption)



Other modes also have substantial potential to reduce fuel consumption cost-effectively.

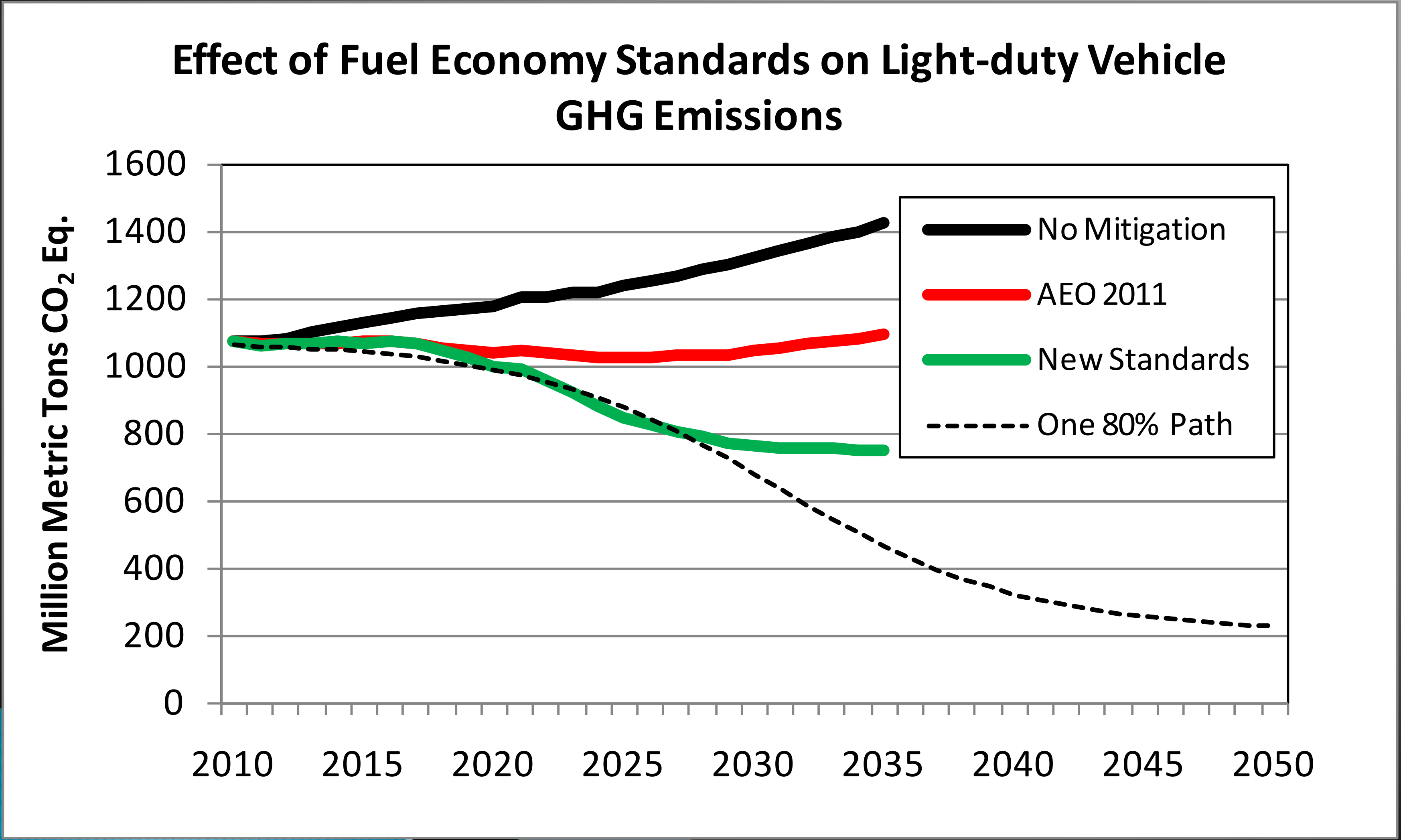
- Air transport uses 10% of transport energy.
  - Next Gen aircraft -40% fuel burn vs. 2005 by 2020: IATA
  - "wing-body" "double-bubble": -50 to -70% by 2035
- Water transport is 7% of transport energy use
  - -60% by 2050: IEA (includes speed reduction)
  - -15% to -30 by 2020 at $<\$100/tCO_2$: IMO
- Rail Transport uses only 4% of transport energy
  - -18% to 24% near term: IEA, USDOT
  - -50% by 2050: Argonne Nat'l Lab.

Accomplishing reductions in energy intensity of 50% or more could hold global transport energy use to today's level in 2050.

