# Low Carbon Transportation:
## A Crucial Link to Economic and Energy Security

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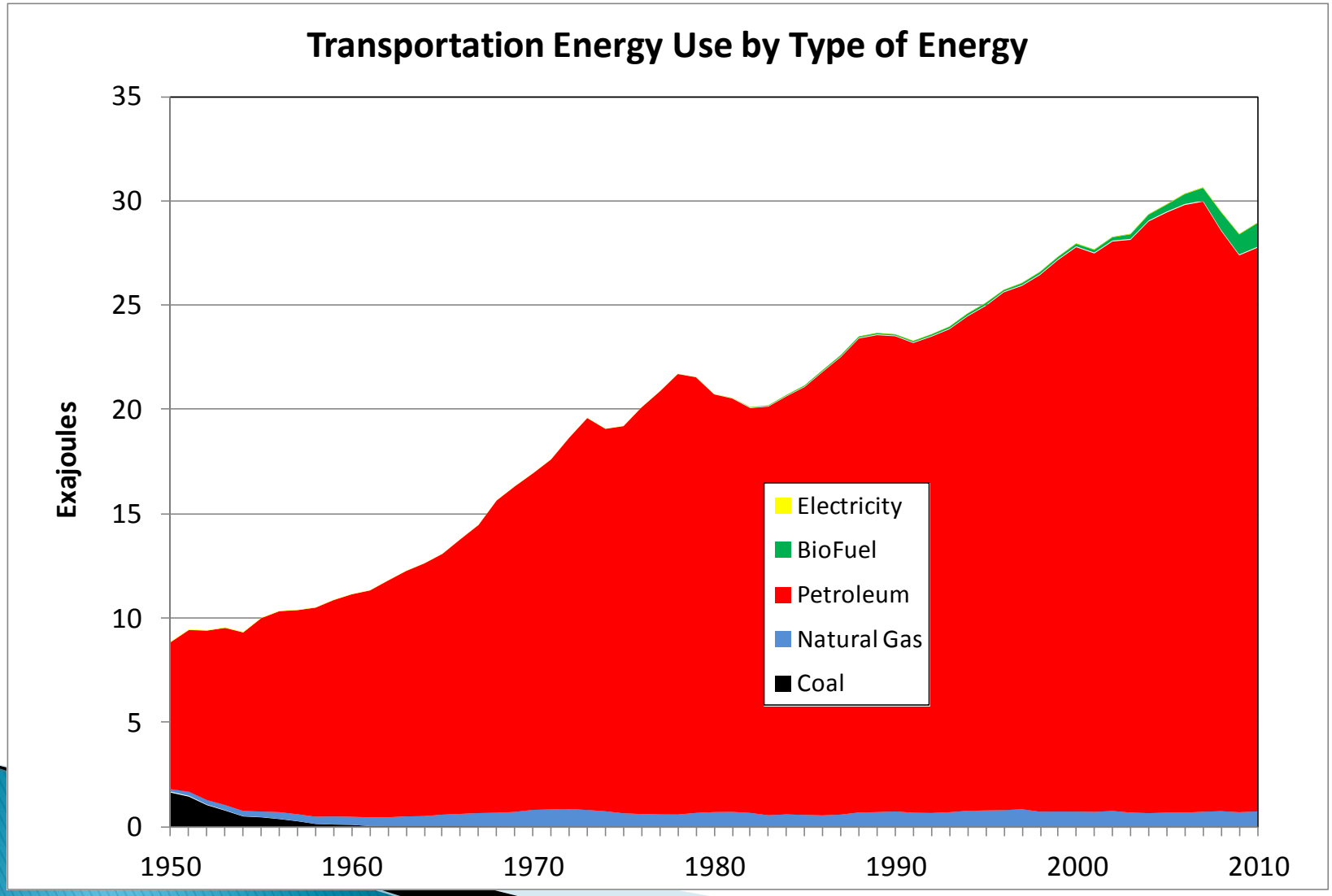
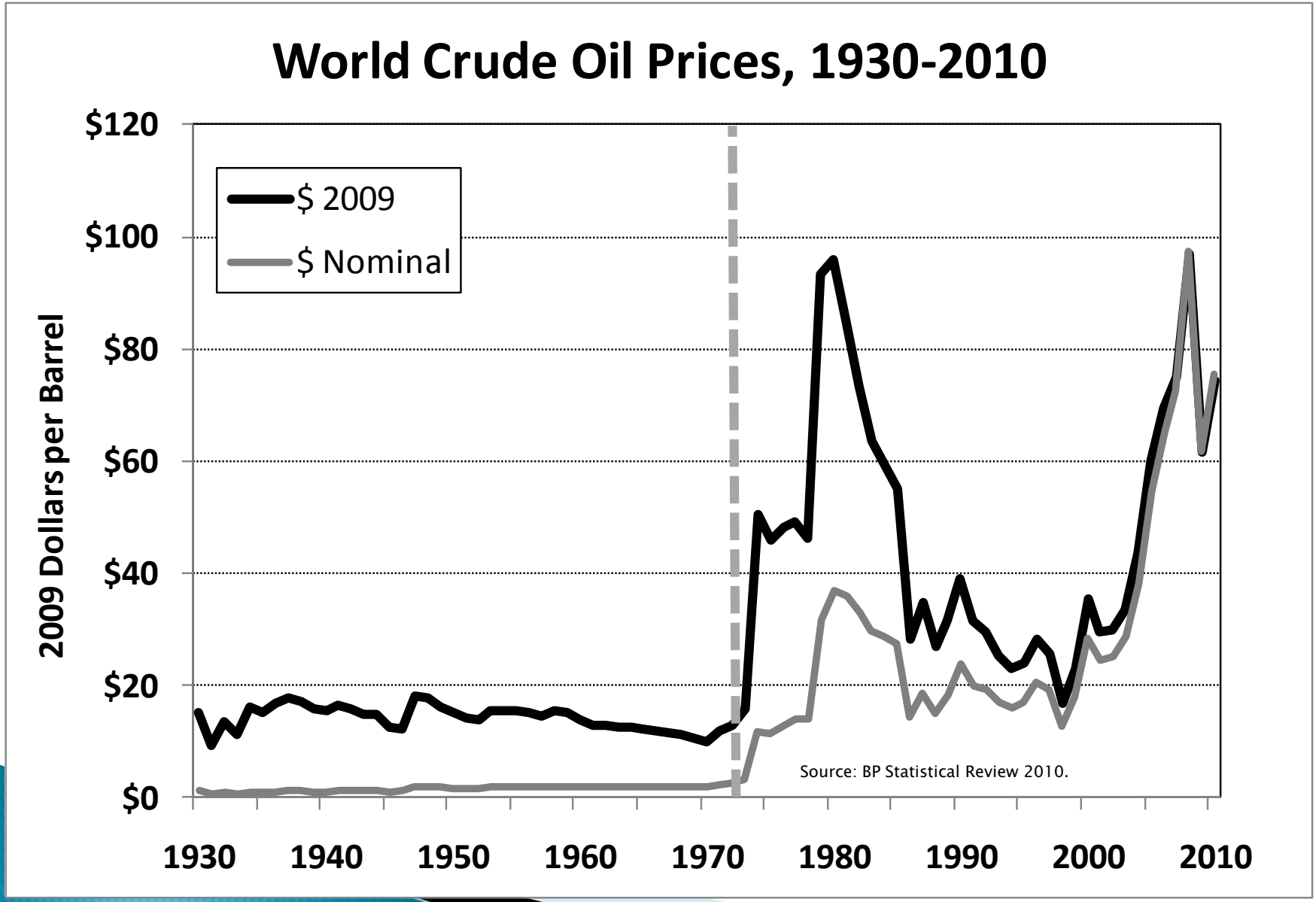
# Our transportation sector, vital to our economy and way of life, has been all but entirely dependent on petroleum for over half a century.



# It is not possible to reduce transportation's greenhouse gas emissions by 80% without nearly eliminating petroleum use in internal combustion engines.

- Transportation 95% dependent on petroleum
- Even if emissions of the other 5% could be reduced to zero, petroleum combustion would have to be reduced by 79%.
- Essentially all low-carbon solutions reduce petroleum dependence.
- Nearly all oil-dependence solutions reduce GHG emissions.

# Why do we care about energy independence?



# Energy independence
## "Now what do we mean by that?" (Soupy Sales)

- "The U.S. may be addicted to oil, but many of its politicians are addicted to "energy independence" – which may be **among the least realistic political slogans in American history**." J.J. Fialka, **Wall Street Journal**, 7/5/2006
- "**Calls for energy independence are unrealistic, to put it mildly**, for the foreseeable future; cutting oil consumption to current domestic production would severely derail an economy in which cheap and rapid transportation is taken for granted." I.W.H. Parry and J.W. Anderson, **Resources for the Future**, 2005.
- "The voices that espouse "energy independence" are doing the nation a disservice by focusing on **a goal that is unachievable** over the foreseeable future and that encourages the adoption of inefficient and counterproductive policies." **Task Force of Council on Foreign Relations**, 2006.
- "**Energy independence is hogwash.** From nearly any standpoint — economic, military, political, or environmental — energy independence makes no sense. Worse yet, the inane obsession with the idea of energy independence is preventing the United States from having an honest and effective discussion about the energy challenges it now faces." (Bryce, 2008) Robert Bryce, *Gusher of Lies: The Dangerous Delusions of Energy Independence*.

# What is oil (energy) independence?

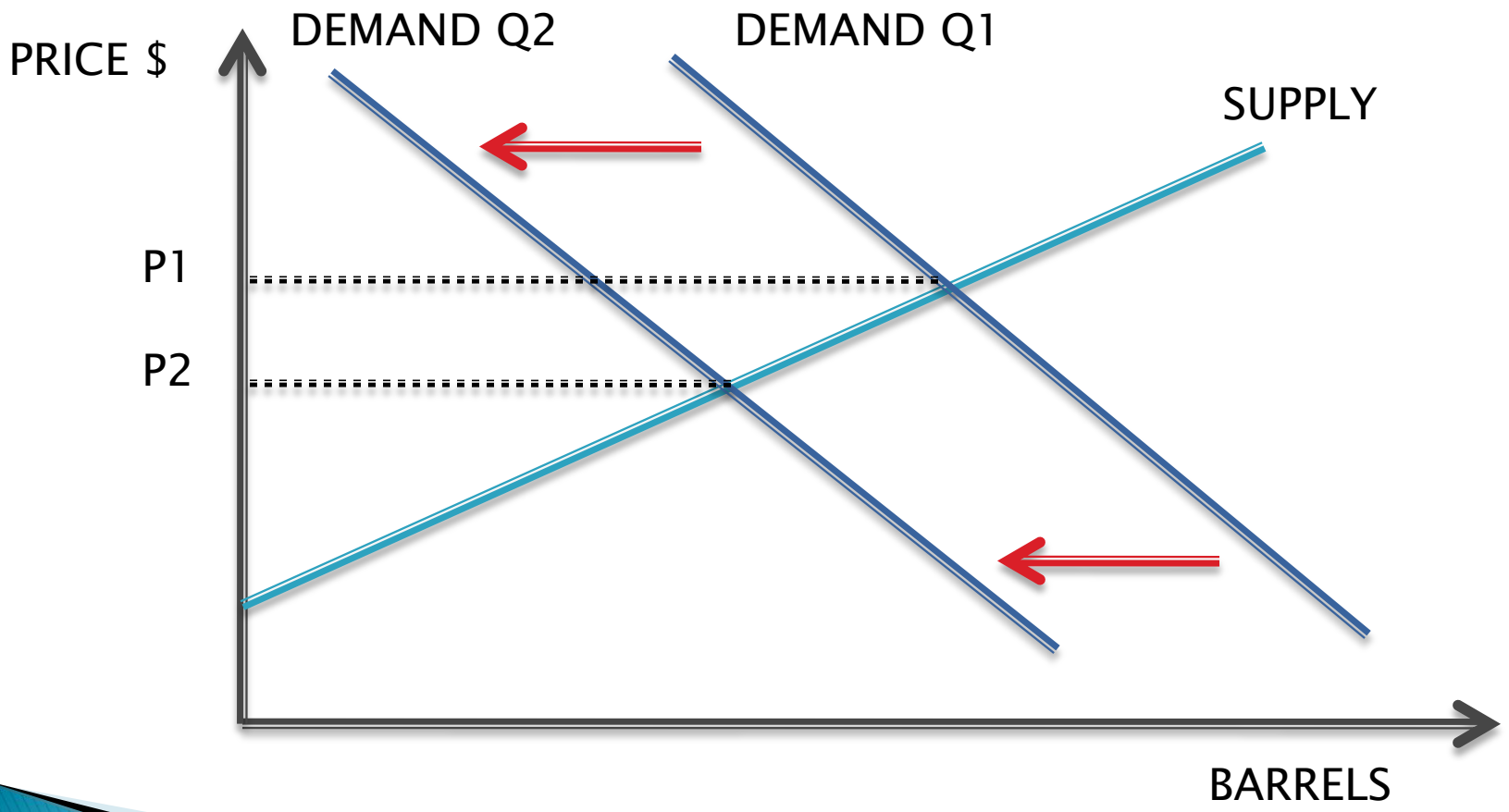
- Use no oil?
- Import no oil?
- Let's consult the dictionary on "independence".
- A state in which our nation is **"not subject to restraining or directing influence by others"** as a consequence of its need for oil.
- Unrealistic? Unachievable? Hogwash?

