Is the Barrel Half Full or Half Empty?

Implications of Transitioning to a New Transportation Energy Future

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Opposing Views

- ***Awash in Oil***

  "There's plenty of cheap oil, says the U.S. geological survey."

  Eric Niiler

  Scientific American, September, 2000

- ***The End of Cheap Oil***

  "Global production of conventional oil will begin to decline sooner than most people think, probably within 10 years"

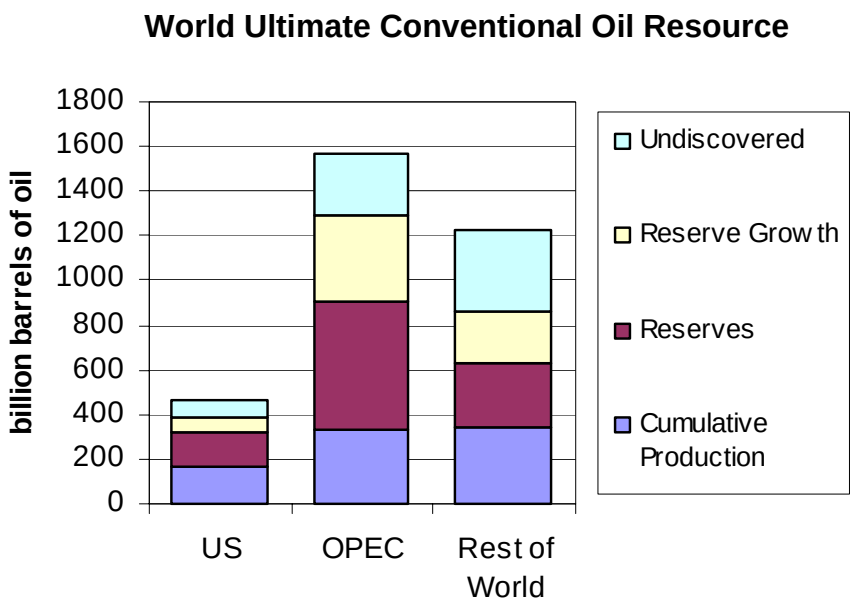
  Colin J. Campbell and Jean H. Laherrère

  Scientific American, March 1998

Overview: Transition from Conventional Oil Is Likely within the Next 20 Years

- **Forecasts of world petroleum supplies are reviewed**
- **Projections of transportation energy demand are made**
- **Alternative "strategies" are examined:**
  - Oil use
  - Energy use
  - Carbon emissions
- **Some important issues have not been explored:**
  - Costs
  - Air quality

World Oil Supplies Are Finite and We Have Used a Sizeable Fraction

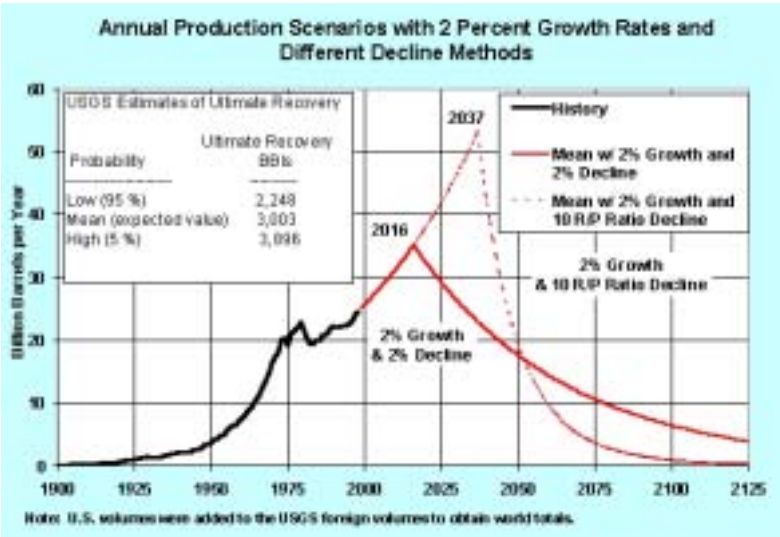


Note: Calculations based on USGS 2000 World Assessment.