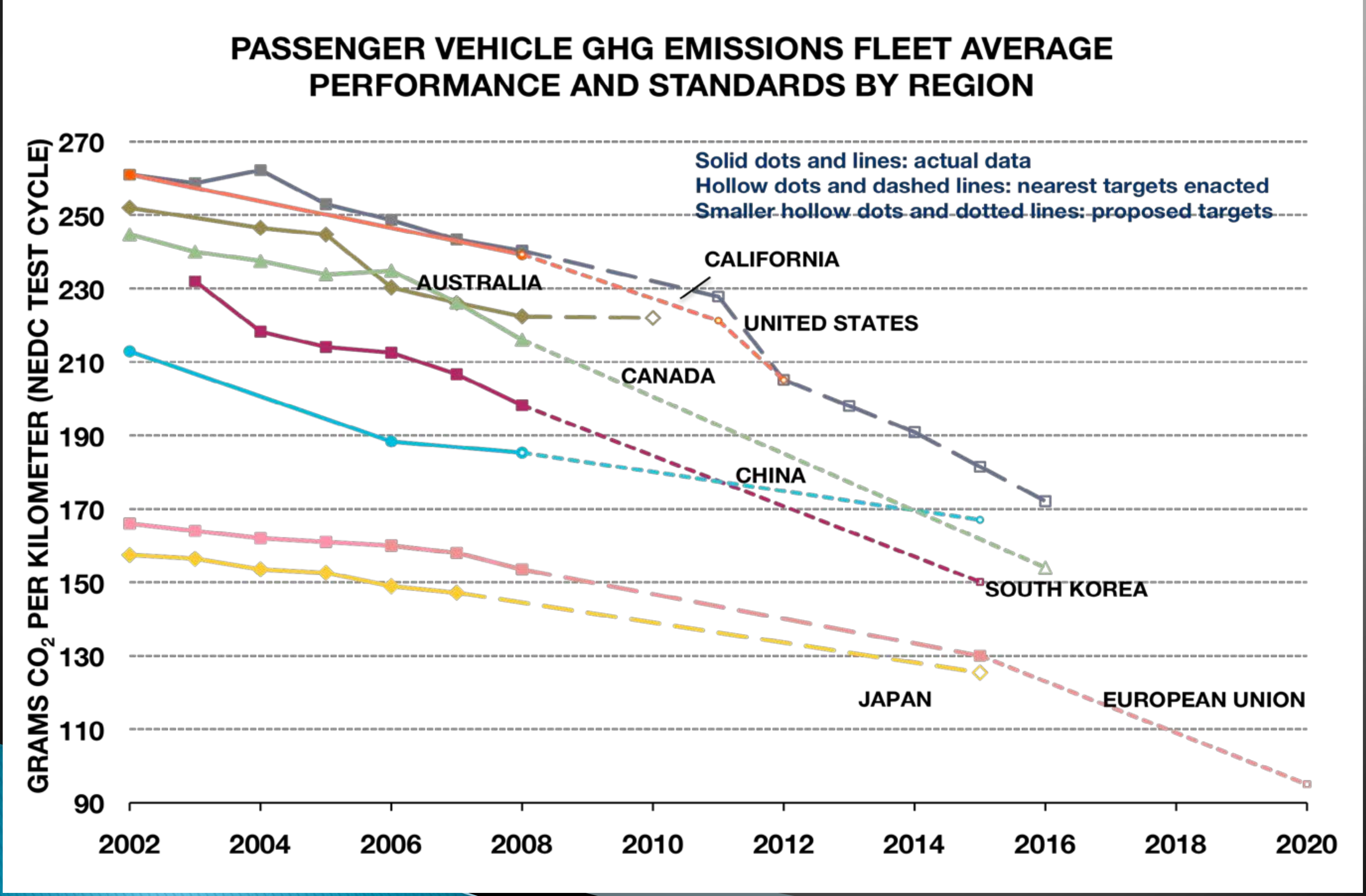
Table 1. Impact of Transport Energy Efficiency Improvement on Energy Use in 2050 (Exajoules)

Mode	Energy Use 2007	Growth Rate %	Extrapolated Energy Use 2050	Efficiency Improvement (% reduction)	Efficient Energy Use 2050	Energy Use With Rebound 2050
Road	103	2.0%	241	70%	72	87
Air	11	3.0%	39	60%	16	18
Water	9	2.0%	21	50%	11	12
Rail	5	1.0%	8	50%	4	4
TOTAL	128		309		102	121