# What's the problem ("market failure")?

- "As the quotation from Parry and Darmstadter (2003) above indicates, the oil premium is a measure of the difference between the private and social costs of petroleum consumption measured in dollars per barrel. The literature identifies two major quantifiable sources of the discrepancy between private and social costs: U.S. monopsony power and economic disruptions arising from unanticipated price shocks." (NRC, 2009, *Hidden Costs of Energy,* p. 233 )
- "But the ability to exercise monopsony power is not the same as an externality. Externalities create market failure. Exercising monopsony power creates a market failure where one did not exist before." (NRC, 2009, p. 235)
- "We believe that oil disruption costs are not an externality." "Given the conceptual difficulties in identifying the basis for and size of the externality, we do not feel it makes sense to include a disruption cost as a component in the list of externalities associated with the production or consumption of energy." (NRC, 2009, p. 236)
- **The NRC panel is right about one thing: oil dependence is not an externality.**

# What is "monopsony" power?

## The US accounts for 20-25% of world oil use.



# What is oil dependence?

Oil dependence is primarily an economic problem with significant national security implications caused by,

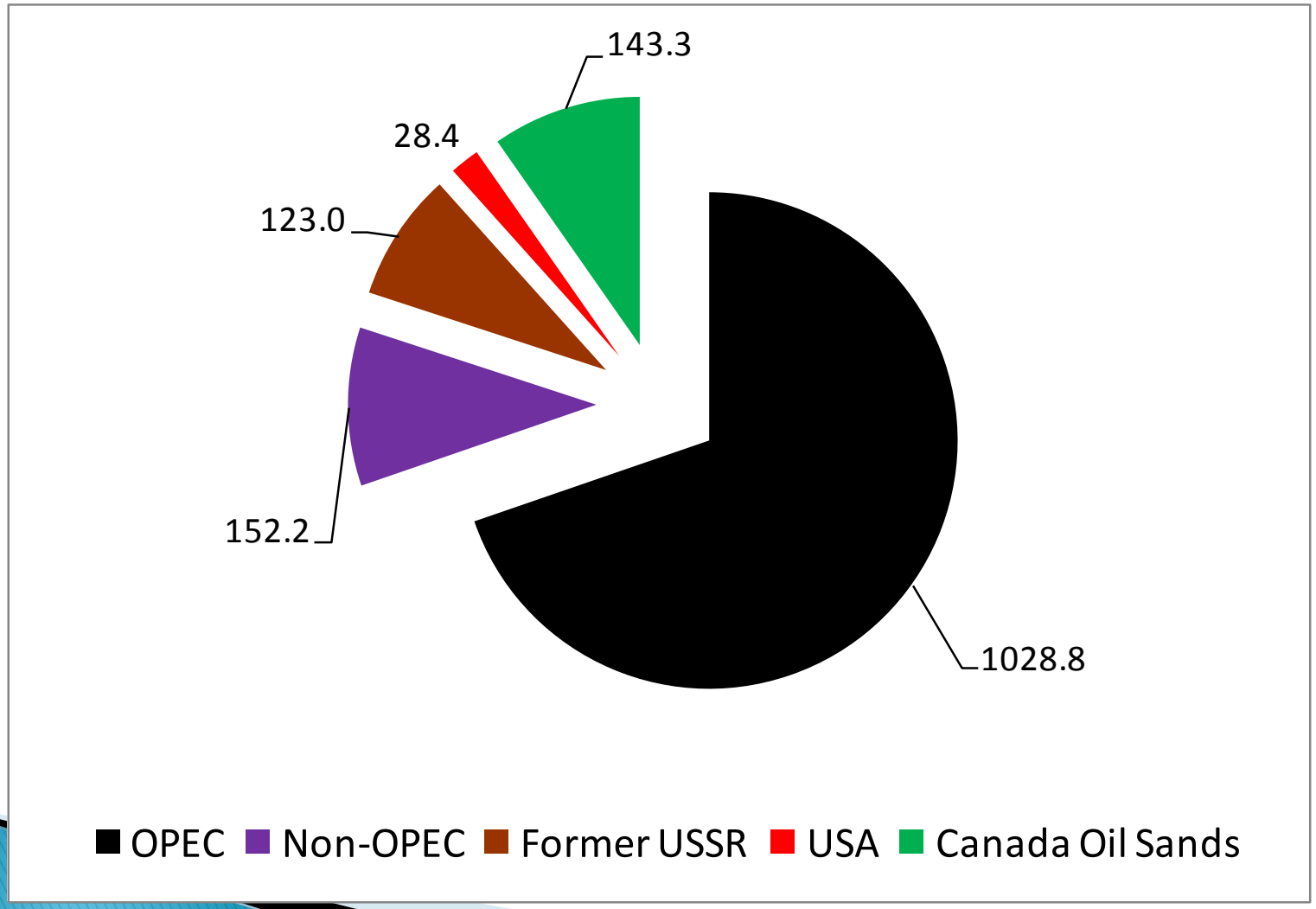
- importance of oil to the economy,
- lack of economical substitutes for oil and
- ***use of market power by oil producers***.

- The national security problem is primarily a result of the economic problem.

# Who are the oil producers?

OPEC members own 70% of the world's proven oil reserves and >50% of the ultimate resources.

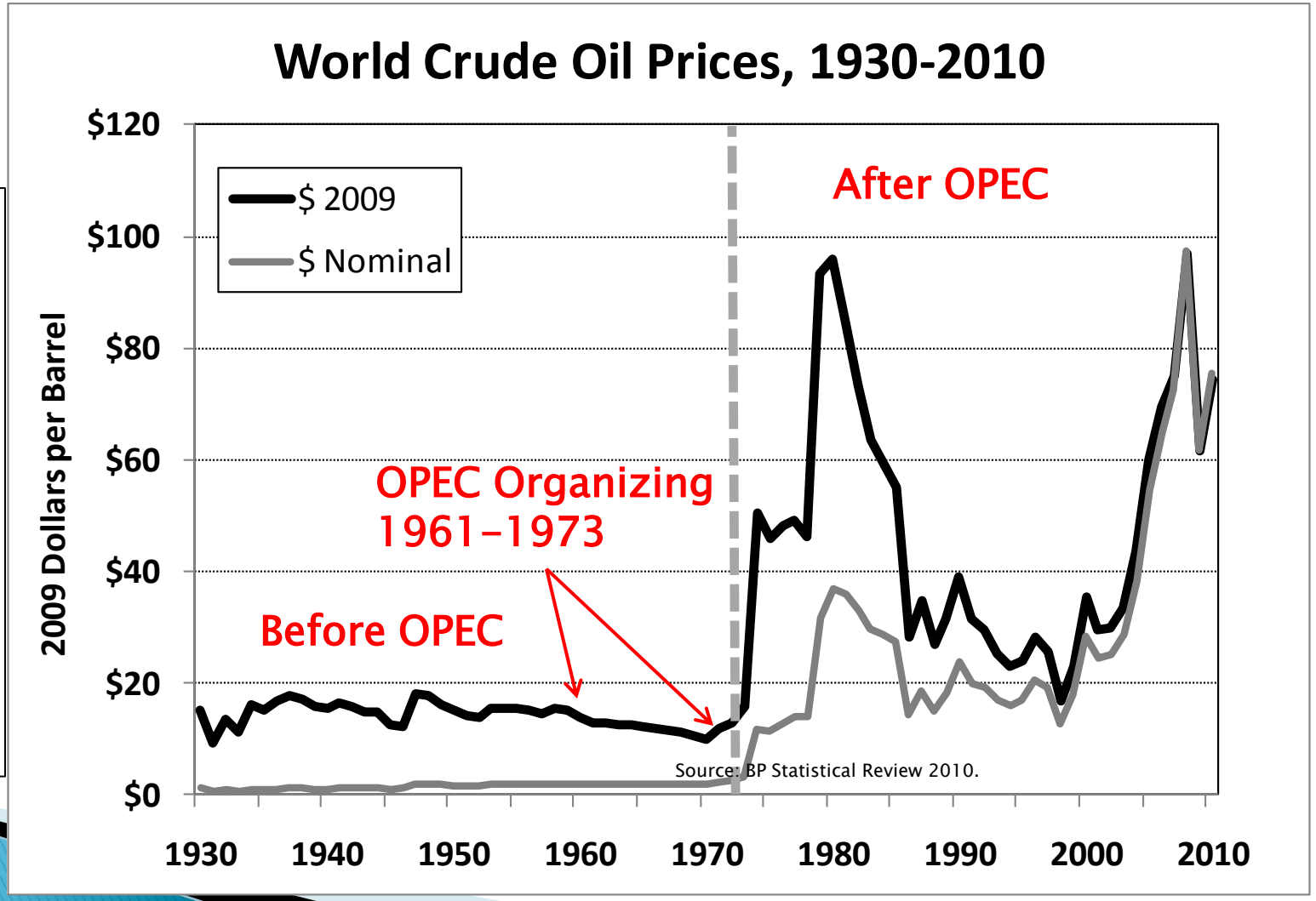
National oil companies own more than 80%.




Source: BP Statistical Review of World Energy 2010, "Oil: Proved Reserves".

"The real problem we face over oil dates from after 1970: a strong but clumsy monopoly of mostly Middle Eastern exporters operating as OPEC." Prof. M. Adelman, MIT, 2004.

- Algeria
- Angola
- Ecuador
- Iran
- Iraq
- Kuwait
- Libya
- Nigeria
- Qatar
- Saudi Arabia
- UAE
- Venezuela



The economic theory to understand the behavior of the OPEC oil cartel was developed more than half a century ago by Heinrich von Stackelberg.

$$P = \frac{C}{1 + \left( \frac{1}{\beta(P)} S\left(\mu(P) + 1\right) \right)}$$

$\beta$ = price elasticity of world oil demand ( $\beta < 0$ )
S = OPEC share of world oil market ( $0 < S < 1$ )
**μ**= non-OPEC supply response ( $-1 <$ **μ** $< 0$ )
Elasticity = % change in quantity / % change in price = d ln(y)/d ln(x)

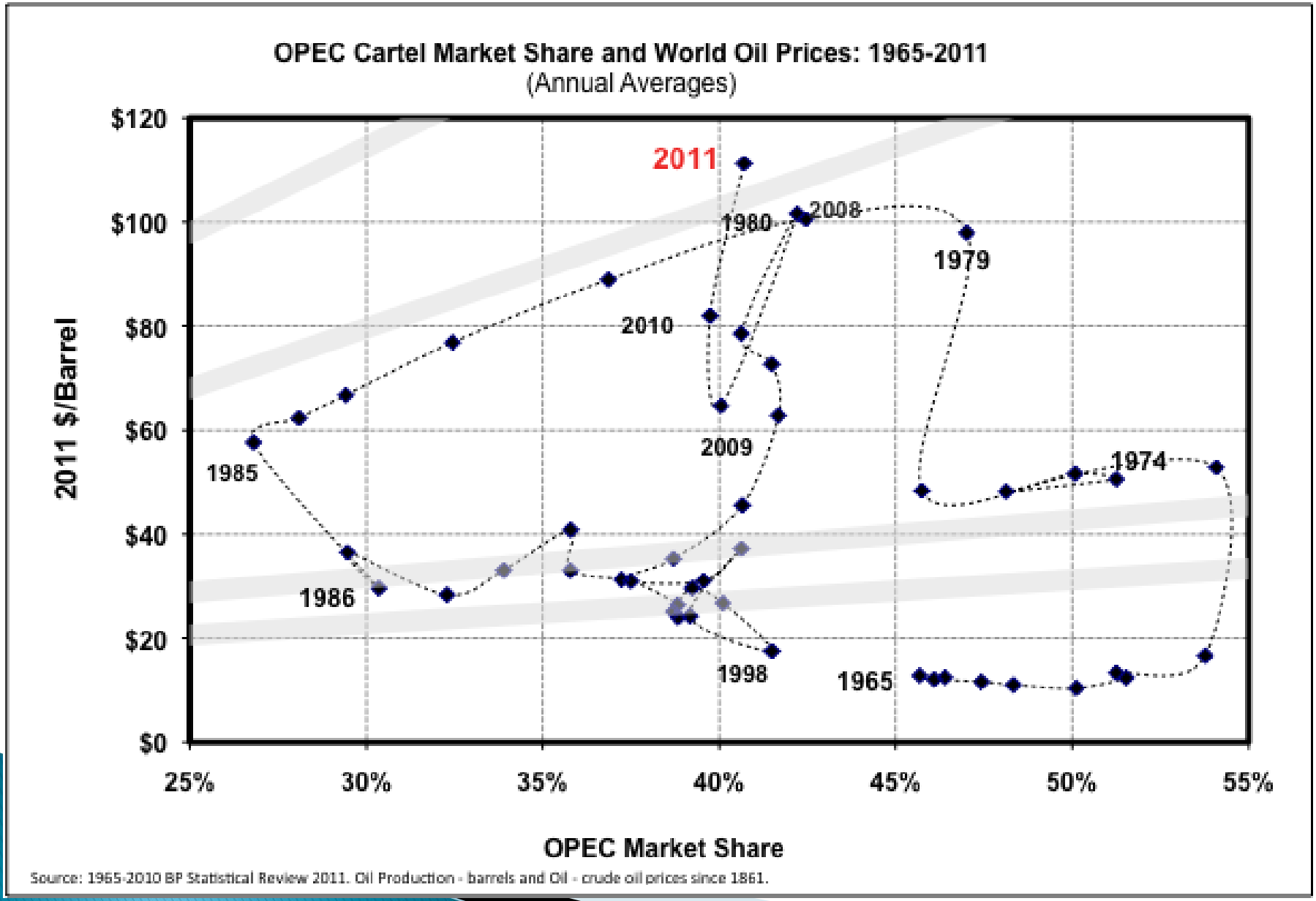
Short- and long-run elasticities differ by an order of magnitude!