- **Latest USGS assessment places world's ultimate oil resources at 3 trillion barrels**
- **World has already used 850 billion barrels of oil**
  - ½ the known resources
  - ¼ of the ultimate resources
- **Estimates of new fields (ANWR)**
  - 6 to 16 billion barrels over 20 years
  - Equivalent to mpg improvement of ~ 2 to 6 mpg in light-duty vehicles

Transition Is Likely After Half of the World's Oil Has Been Consumed

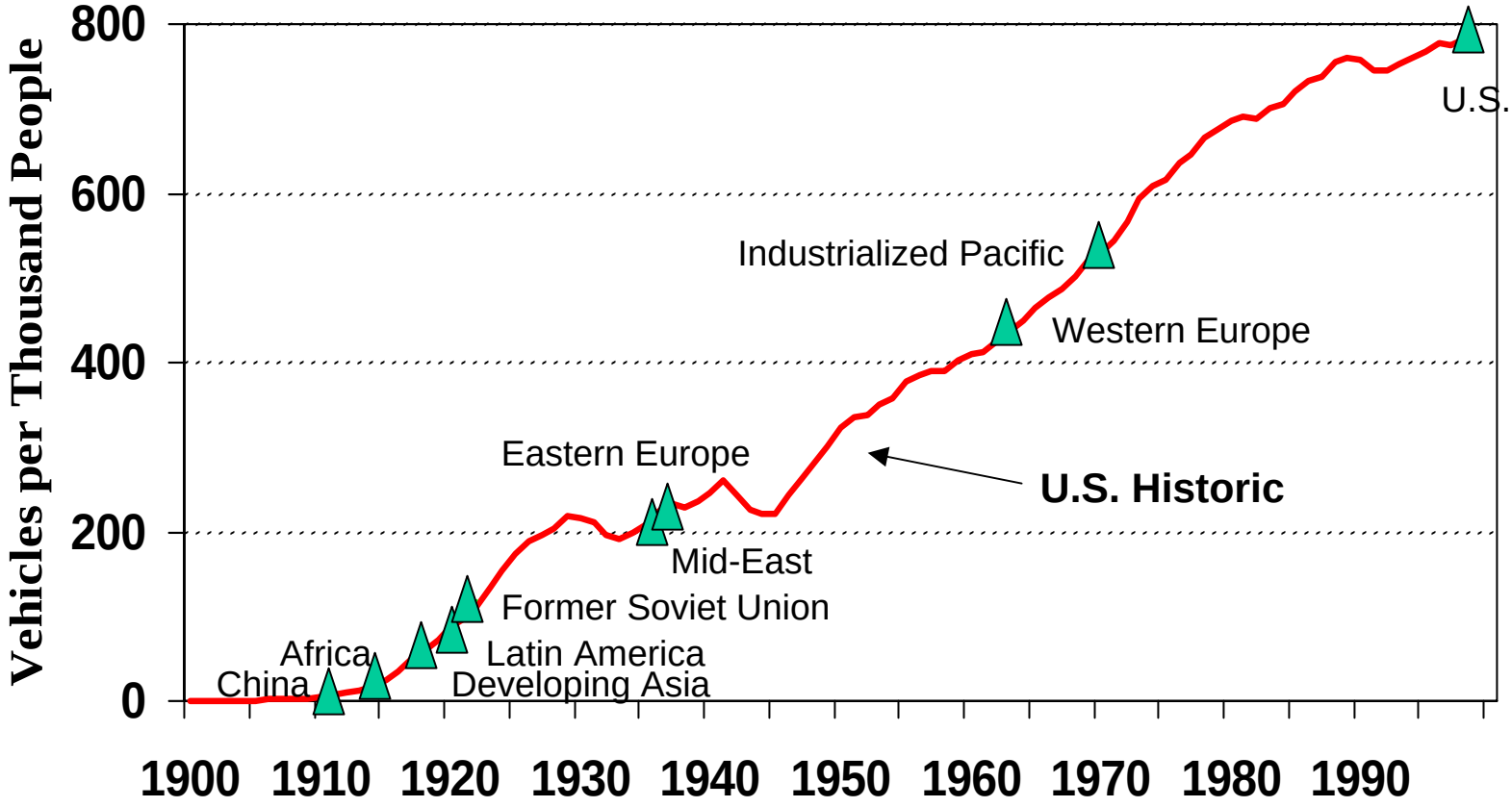
Illustrative World Conventional Oil Production Paths



Note: Production paths ignore price feedbacks and are illustrative only.
Source: EIA, Long Term World Oil Supply, July 28, 2000.