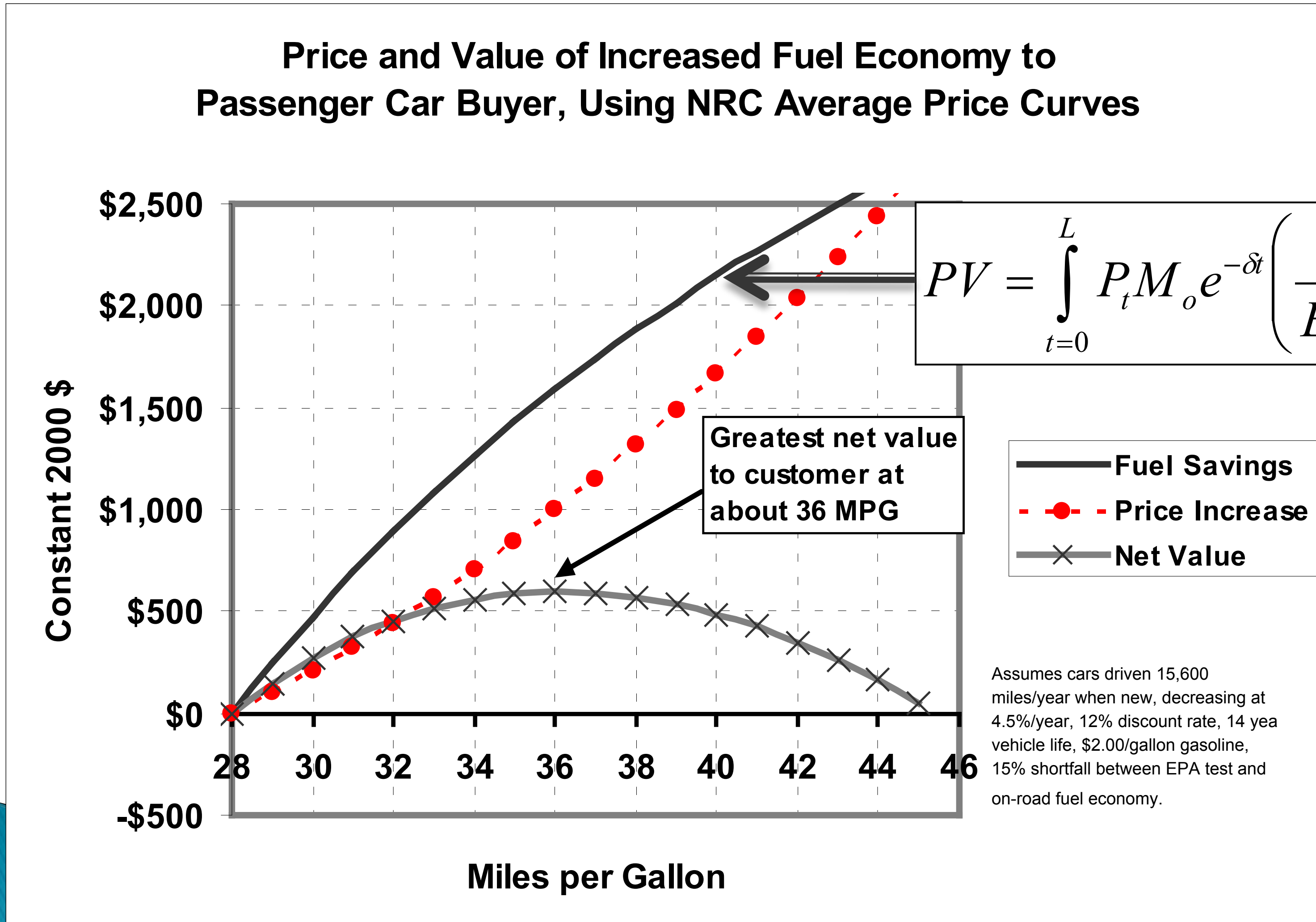
The proposed 2017-2025 US standards will put the LDV industry on a "climate sustainable" path toward oil independence.



Every major automobile manufacturing nation has fuel economy or CO_2 emissions standards. Why?