# Can this simple theory explain the large-scale behavior of the world oil market?

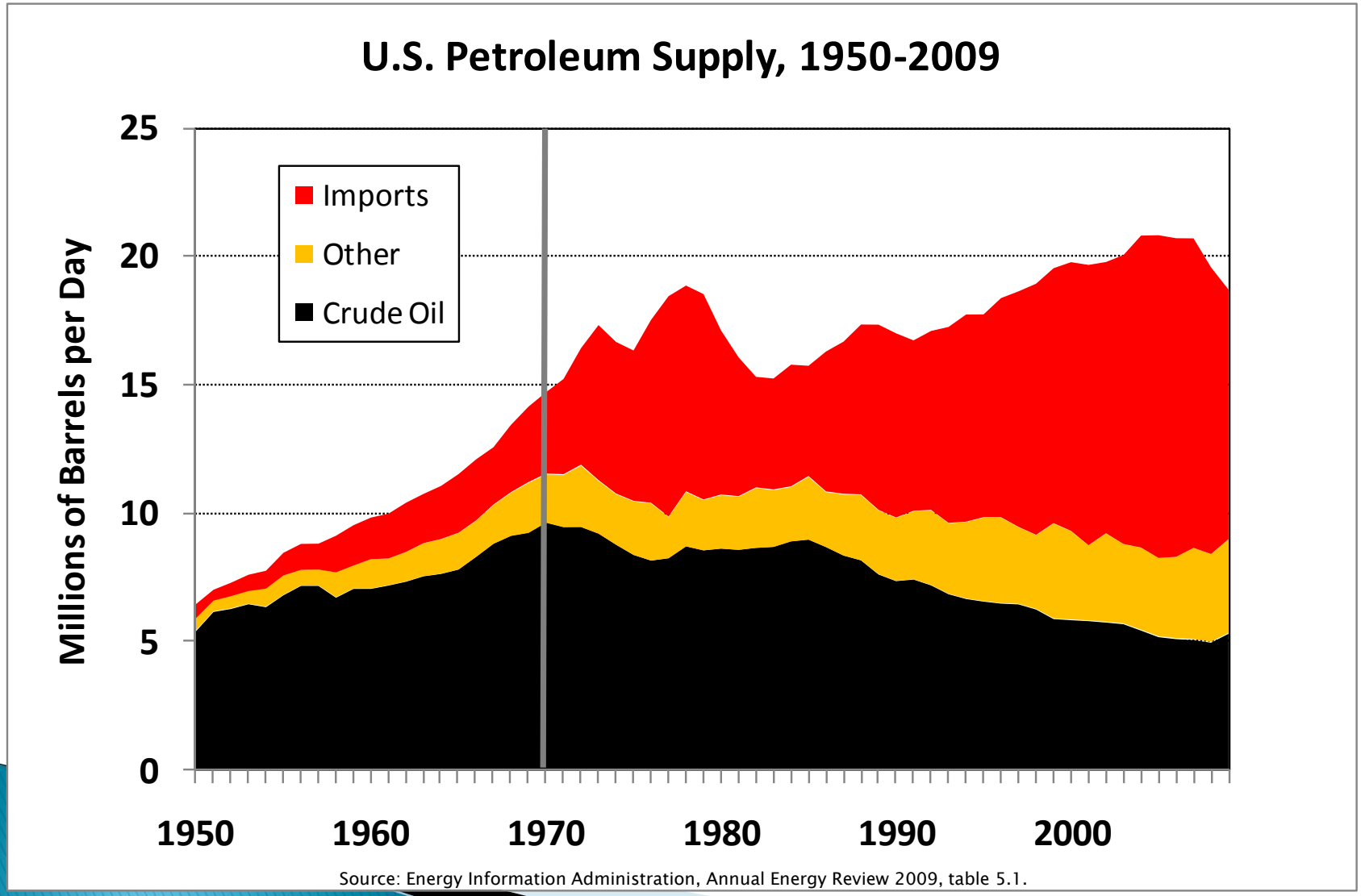
Parameter Assumptions Used in Calculating Long- and Short-run Profit-Maximizing Price Curves for the OPEC Cartel

| Parameter | High Value | Low Value |
|---|---|---|
| | World Oil Demand | |
| Long-run price elasticity | -0.60 | -0.45 |
| Short-run price elasticity | -0.090 | -0.068 |
| Adjustment rate | 0.15 | 0.15 |
| Average, 1965-2005 | Price per barrel = $36 | Million barrels per day = 61.3 |
| | Non-OPEC Oil Supply | |
| Long-run price elasticity | 0.500 | 0.400 |
| Short-run price elasticity | 0.125 | 0.080 |
| Adjustment rate | 0.25 | 0.2 |
| Average, 1965-2005 | Price per barrel = $36 | Million barrels per day = 36.5 |

# The “random walk” of oil prices since 1974 takes place within the partial monopoly framework.



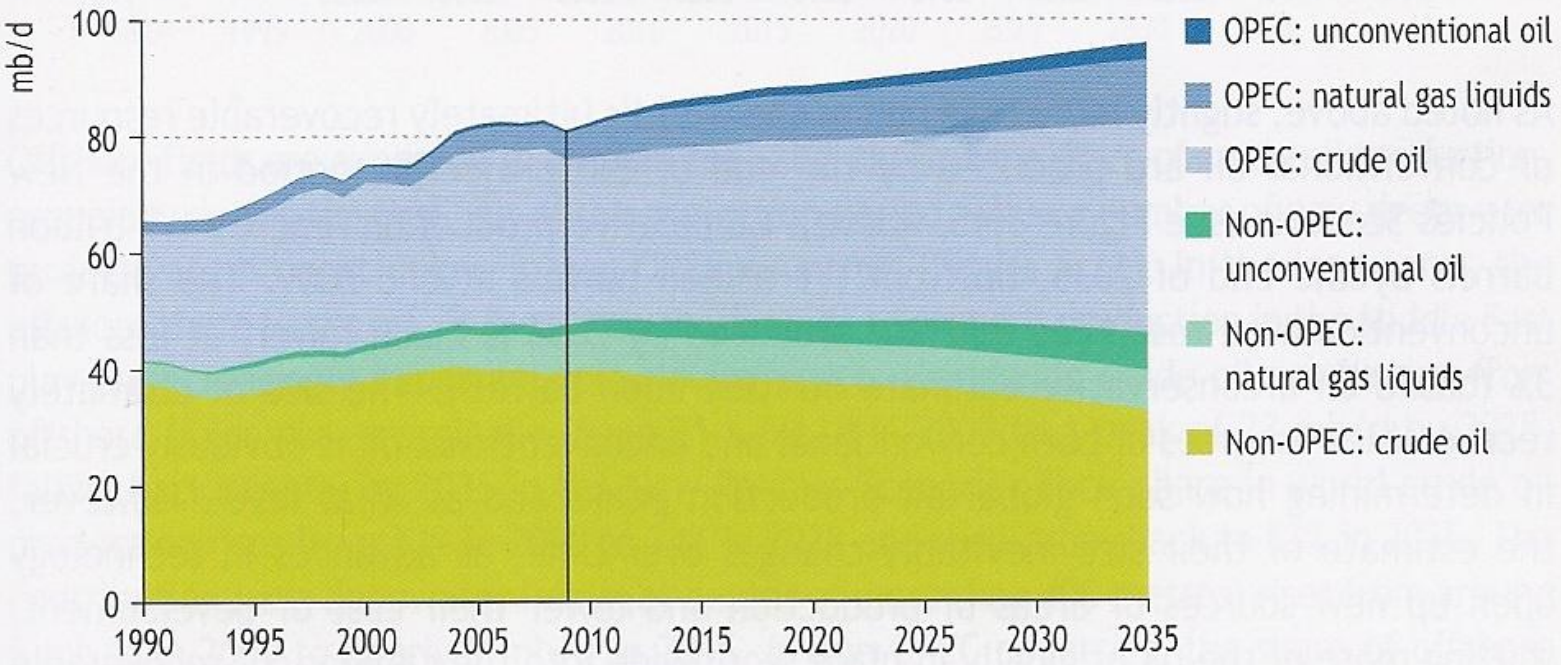
# The cartel's market power was strengthened by growing world demand, its increasing market share and…the peaking of US crude oil production in 1970.




Source: Energy Information Administration, Annual Energy Review 2009, table 5.1.

# The International Energy Agency foresees a plateau in non-OPEC conventional and unconventional oil production from now to 2030. So do BP and ExxonMobil.

**Figure 3.18 • World oil production by source in the New Policies Scenario**

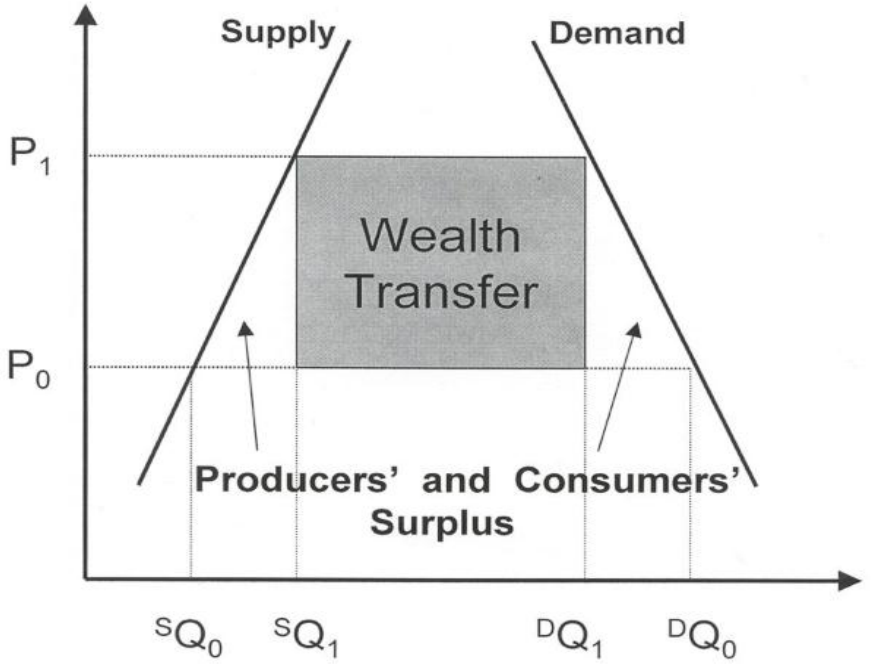



Source: International Energy Agency, *World Energy Outlook 2010*, OECD, Paris.

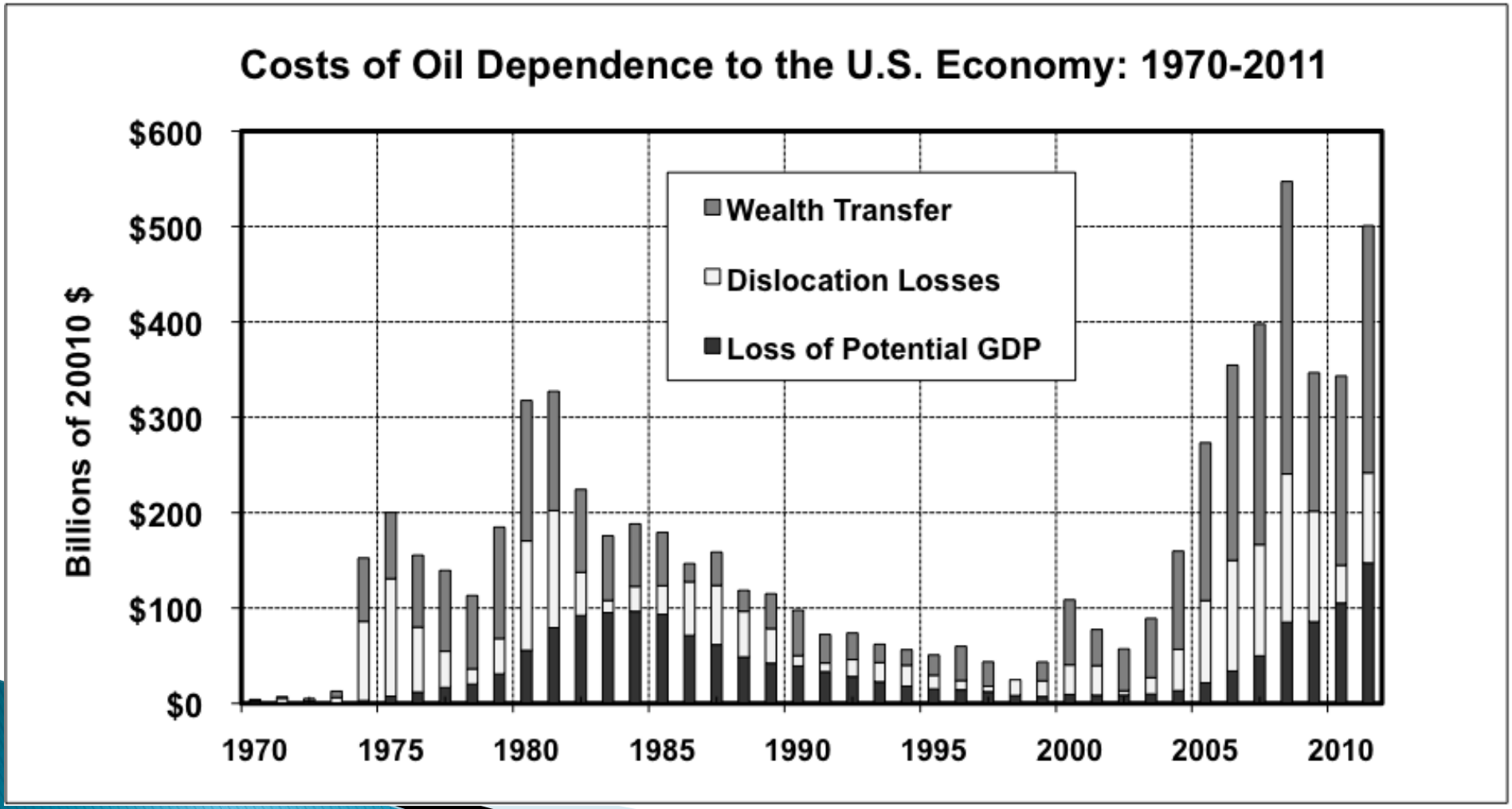
# What does oil dependence cost?