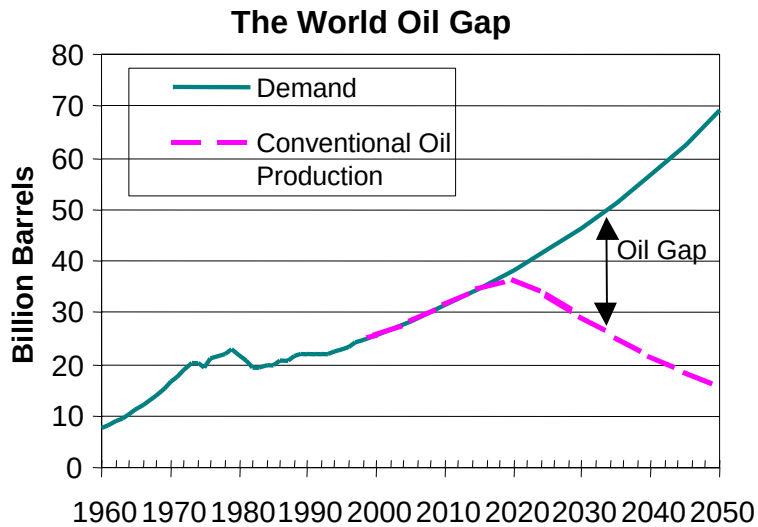
- **Soon after oil fields reach the halfway point of depletion, oil production will inevitably begin a permanent decline – e.g. U.S. in 1970s**
- **Oil demand will principally be determined by transportation**
- **From 1973 to 1997:**
  - **Transportation oil use increased 75%**
  - **Transport accounted for 80% of the increase in world oil consumption**
- **Between now and 2020, transportation oil use will increase at twice the rate of non-transportation petroleum consumption**

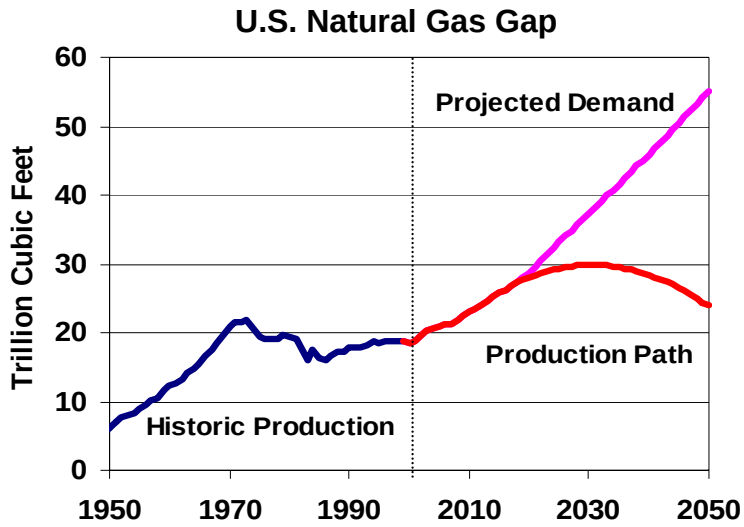
Asia Expected To Account for Much of Additional Transportation Oil Demand