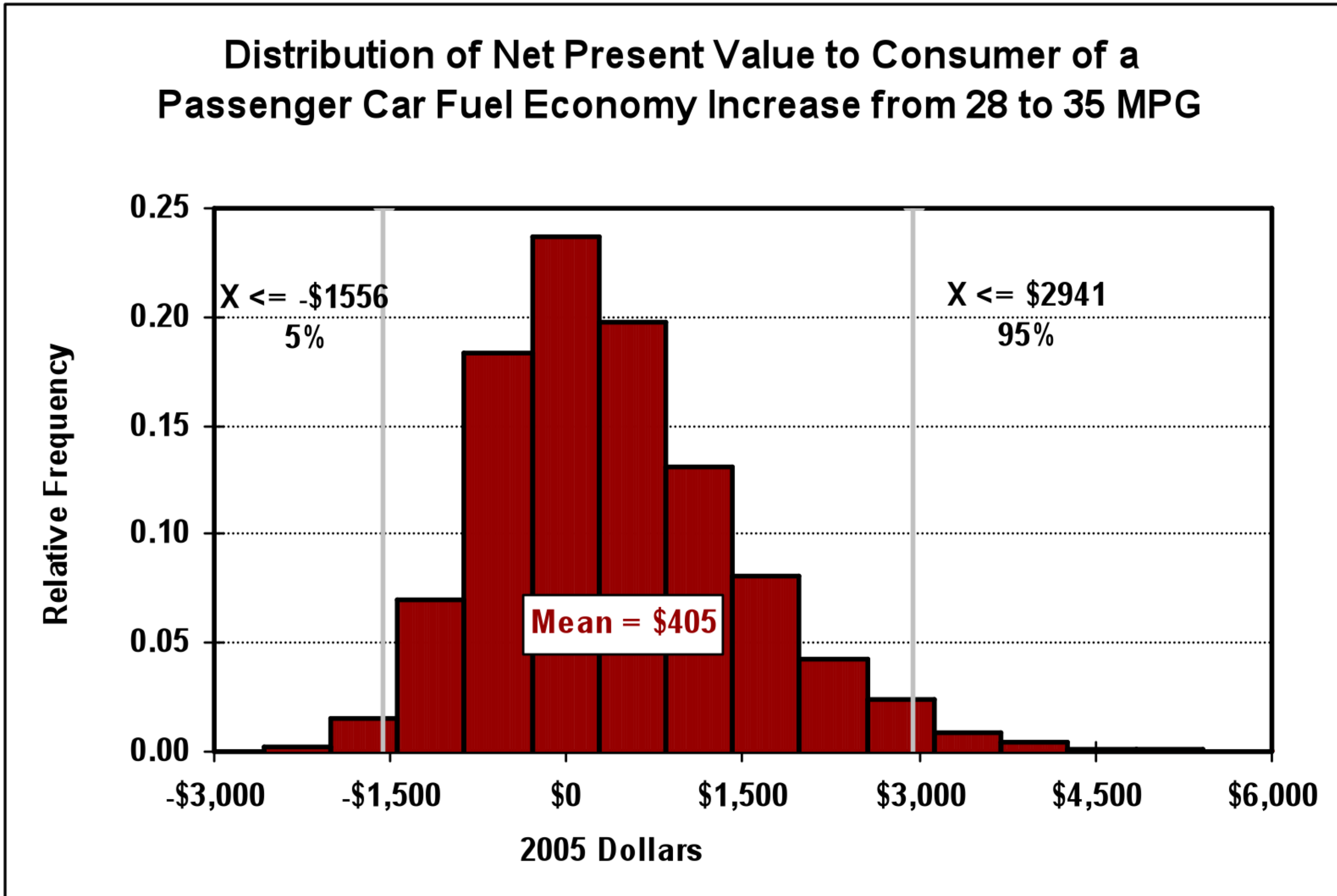


If there is no uncertainty, the net value of higher fuel economy is the difference between the present value of future fuel savings and the price increase. (NRC, 2002)

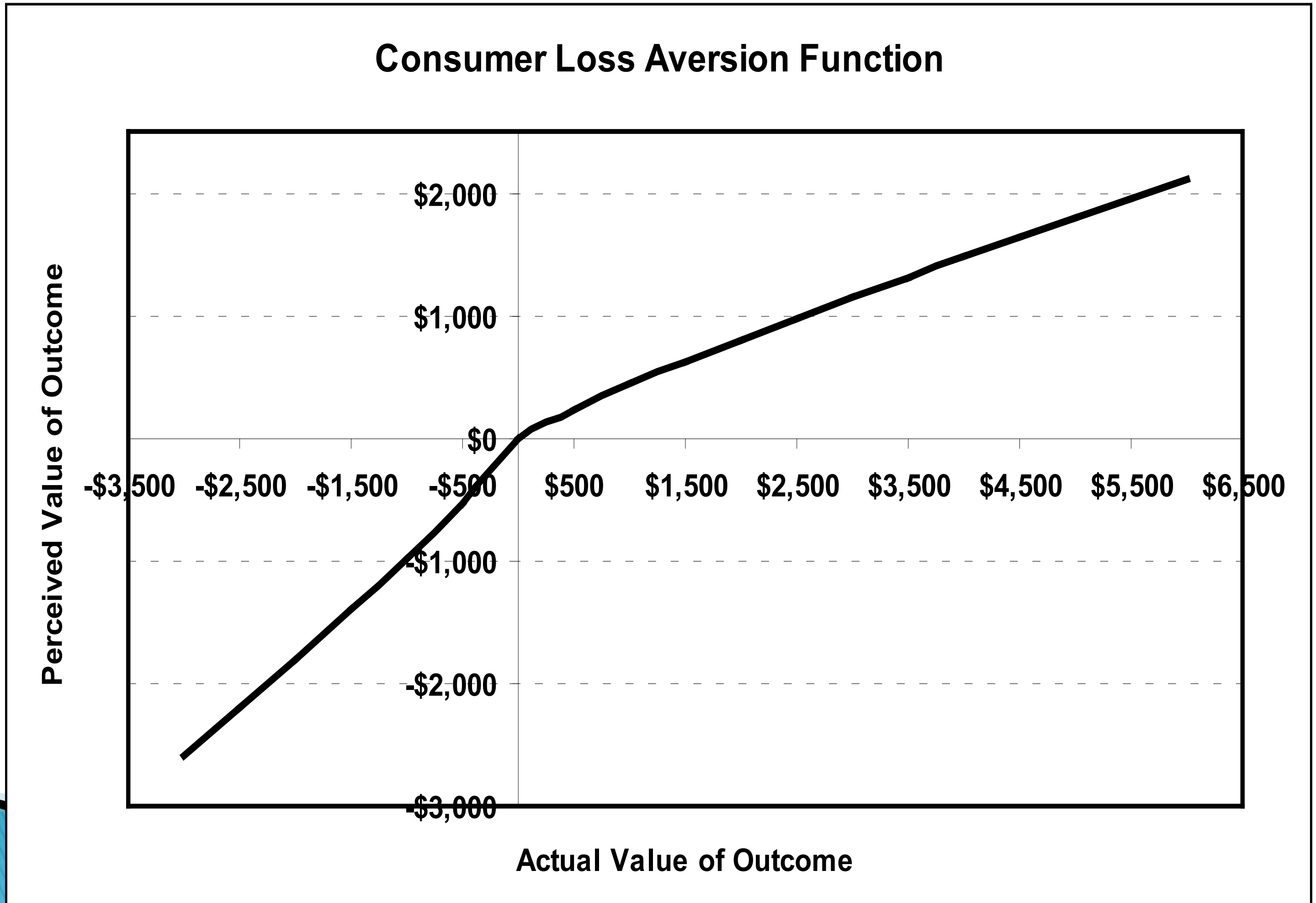


$$PV = \int_{t=0}^{L} P_t M_o e^{-\delta t} \left(\frac{1}{E_o} - \frac{1}{E_1} \right) e^{-rt} dt$$