1. **Loss of potential GDP** = producers' & consumers' surplus losses in oil markets (dynamic).
2. **Dislocation losses** of GDP due to oil price shocks.
3. **Transfer of wealth** due to monopoly pricing and price shocks (requires counterfactual competitive price).

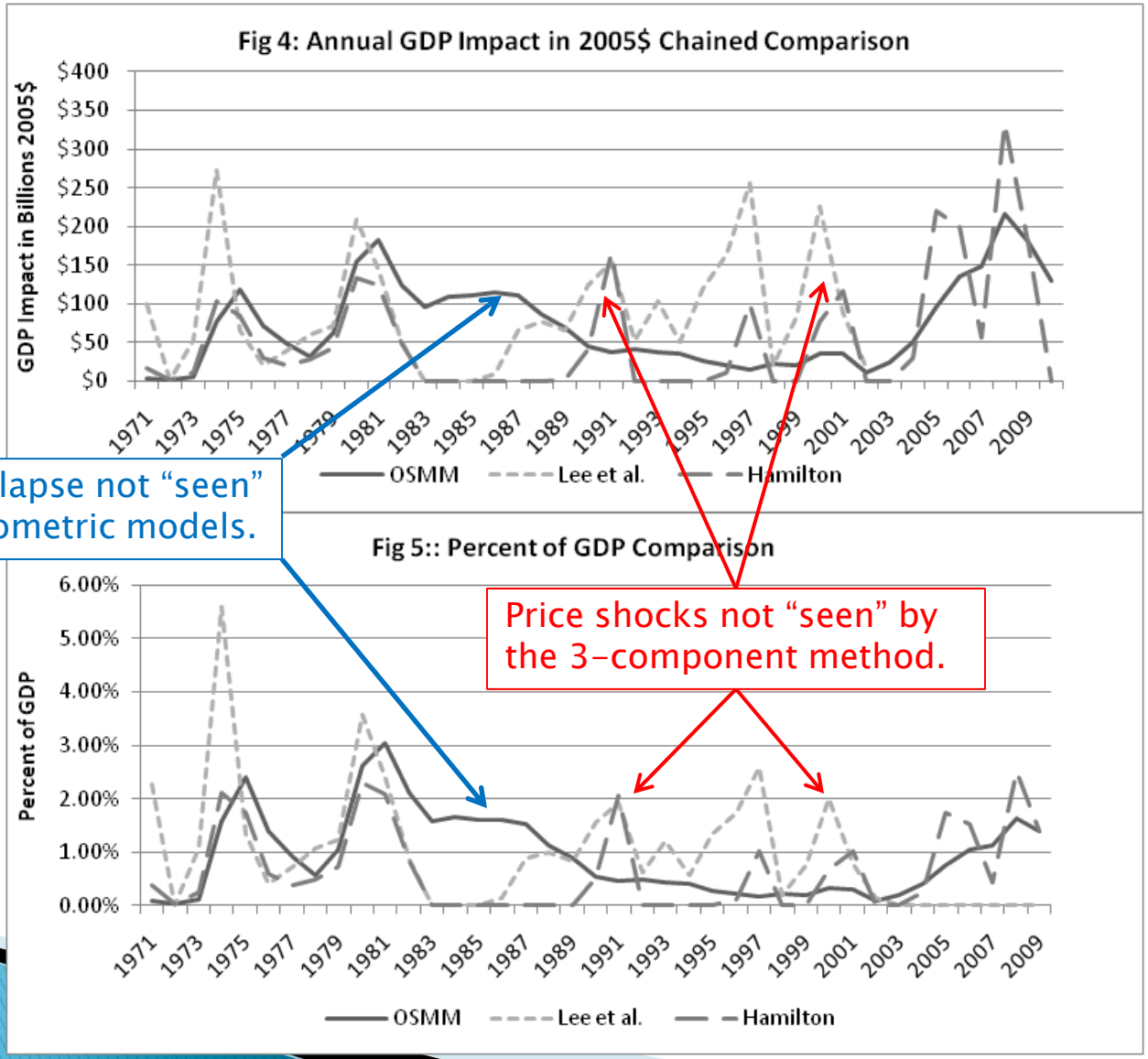
**Transfer of wealth** is not a loss of GDP but a **change in the ownership of GDP.** It can occur in disrupted and undisrupted markets and occurs whether or not OPEC is the cause of the disruption.



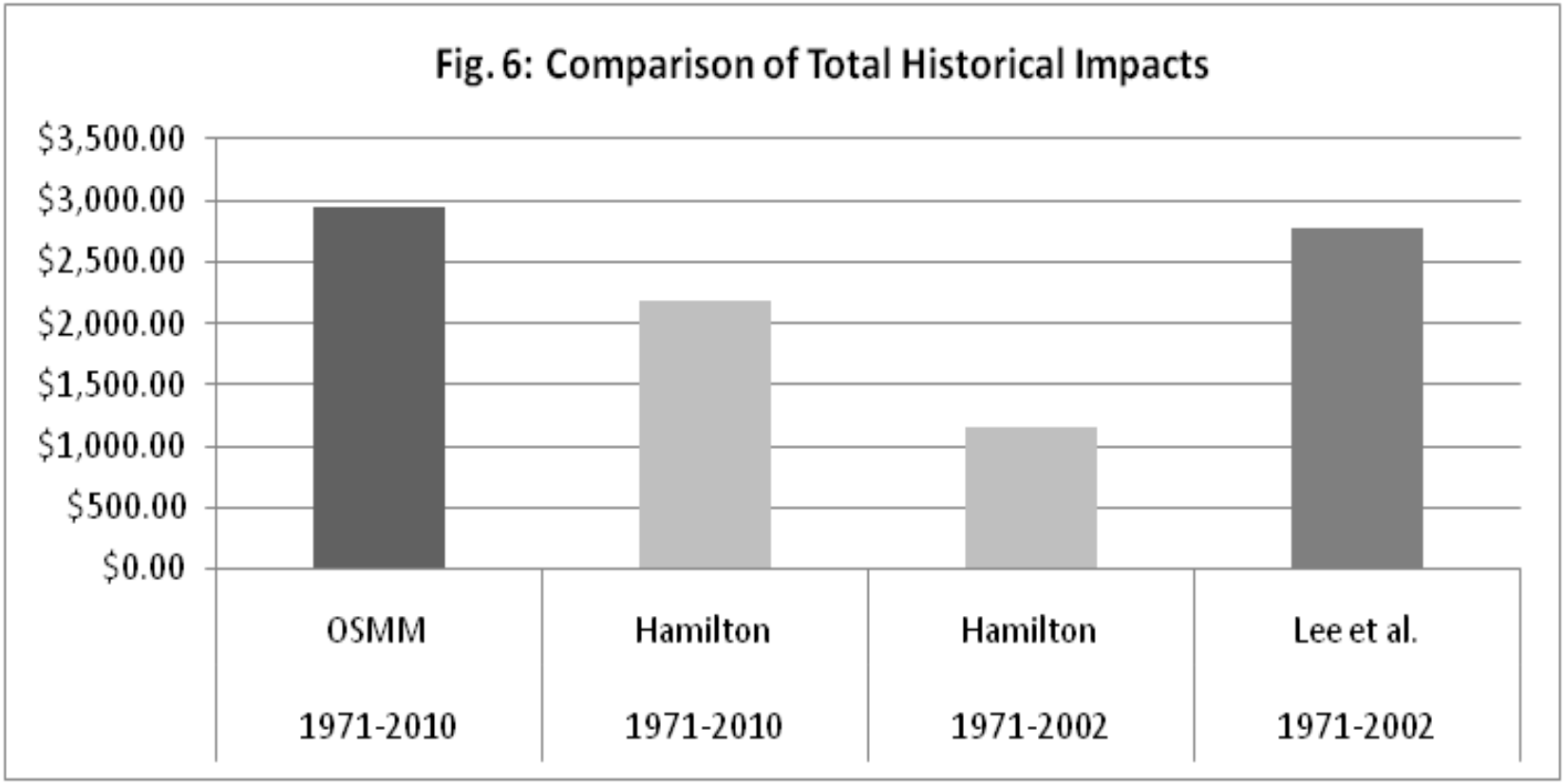
**Oil dependence cost the US economy about $500 billion in 2008 and 2011, and $2 trillion over the five years from 2007 to 2011.**



# The “3 component” method compares reasonably well with some well-known econometric models.



# The three models estimate disruption impacts of $2–$3 trillion from 1971–2002. And then there is the transfer of wealth.



# It is crucial to get the market failure right.

- Socrates is a mammal.
- Cats are mammals.
- Therefore, Socrates is a cat.

- Oil dependence is a market failure.
- Externalities are market failures.
- Therefore, oil dependence is an externality.

- NRC Hidden Costs Study: Because oil dependence is not an externality it's cost = $0.

# Oil dependence is not an externality, and Socrates is not a cat.

- The market failure is monopoly power.
- The costs are due to;
  - Higher than competitive market prices
  - The quantity we consume
  - The quantity we import
  - The lack of economical substitutes
- It is useful to measure the ***marginal social cost of oil use***. (e.g., Leiby, 2011)
- It is fallacious to insist that the marginal social cost of oil use is an externality.
  - A tax on oil is not the efficient solution.

# It is useful to estimate the marginal social cost of consuming petroleum.

Oil Security Premiums, Midpoint and (Range) by Year (2009 $/barrel)

| Year | Monopsony | Disruption Costs | Total |
|---|---|---|---|
| 2020 | $11.12<br>($3.78 - $21.21) | $7.10<br>($3.40 - $10.96) | $18.22<br>($9.53 - $29.06) |
| 2025 | $11.26<br>($3.78 - $21.48) | $7.77<br>($3.84 - $12.32) | $19.03<br>($9.93 - $29.75) |
| 2030 | $10.91<br>($3.74 - $20.47) | $8.32<br>($4.09 - $13.34) | $19.23<br>($10.51 - $29.02) |
| 2035 | $10.11<br>($3.51 - $18.85) | $8.60<br>($4.41 - $13.62) | $18.71<br>($10.30 - $28.20 |

EPA/NHTSA, 2011, table 4-11, taken from Leiby (2011) table 3.

# Can one ignore the military costs?

- "First, **it is difficult** to disentangle military spending for such political goals as reducing terrorism of providing support for Israel from spending to protect oil supply routes. And it is unlikely that whatever spending is specific to securing the supply routes would change appreciably for a moderate reduction in oil flowing from that region to the United States. In other words, the marginal cost is essentially zero." "We adopt this position in this report." (NRC, 2009, *Hidden Cost of Energy,* p. 238)

- There are, in fact, several serious attempts to estimate it.
  - GAO, 1991: $0.5 billion/year
  - Parry and Darmstadter, 2003: $5 billion/year
  - Coupolos, 2003: $50 billion/year
  - Delucchi & Murphy, 2008: $6-$25 billion/year
  - Stern, 2010: $500 billion in 2007

- Difficult? Yes.
- Zero? No. At least $5/barrel and probably much more.

# What is oil dependence?

It is primarily an **economic problem** with major national security implications caused by,

- use of **market power** by oil producing states,
- importance of oil to the economy and,
- lack of economical substitutes for oil.
- Oil dependence is NOT an externality.