China, with 12 vehicles per 1000 people, is where the U.S. was in 1913

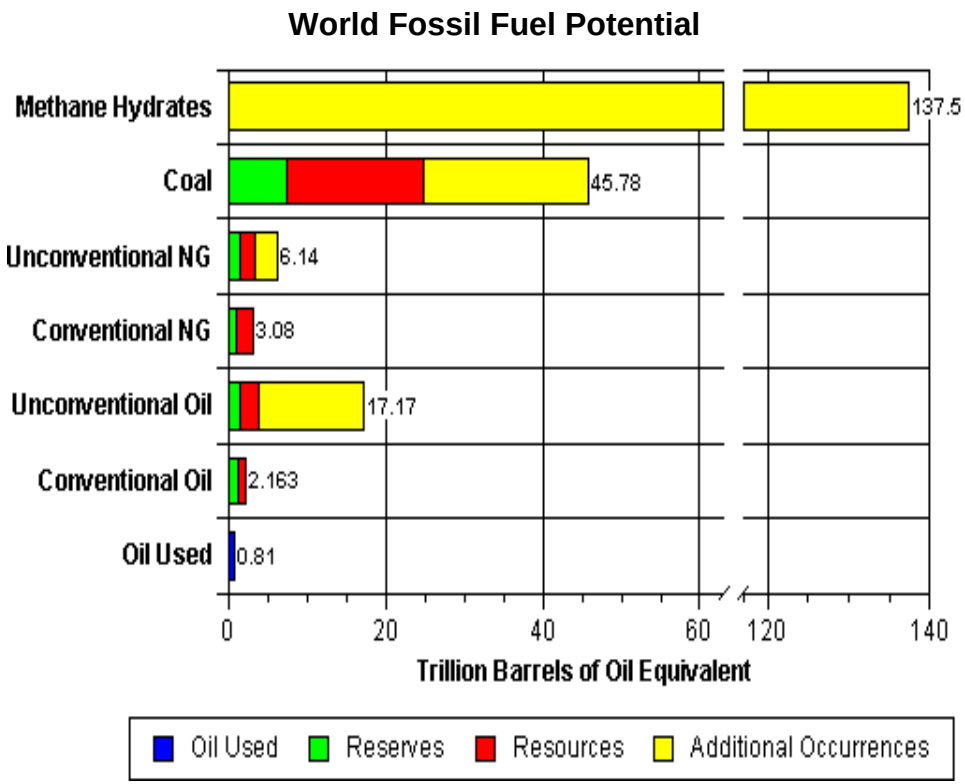
A Gap Is Expected between the Supply and Demand for Transportation Fuels





- **The world oil gap is likely to begin between 2010 and 2040, most likely by 2020 as shown here**
- **U.S natural gas supply and demand are expected to have a similar gap**
- **The question: how will the gap for transportation fuel be filled?**

Unconventional Oil Is a Likely Way to Fill the Gap. Fossil Fuels Are Plentiful



Source: H. H. Rogner, "An Assessment of World Hydrocarbon Resources," Annual Review of Energy and Environment, 1997.

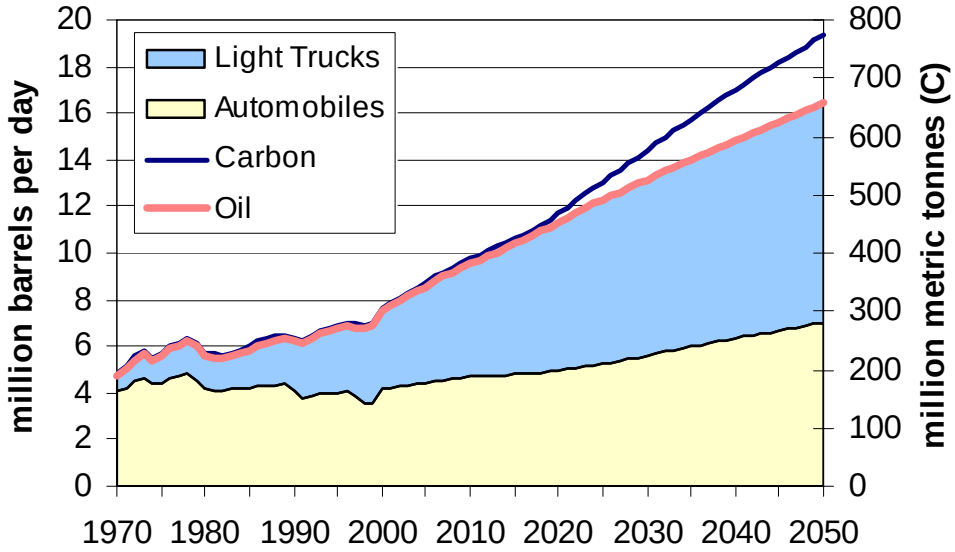
- **Cheapest substitutes first?**
  - Unconventional oil
  - Natural gas
- **Other issues important?**
  - Domestic resource? (energy security)
  - Criteria emissions?
  - Greenhouse gases?
- **Is there a role for:**
  - energy efficiency?
  - alternative fuels?