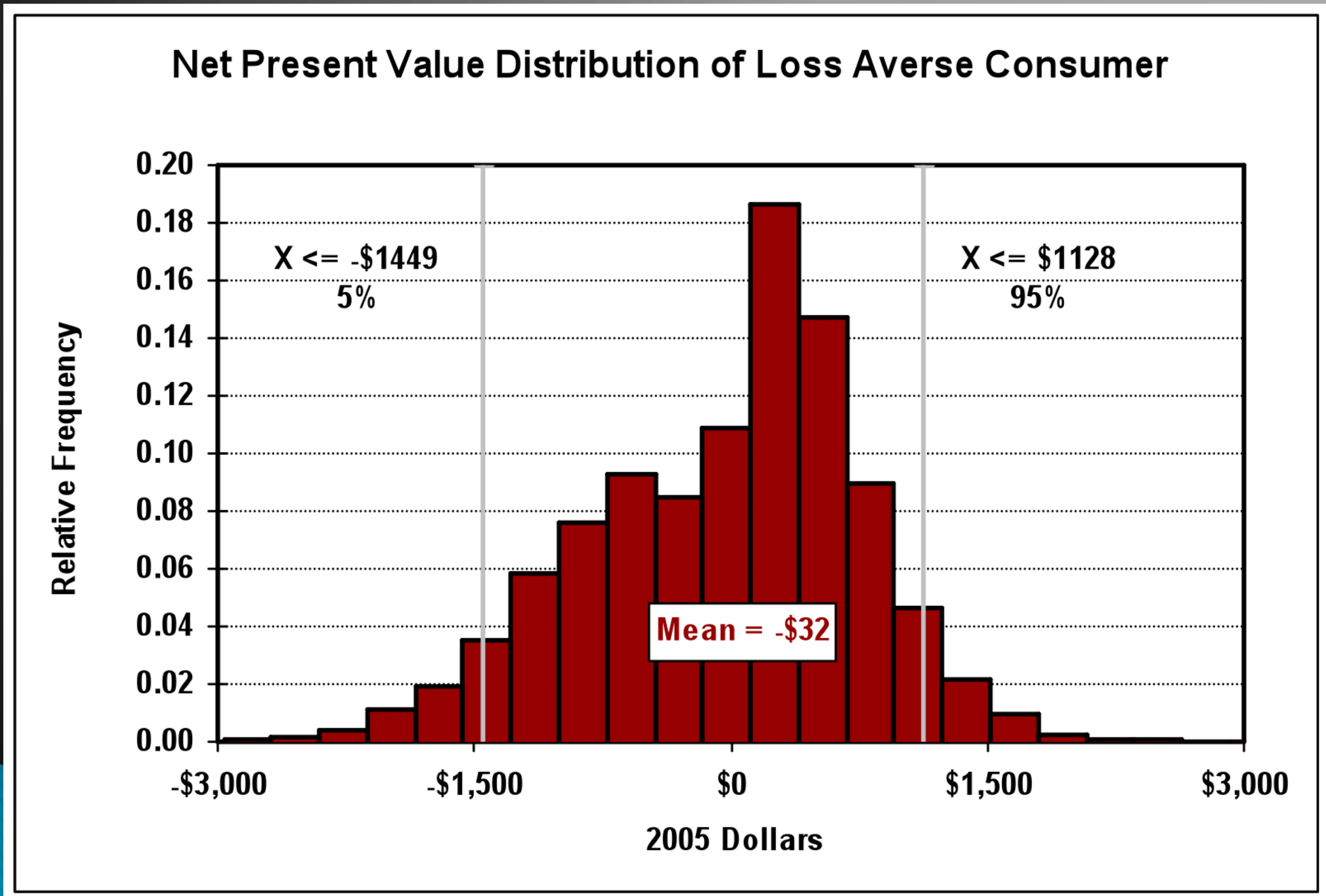
Quantifying uncertainty, a 25% increase in new car fuel economy is optimal and has a net present *expected* value of $405.