# What is oil independence?

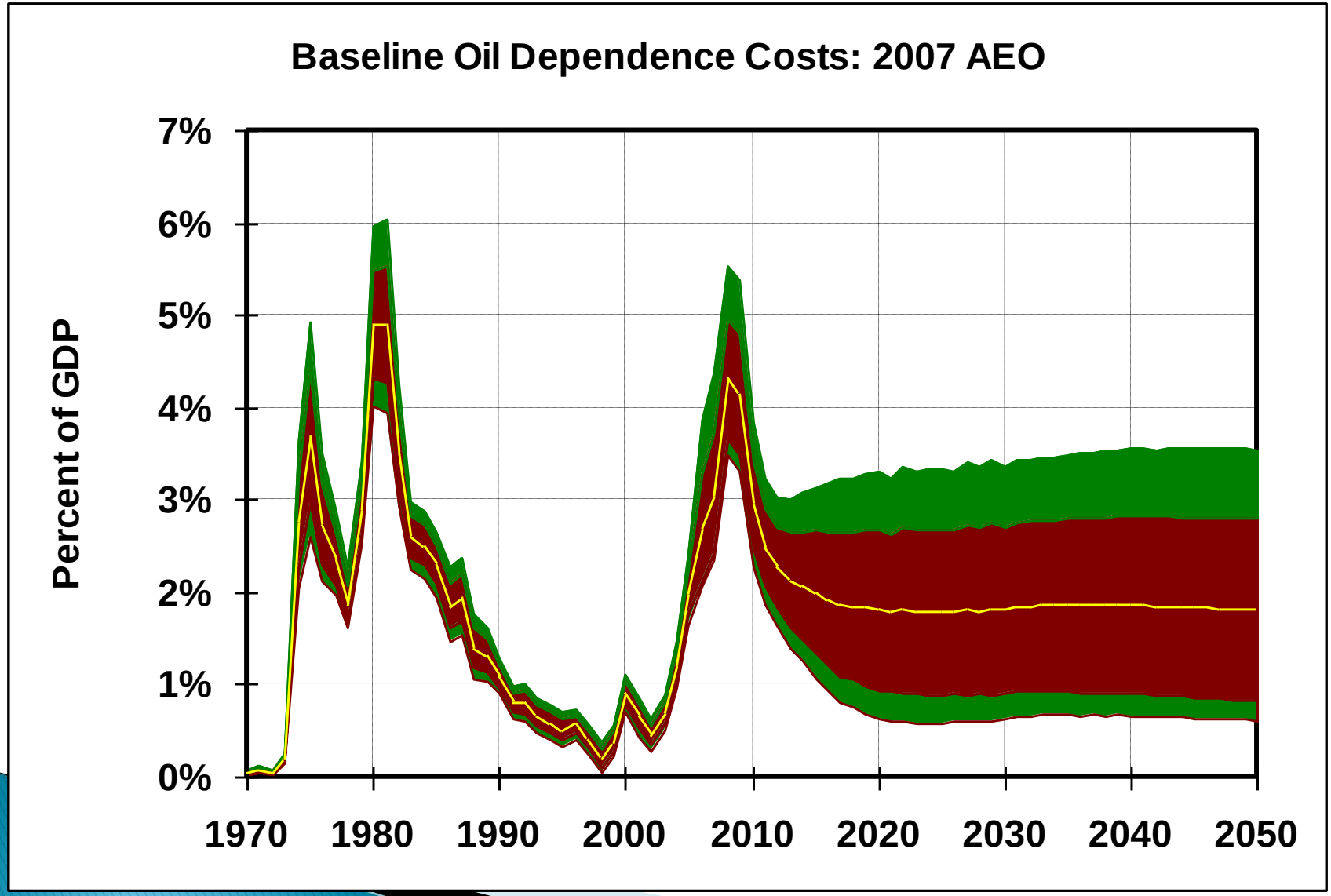
- QUALITATIVE:
  - For all conceivable world oil market conditions, the costs of oil dependence to the economy will be so small that they have no effect on economic, military or foreign policy.
- QUANTITATIVE:
  - The estimated total economic costs of oil dependence in any year will be less than 1% of GDP with 95% probability by 2030.

# The ORNL Oil Security Metrics Model estimates future U.S. oil dependence costs, incorporating key uncertainties.

- Uncertainty about future oil resource availability and OPEC's willingness to expand output represented by the Energy Information Administration Annual Energy Outlook High, Reference & Low Oil Price Projections.
- Simulates potential supply disruptions, with a stochastic model calibrated to historical deviations of OPEC supply from AEO projections.
- Policies & technologies change both the level of oil demand & its response to oil prices.
- 10,000 simulations are run to characterize alternative oil futures and allow for uncertainties in key parameters.

Greene, D.L. and P.N. Leiby, 2006. *The Oil Security Metrics Model*, ORNL/TM-2006/505, Oak Ridge National Laboratory, Oak Ridge, Tennessee, May.

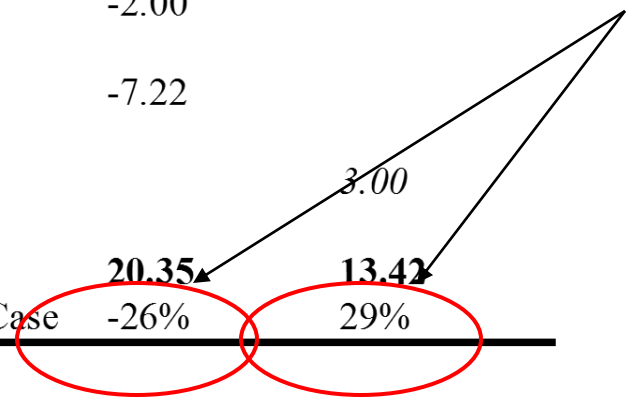
# In the baseline, expected costs are about 2% of GDP, over $400 billion per year in 2030.



# With a few additions the National Commission on Energy Policy plan represents an adequate oil independence policy.

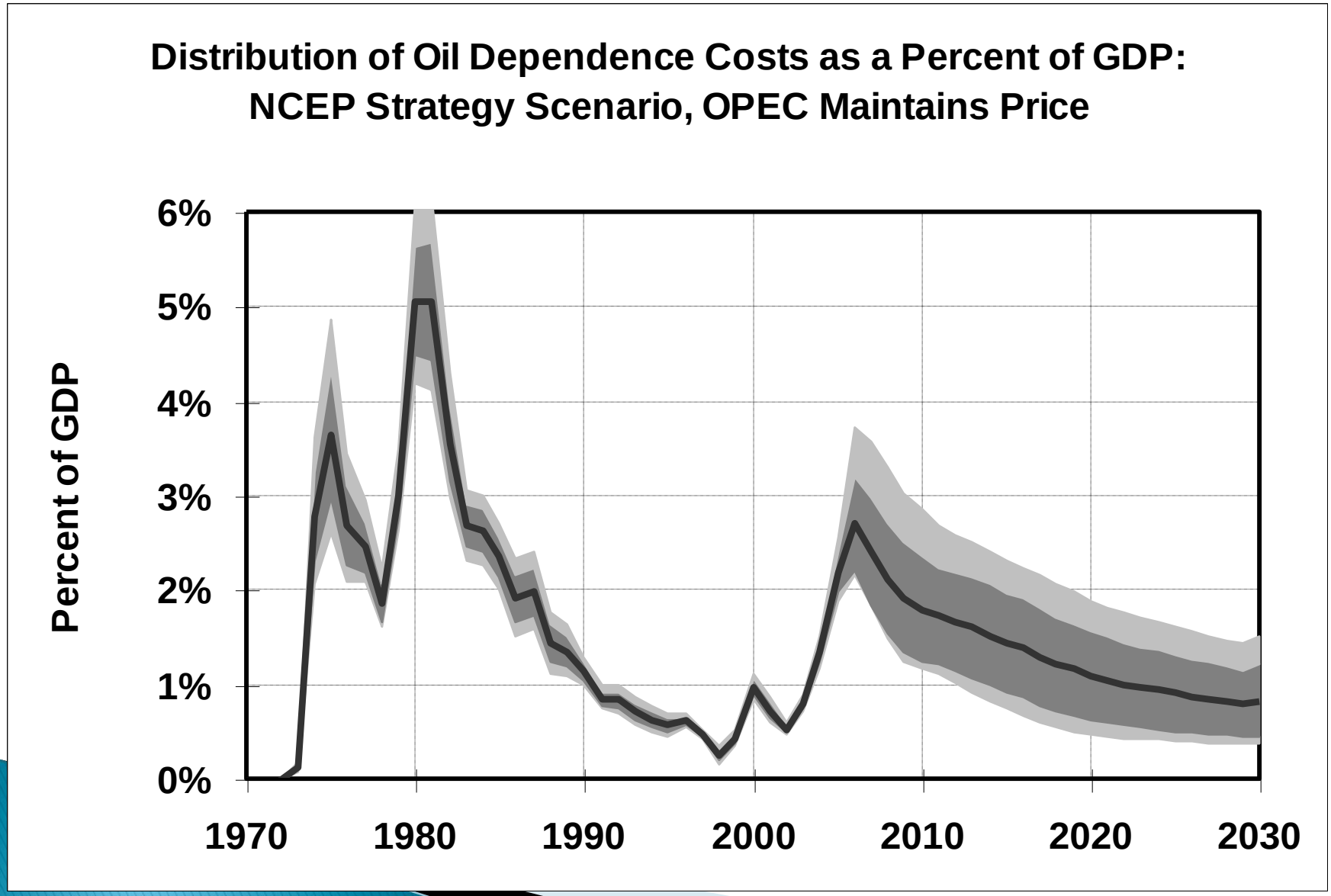
**TABLE 1 Estimated Changes in U.S. Oil Supply and Demand in 2030 for the Modified NCEP Oil Independence Strategy (Millions of Barrels per Day)**

| | Oil Demand | Oil supply |
|---|---|---|
| Reference Case | 27.57 | 10.42 |
| NCEP Case Changes | | |
| Light vehicle fuel economy | -3.50 | |
| Heavy vehicle fuel economy | -0.53 | |
| Rail and ship energy efficiency | -0.20 | |
| Eliminate building heating with oil | -0.37 | |
| Industrial efficiency, substitution | -0.62 | |
| Coal to liquids | | 1.00 |
| ANWR and Pacific Offshore | | 2.00 |
| Biofuel | -2.00 | |
| Subtotal: Decrease in Demand | -7.22 | |
| *Subtotal: Increase in Supply* | | *3.00* |
| **NCEP Case Totals** | **20.35** | **13.42** |
| Percent Change from Reference Case | -26% | 29% |

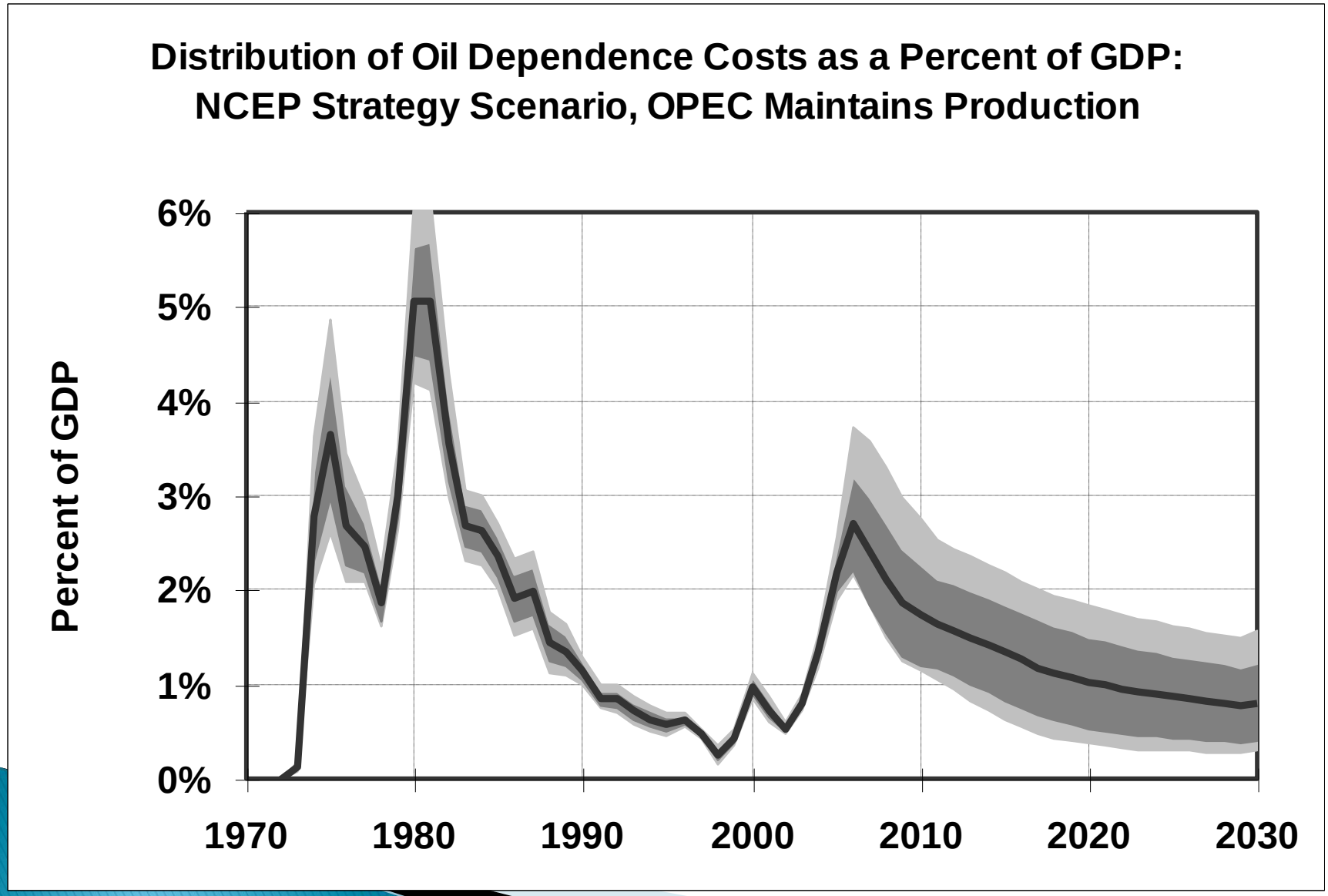


Does not eliminate oil demand or oil imports.