A Base Case and Six Alternative Strategies Were Examined

	Scenario Technologies	Fleet Fuel Economy in 2050 vs 2000
• Base Case	"Stagnant" Fuel Economy	1.0X
• Strategy 1	Enhanced Conventional Vehicles	1.4X
• Strategy 2	HEVs and Electricity	1.7X
• Strategy 3	Travel Reductions Plus Efficiency	1.8X
• Strategy 4	HEVs with Accelerated Biomass	1.8X
• Strategy 5	F-T Diesel and H2 Fuel Cells	2.2X
• Strategy 6	Three Fuel Future (ethanol, electricity, and hydrogen)	2.8X

The Base Case Is a Business-As-Usual Future Using Fossil Fuels

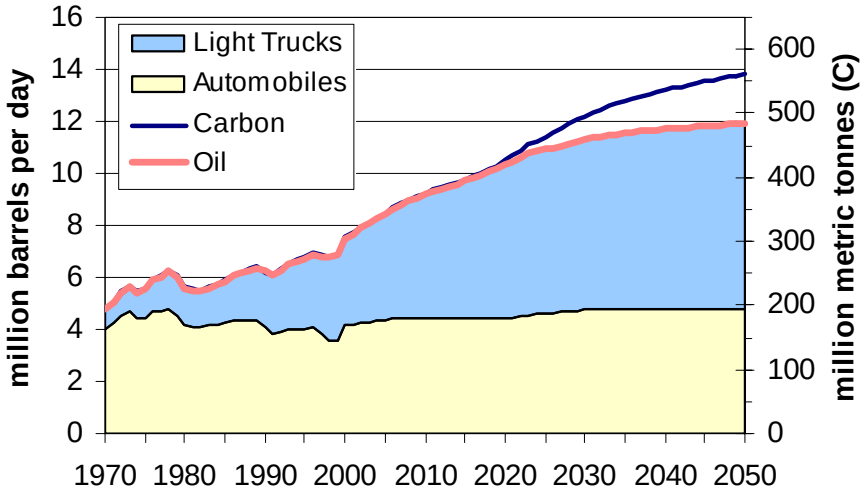
- **Base Case reflects**
  - Continued growth in:
    -- population
    -- economic activity
  - Modest fuel price increases; i.e., inexpensive oil substitutes
  - Declining rate of growth in vehicle miles of travel
- **Stagnant fuel economy; little incentive for MPG increases;**
  - Cars: 28 mpg
  - Trucks: 19 mpg
- **Light truck assumption**
  - Sales remain at 1999 level of 50% of LDV
  - Impact: stock of LDT grows



- **Implication of this future:**
  - Oil use more than doubles
  - Carbon emissions increase two and a half times

Strategy 1:
Enhanced Conventional Vehicles

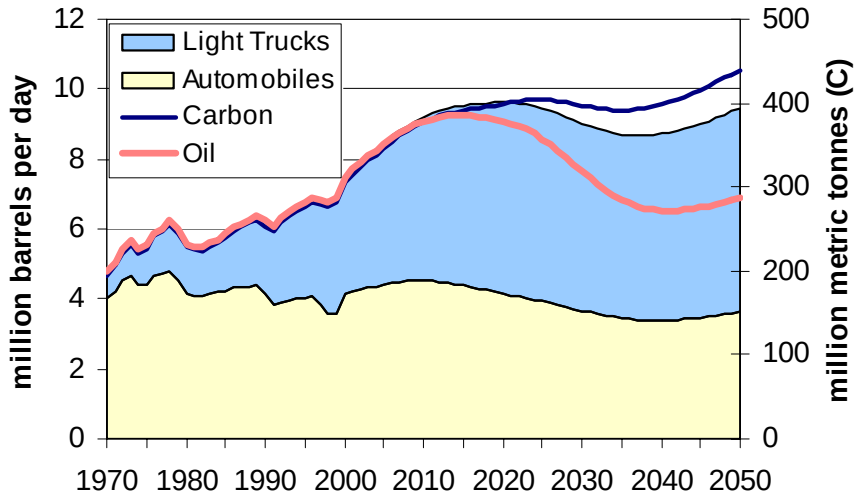
- **Light-duty vehicle fuel economy increase 50% by 2050**
  - Cars: 42 mpg
  - Lt Trucks 29 mpg
- **Auto fuel use is relatively flat**
- **Fuel economy improvement offset by VMT from light trucks**
- **Fuels used in transportation**
  - petroleum and synthetics
  - no alternative fuels



- **Energy and carbon use in 2050**
  - down 30% from Base Case
  - up 80% from 2000 levels