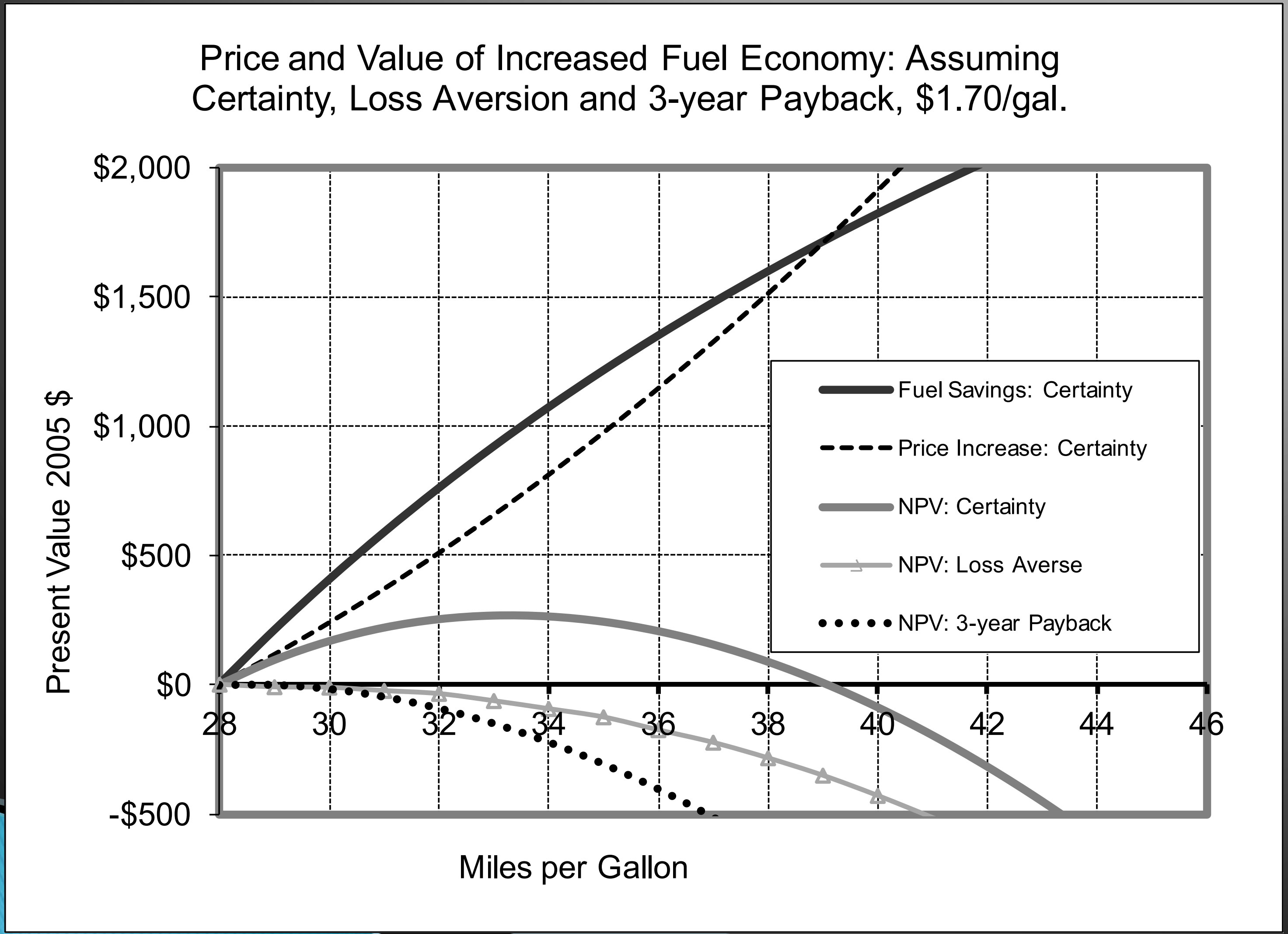
According to prospect theory (2002 Nobel Prize in Economics), typical consumers magnify potential losses relative to gains and exaggerate the probability of loss.
"A bird in the hand is worth two in the bush."



Loss-averse markets would decline the increase in MPG, as would a consumer requiring a three-year payback.



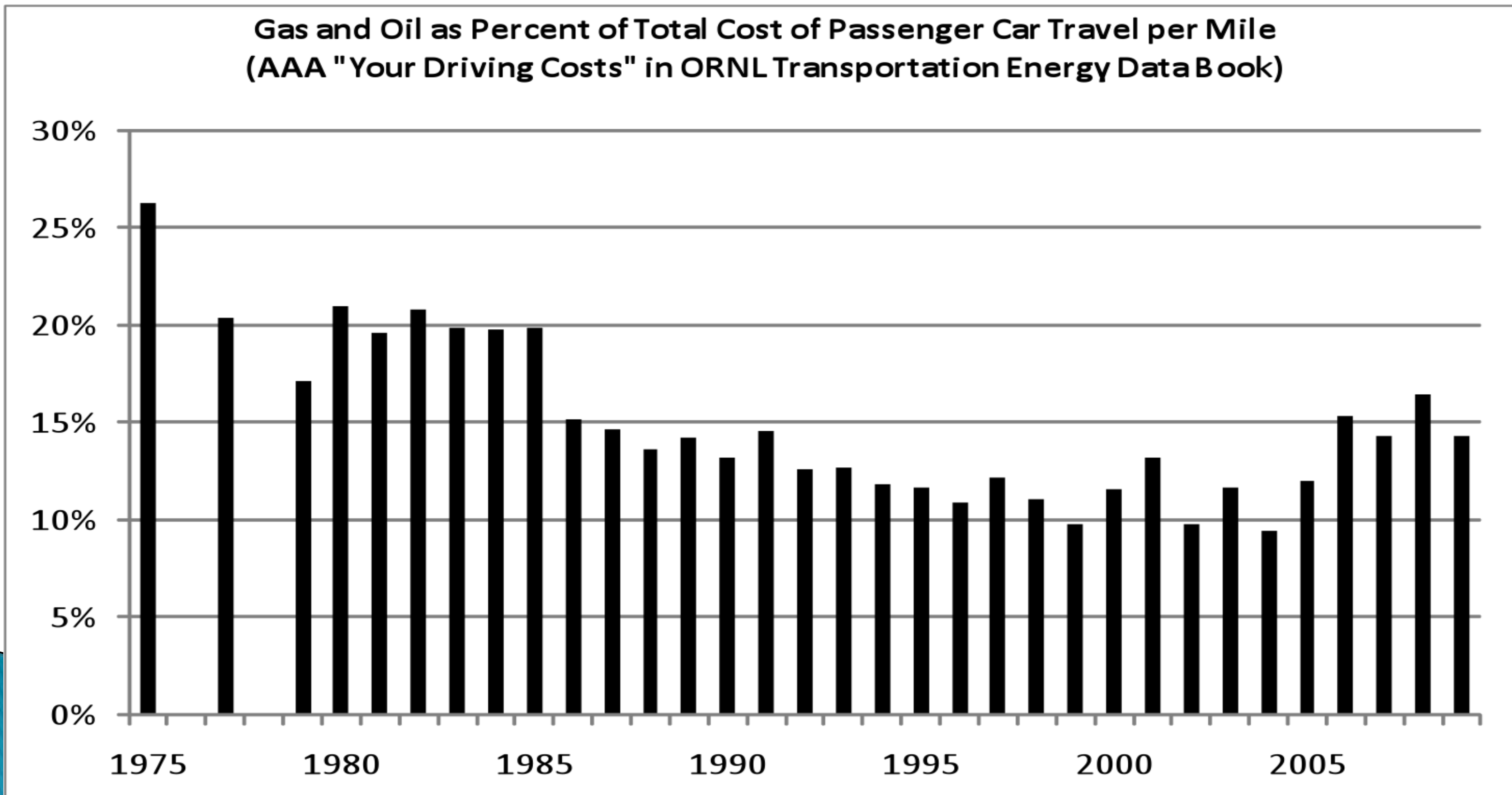
The undervaluing of energy efficiency implies under-utilization of cost-effective technologies and under-investment in R&D.