# NCEP strategy falls just short of the independence goal.
## More is needed, progress must be sustained beyond 2030.

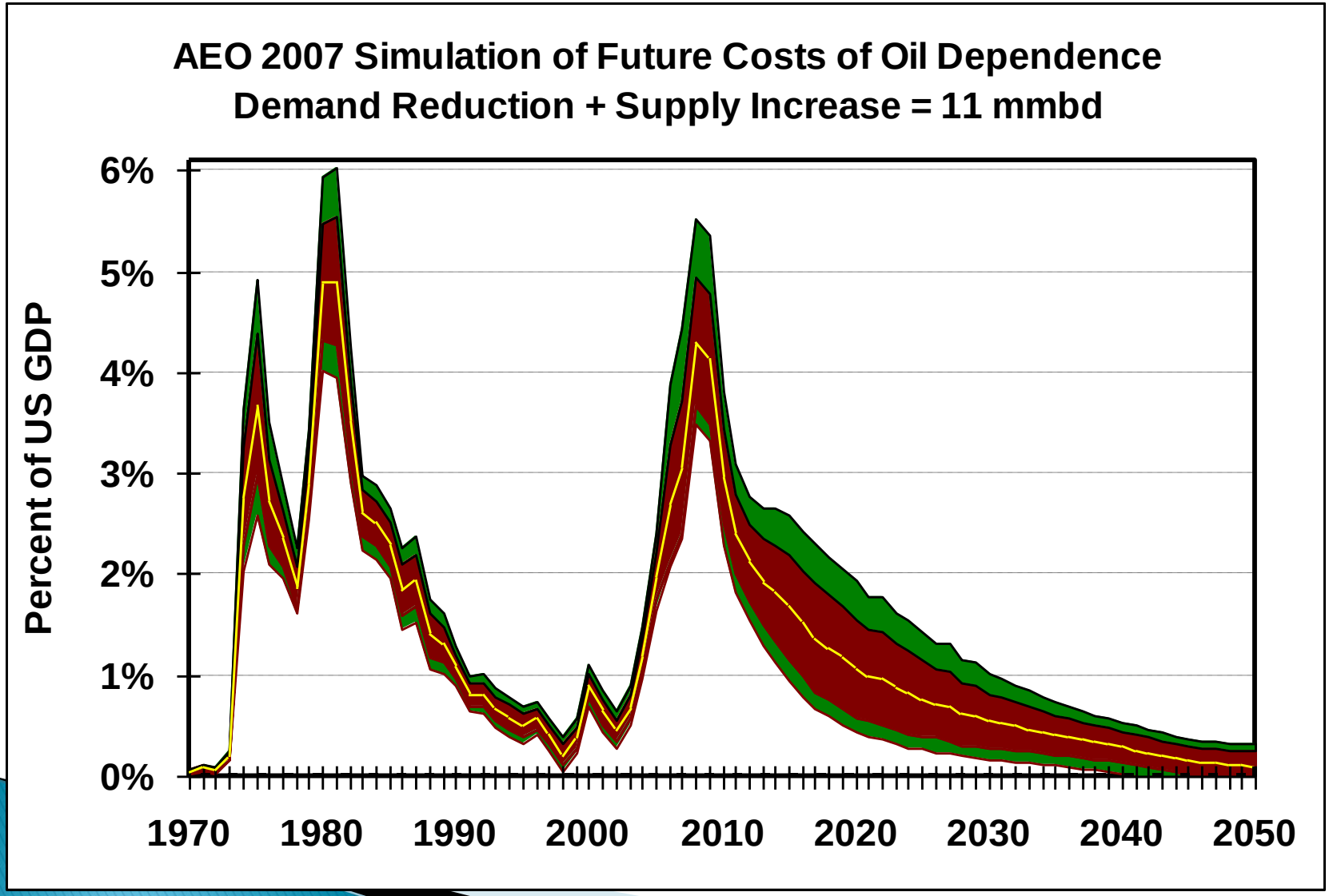


# The oil independence strategy works regardless of OPEC's response strategy. Worth repeating.



# “Oil independence” required an 11 mmbd change in the U.S. petroleum balance (Δsupply + Δdemand) by 2030.

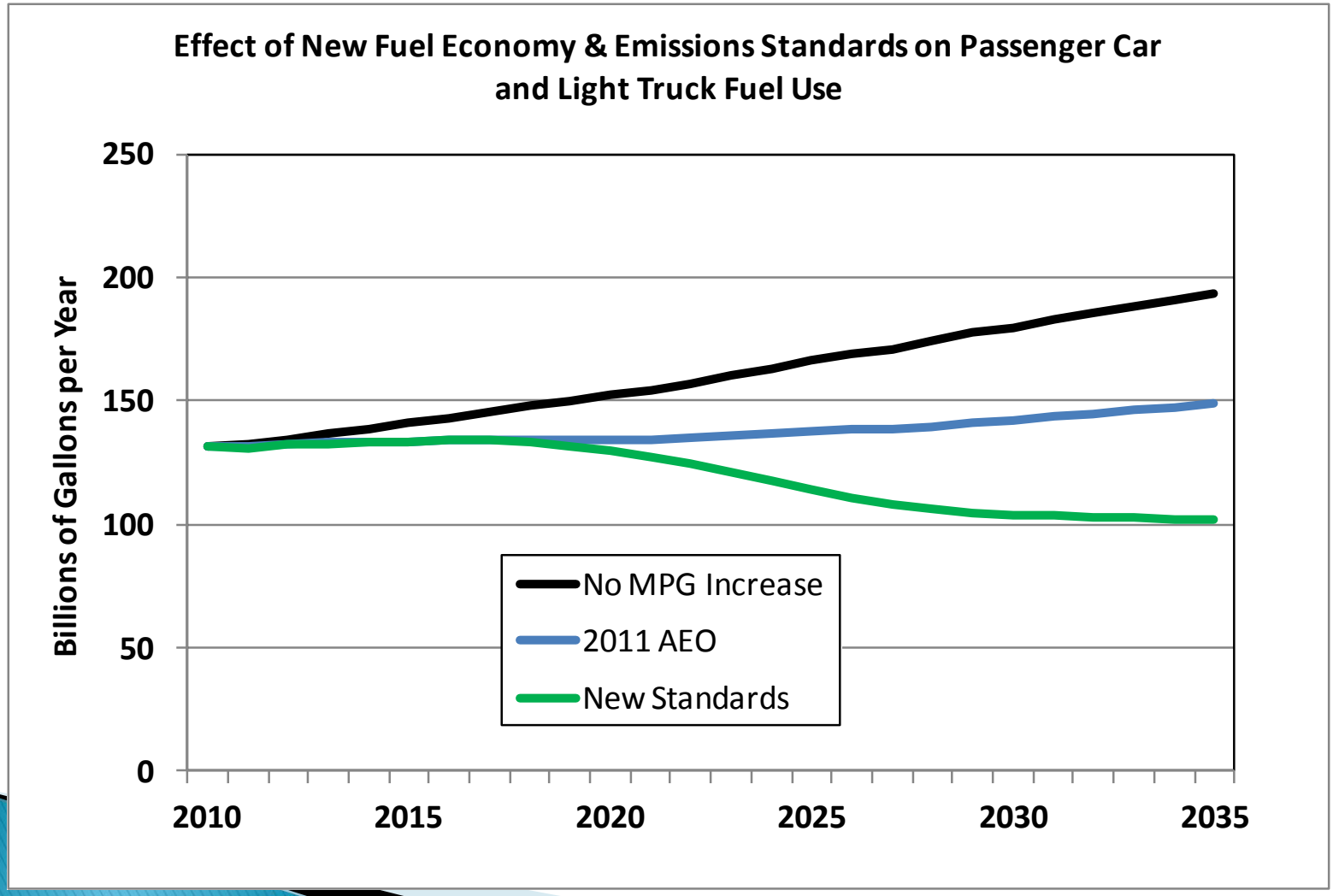
Reference 27 mmbd of consumption and 10 mmbd of production in 2030.



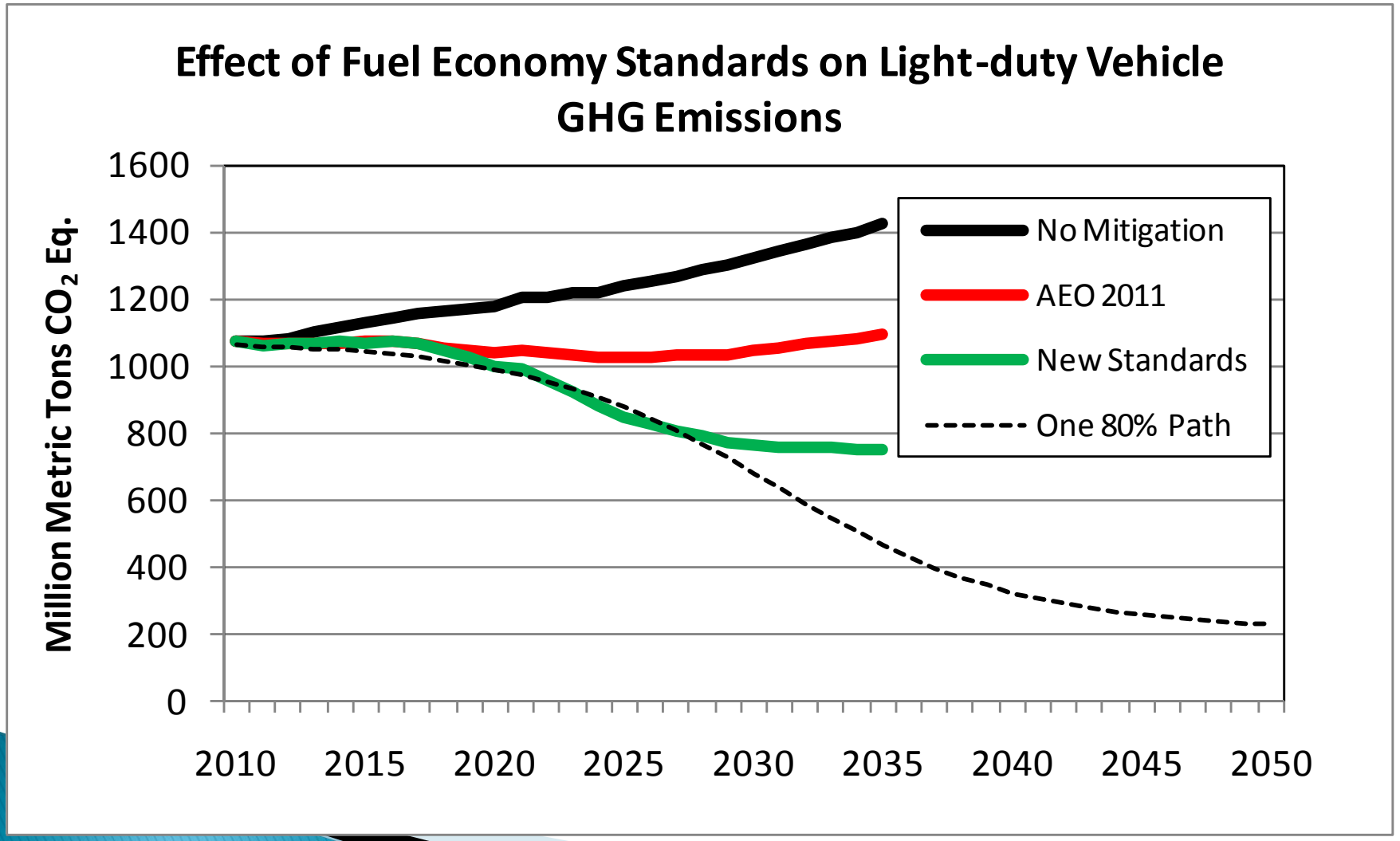
# We're doing  a lot of the right things.

- **Light-duty vehicle fuel economy standards.**
  - 35 mpg by 2016: 54.5 mpg for 2025.
- **Heavy-duty vehicle standards.**
  - 9% to 23% increase depending on truck type.
- **RFS 2 & LCFS**
  - EIA projects 2.0 mmbd by 2030
- **"Fracking"** of shale oil and shale gas
  - 2 mmbd domestic petroleum production by 2030.
- **We need to do more, though.**

# The 2025 fuel economy/GHG standards will reduce petroleum use in 2030 by another 38 billion gallons per year or 2.5 mmbd.



# The proposed 2025 standards plus other existing policies put LDVs on a plausible path to an 80% reduction in GHG emissions until 2025-2030.



# In a forthcoming report for the ICCT, we estimate the costs and benefits of transition to electric drive vehicles in California, the 177 states and the U.S.

- In general, the net present value of benefits is an order of magnitude greater than the excess transition costs.
  - Consumers' surplus benefits
  - Additional energy savings
  - GHG mitigation benefits
  - Oil independence benefits
  - Air quality benefits
- Scenarios that achieve an 80% reduction in GHG emissions always achieve a greater reduction in petroleum use.
- Conditional on expected technological progress and strong, adaptive public policies.