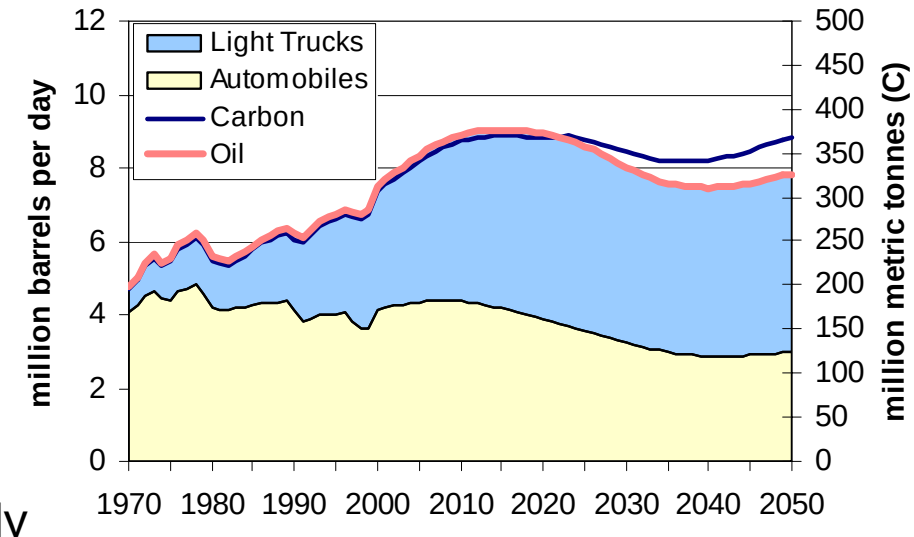
Strategy 2:
Hybrid Vehicles and Electricity

- **New 2X HEVs introduced in 2005 and become 100% of LDV sales by 2030**
- **Half of HEVs are grid-HEVs with 50% of their energy coming from the grid**
- **By 2050, hybrids make up virtually 100% of LDV fleet**
- **Impacts by 2050:**
  - Energy: 42% < Base Case
  - Oil: 58% < Base Case
  - Carbon: 43% < Base Case
- **But benefits eventually overcome by VMT**



Strategy 3:
Travel Reductions Plus Efficiency

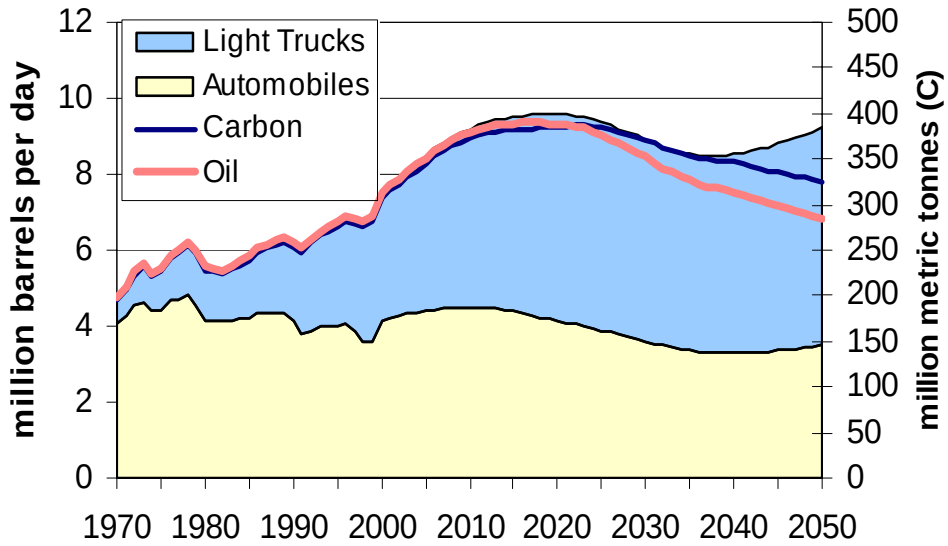
- **2X HEVs introduced as in Scenario 2, but none are grid connected**
- **VMT grows more slowly than in Base Case**
  - 15% reduction by 2050
- **By 2050,**
  - fleet composed almost entirely of 2X vehicles
  - 52% reduction in energy use, oil use, and carbon emissions