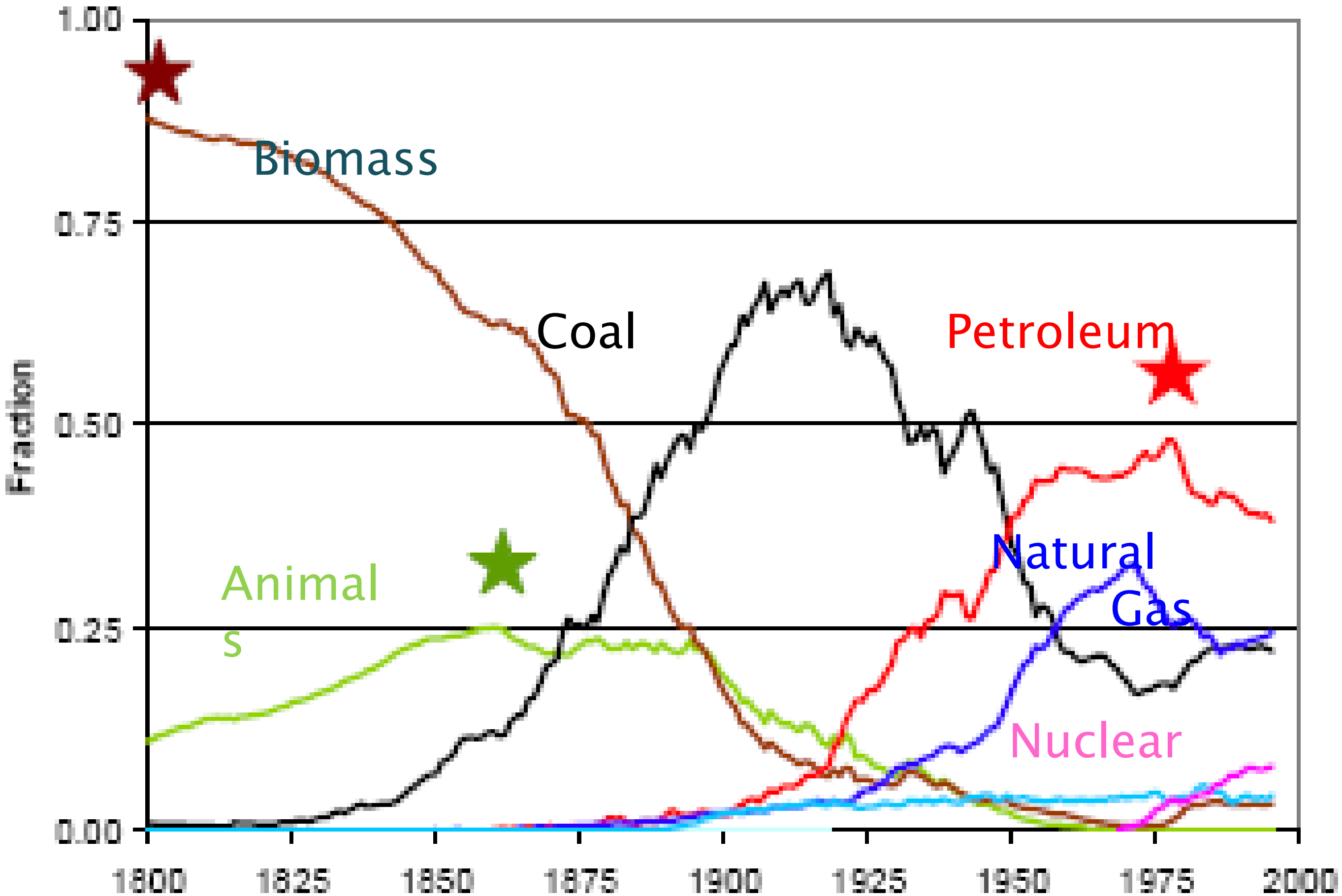
Will energy efficiency improvement really reduce energy use?

Rebound effect: lower energy cost ⟶ greater use of energy services, increased real income and increased consumption.

Direct rebound effect decreases with energy's share of total costs.
Indirect rebound decreases with energy's share of total expenditures.