# Reducing the costs of oil dependence is a major co-benefit of sustainable transportation.

- Reduced transportation GHG emissions will be the cornerstone of energy independence via energy efficiency and low-C, non-petroleum fuels.
- How much is it worth?
  - 2.0% – 0.5% = 1.5% of a $20 trillion GDP
  - In 2030 = approximately **$300 billion per year.**
- **Next steps?**
  - 2025 standards and beyond for LDVs and HDVs
  - Overcome barriers to transition to hydrogen and electricity
  - Develop and supply truly low-C biofuels
  - Set a floor on the price of oil (benchmark the counterfactual)

# Thank you.

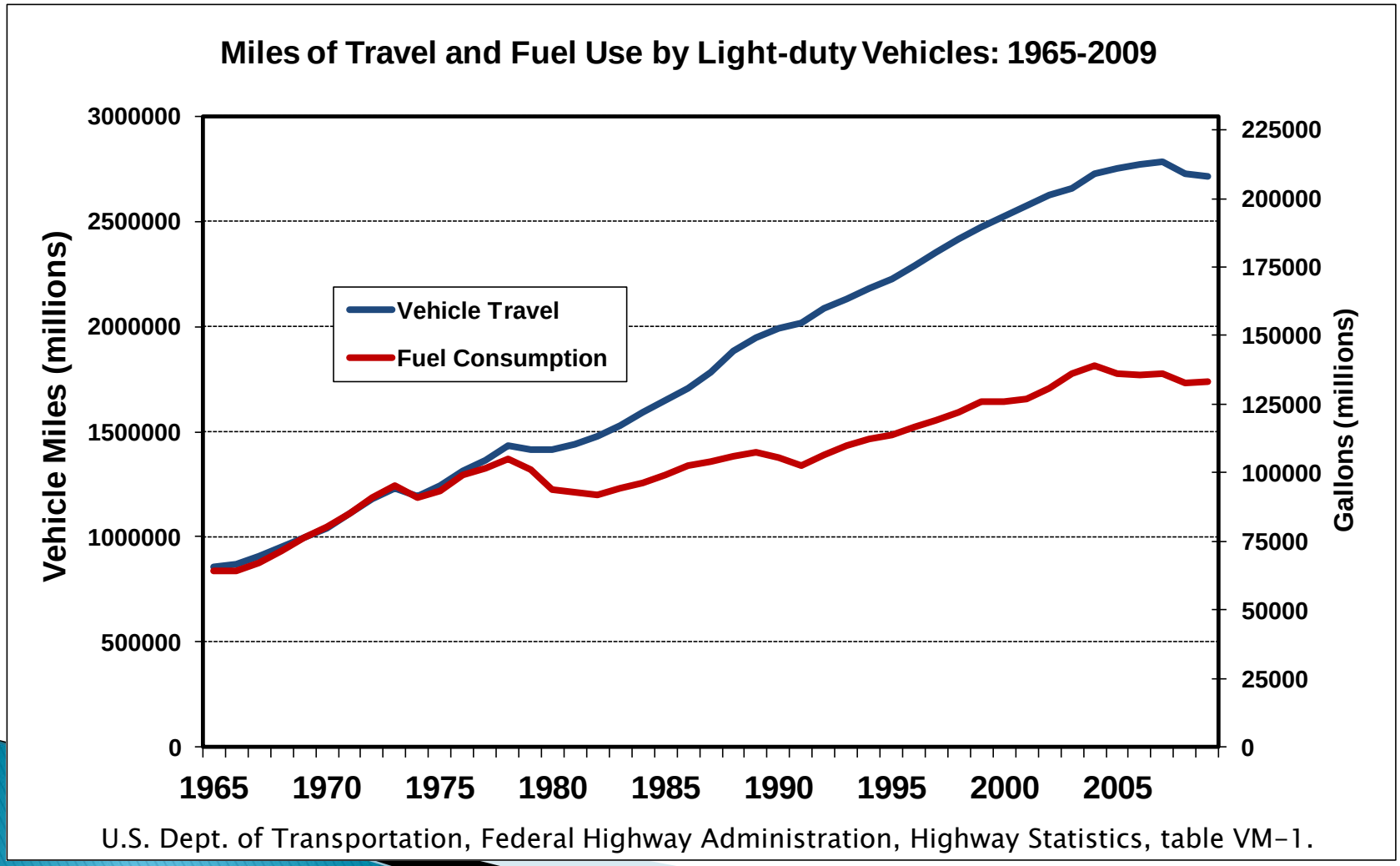
http://www.thedailyshow.com/watch/wed-june-16-2010/an-energy-independent-future


"Measuring Energy Security: Can the United States Achieve Oil Independence?" *Energy Policy*, 2009, Vol. 38, No. 4, pp. 1614-1621.

"The Outlook for U.S. Oil Dependence," *Energy Policy*, vol. 26, no. 1, pp. 55-69, 1998.

"OPEC and the Costs to the U.S. Economy of Oil Dependence", presented at the conference, *OPEC at 50*, National Energy Policy Institute, University of Tulsa, Tulsa, Oklahoma.

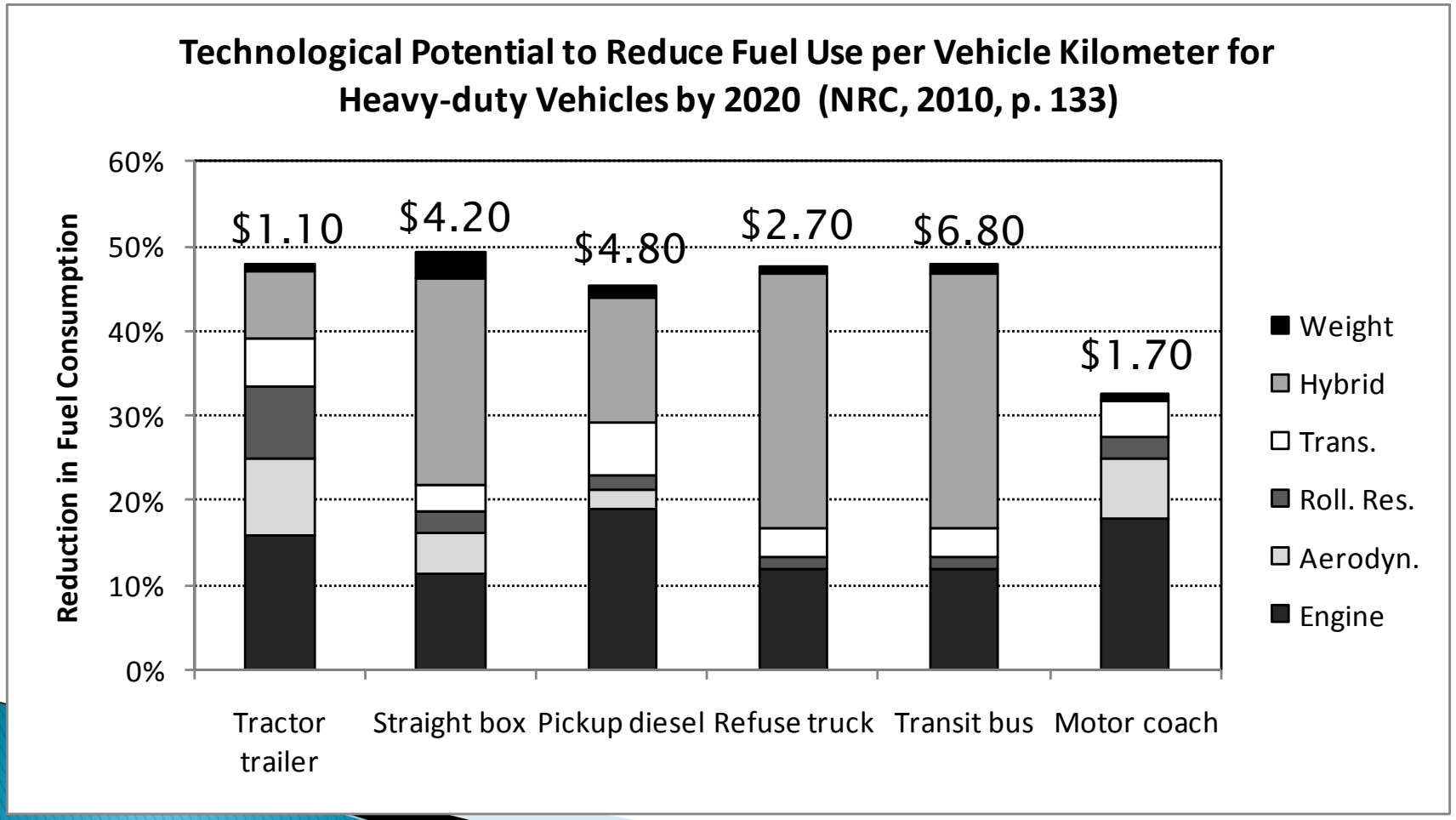
In the near term improving energy efficiency is the most promising strategy.
(approximately 70 billion gallons saved each year)
The public *supports* fuel economy standards by about 3:1.




U.S. Dept. of Transportation, Federal Highway Administration, Highway Statistics, table VM-1.

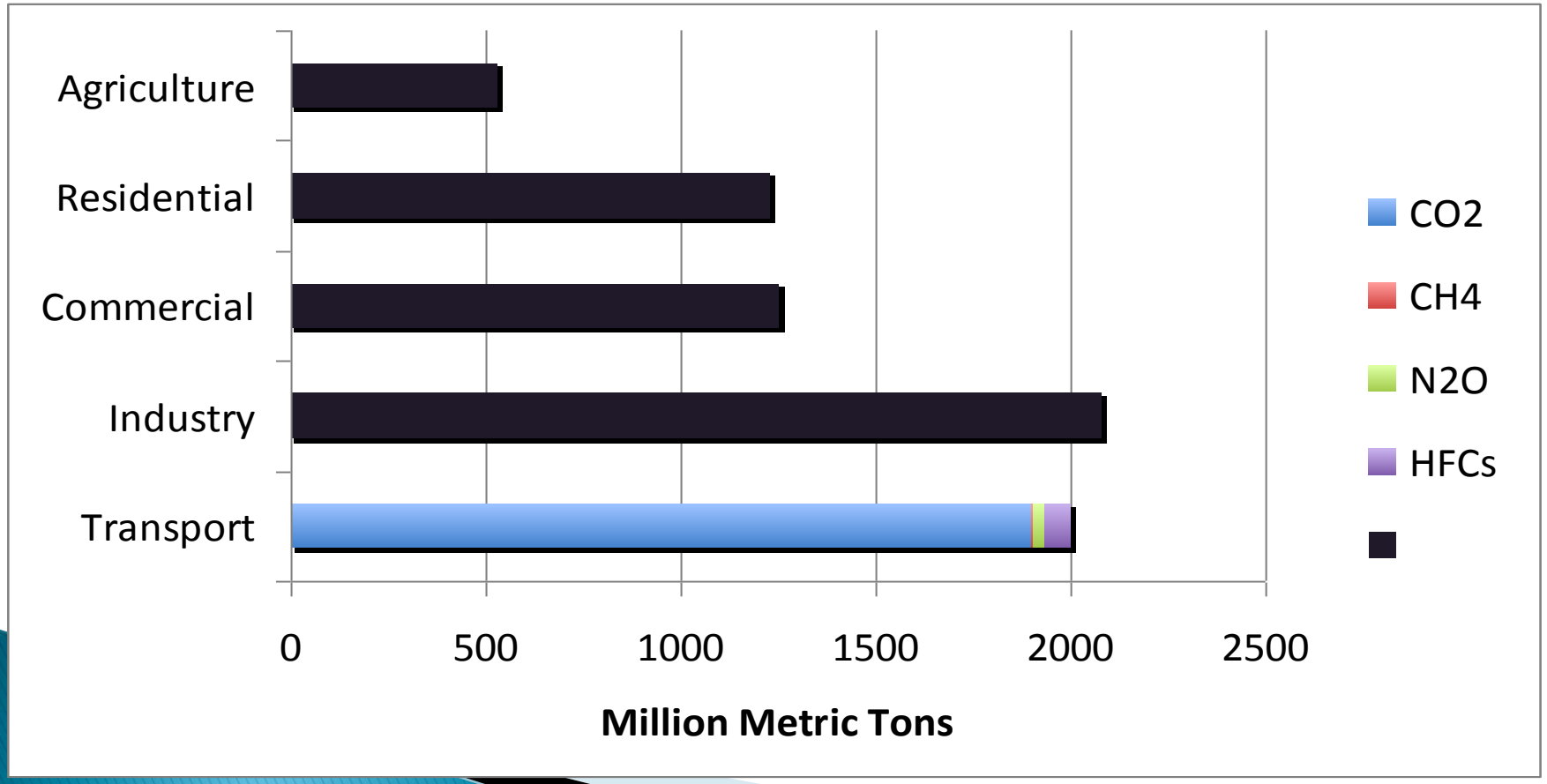
The US emissions standards for heavy-duty vehicles require modest gains compared to the NRC's estimates of the cost-effective potential.

(US 2014-2018: 9-23% reduction in fuel consumption, based on ton-miles)

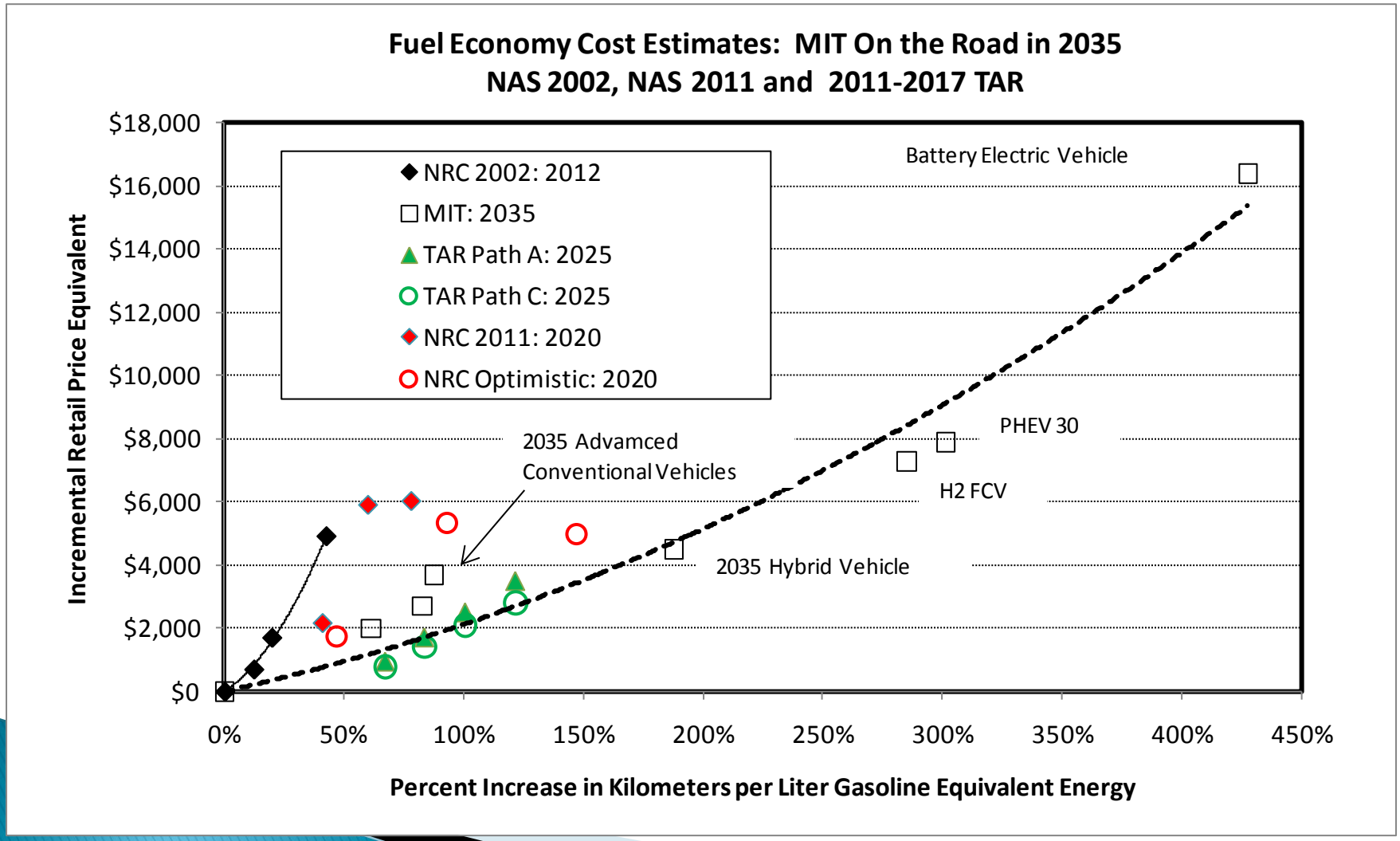


# Transportation's GHG emissions are overwhelmingly $CO_2$ from petroleum combustion.

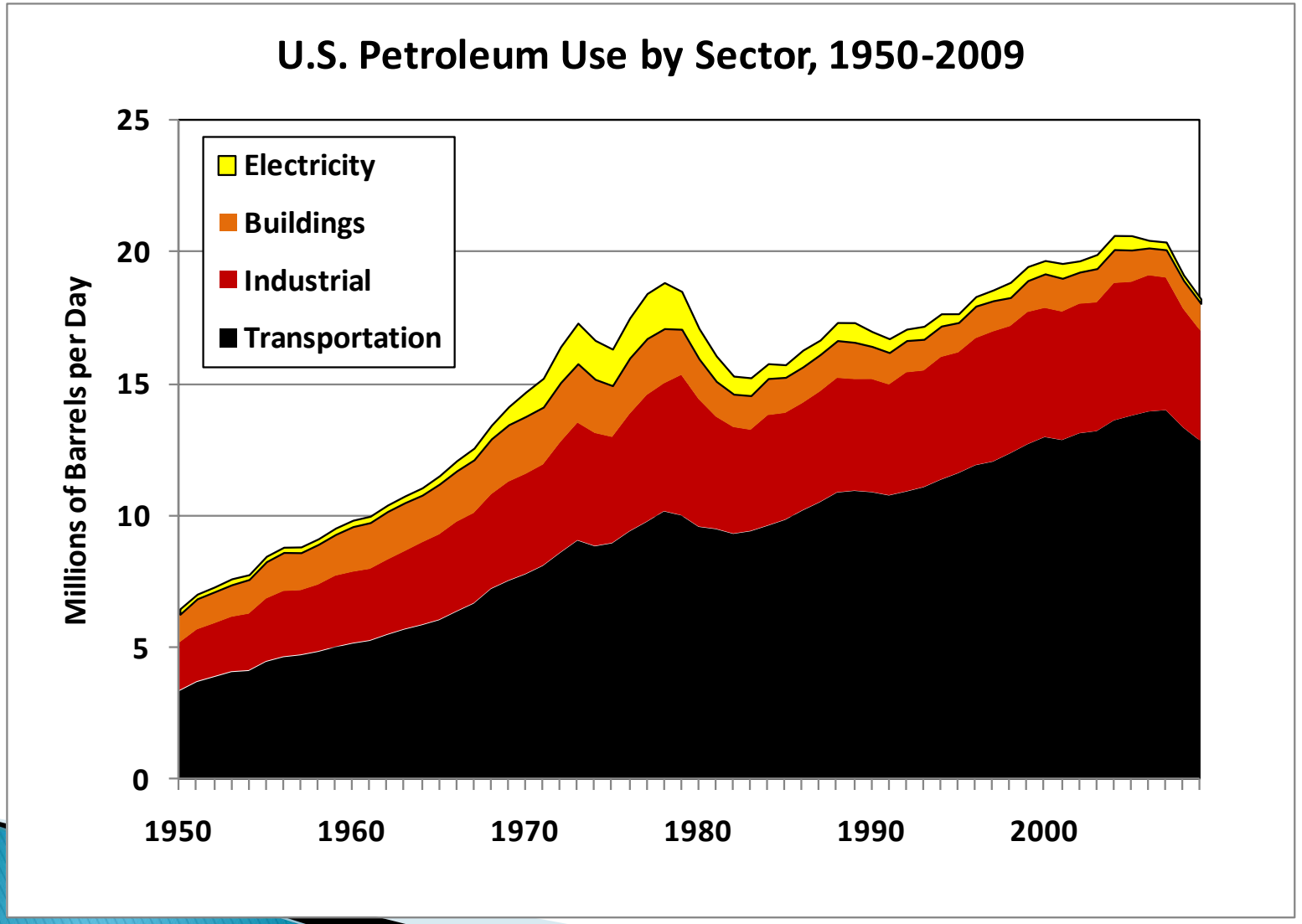
U.S. transportation emits more $CO_2$ than any country's entire economy except China.



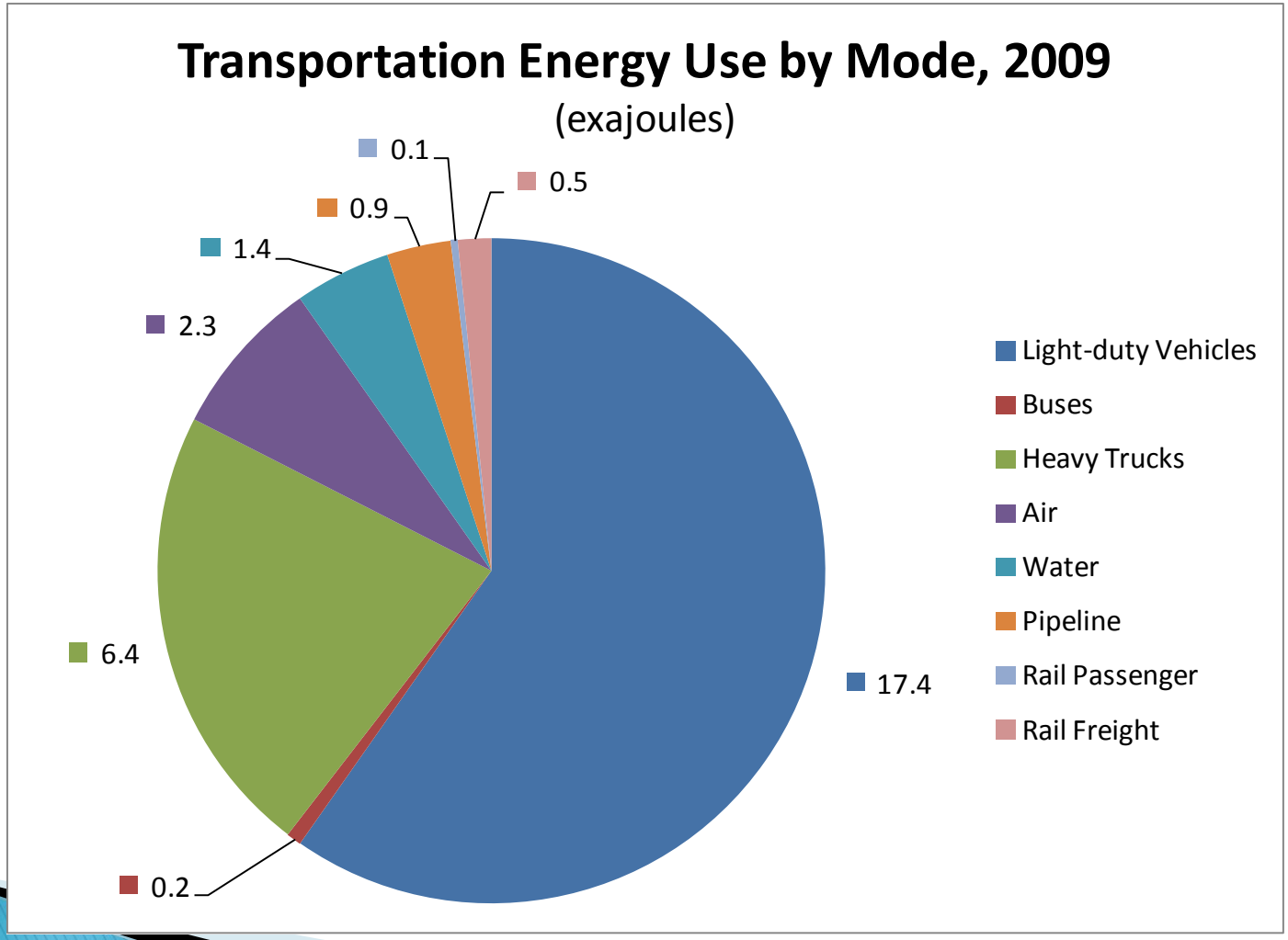
# Proposed fuel economy standards require more than a doubling of miles per gallon by 2025.
# **Can it be done cost-effectively?**



# The U.S. transportation sector alone consumes more petroleum than any other nation's entire economy: about 6,300 gallons per second.



# Highway vehicles dominate U.S. transport energy use: Light-duty vehicles account for 60%, heavy-duty trucks 22%. All bus energy use plus all passenger rail equals 0.3%.




Davis, S.C., S.W. Dieg[illegible] C. Boundy, 2011, Transportation Energy Data Book Ed. 30, Tables 2.6 7 2.13.

# WHAT CAN WE DO?

## The non-partisan National Commission on Energy Policy's comprehensive plan to address oil dependence and reduce GHG emissions addresses both supply and demand.

### Demand

- From 35 MPG in 2017 increase light-duty vehicle MPG to 43 MPG by 2030 (+75%).
- Displace 2 mmbd of gasoline with biofuel by 2020.
- Reduce heavy truck energy use by 0.5 mmbd by increasing fuel economy by 15%.
- Reduce rail and water transport oil use by 0.2 mmbd.
- Eliminate the use of #2 distillate fuel to heat residential and commercial buildings.
- Cut industrial petroleum use by 0.6 mmbd.

### Supply

- **Expand oil drilling to the ANWR and deep offshore areas by 2 mmbd.**
- **Produce 1 mmbd petroleum fuels from coal with carbon sequestration.**

# What is the appropriate counterfactual for estimating oil dependence costs?

- Retrospectively: a hypothetical competitive world oil market.
  - How would the world oil market have evolved as a competitive market?
  - Estimating costs using historical supply, demand and GDP data must diverge from the counterfactual and thus costs estimated by this method cannot be integrated over a long time interval.
- Prospectively: alternative scenarios, incorporating uncertainties.
  - Impacts of fuel economy & GHG emission policies
  - Various world oil market conditions
  - Various OPEC strategies
  - Supply/disruptions