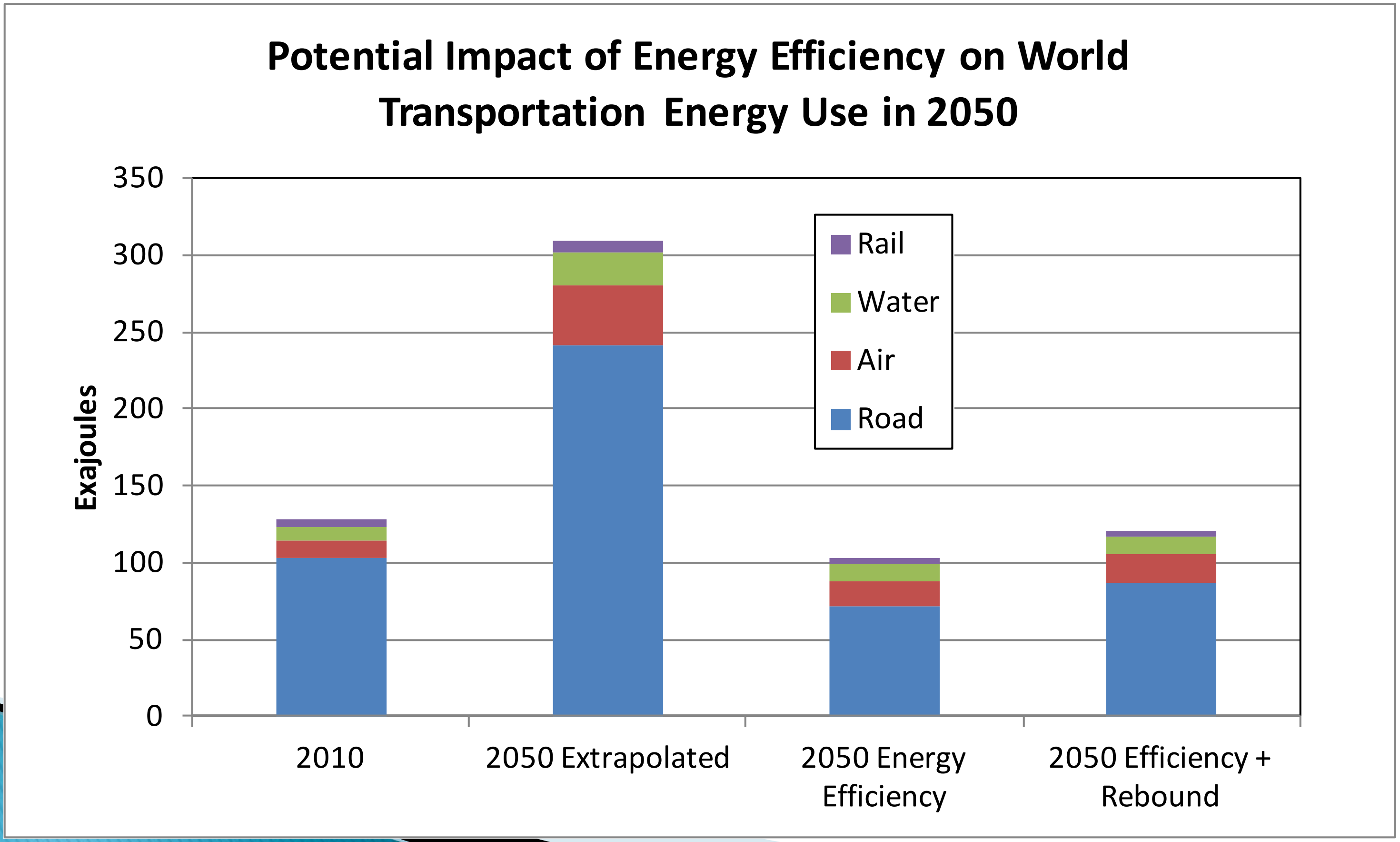
The great energy transformations of the past were driven by technology and market forces.
Creating a transition for the public good poses a new challenge.



Source: A. Grubler, 2007, International Institute for Applied Systems Analysis.

Holding transportation energy use to today's level buys time for the transition and helps make it affordable. But it won't happen without:

- Technological advances
- Public policy intervention



THANK YOU.

The NRC's 2010 study indicated substantial, cost-effective technological potential to reduce heavy truck fuel consumption.

Vehicle Class	Fuel Consumption Reduction	Capital Cost	Breakeven Fuel Price ($/gallon)
Tractor-trailer	51%	$84,600	1.10
Class 6 box truck	47%	$43,120	4.20
Class 6 bucket truck	50%	$49,870	5.40
Class 2b pickup	45%	$14,710	4.80
Refuse truck	38%	$50,800	2.70
Transit bus	48%	$250,400	6.80
Motor coach	32%	$36,350	1.70

NRC, 2010. *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles* , The National Academies

The National Academies of the G8+5 called for urgent action to address climate change and endorsed a 50% reduction in global emissions over 1990 levels by 2050.

"The IPCC 2007 Fourth Assessment of climate change science concluded that large reductions in the emissions of greenhouse gases, principally CO_2, are needed soon to slow the increase of atmospheric concentrations, and avoid reaching unacceptable levels. However, ***climate change is happening even faster than previously estimated***; global CO_2 emissions since 2000 have been higher than even the highest predictions, Arctic sea ice has been melting at rates much faster than predicted, and the rise in the sea level has become more rapid. Feedbacks in the climate system might lead to much more rapid climate changes. ***The need for urgent action to address climate change is now indisputable.*** For example, limiting global warming to 2° C would require a very rapid worldwide implementation of all currently available low carbon technologies."

May 2009

Emphasis added.

Oil dependence cost the US more than $500 billion in 2008.
Oil independence doesn't mean using no oil or importing no oil.