- **An upturn in the out-years occurs despite slower VMT growth**

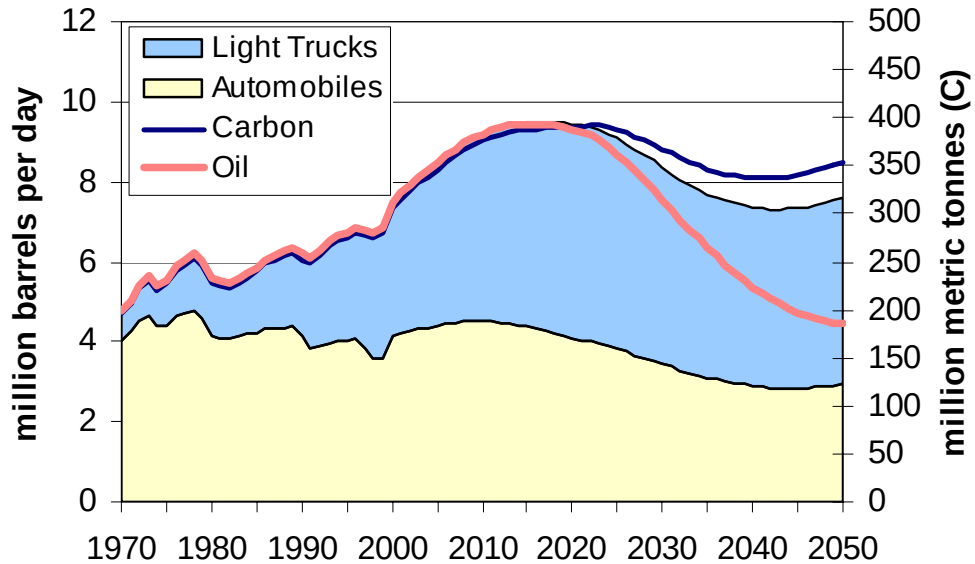
Strategy 4:
HEVs with Accelerated Biomass

- **2X HEVs introduced as in Scenario 3**
- **Emphasis on renewable fuels – 5 quads by 2050**
  - Cropland: 44%
  - Grassland: 19%
  - Ag Waste: 25%
  - Waste Wood: 12%
- **By 2050, ethanol provides 45% of fuel used in gasoline vehicles**
- **Carbon emissions in 2050:**
  - Only 6% above today's level



Strategy 5:
F-T Diesel HEVs with H2 Fuel Cells

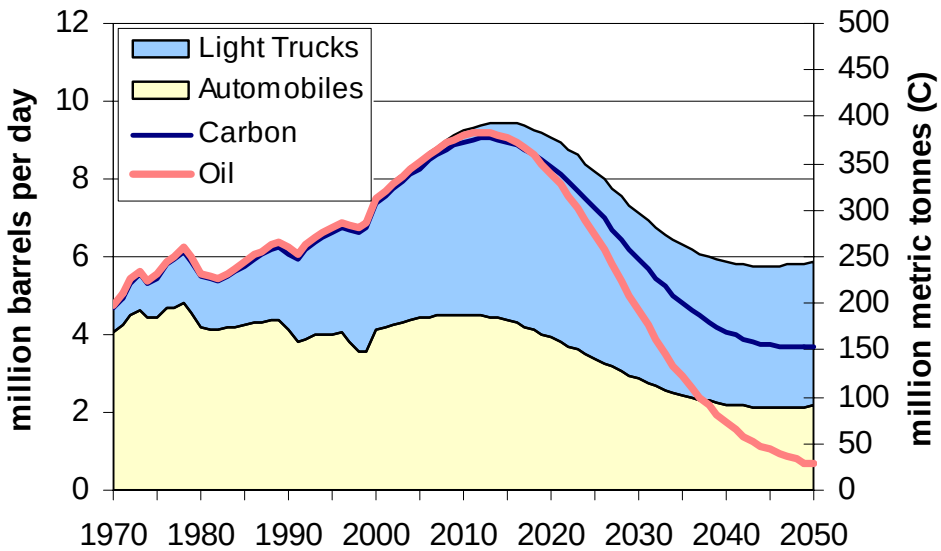
- **Radical shift to new fuels and technologies**
- **New vehicle sales in 2050**
  - Gasoline: 30%
  - Diesel: 40%
  - H2 Fuel Cell 30%
- **Natural gas resources:**
  - clean hydrocarbons with F-T
  - eventual use of methane hydrates



- **Methane to hydrogen starts in 2015; grows as fast as fuel cell vehicles**
- **Carbon emissions**
  - -- down 55% from base case
  - -- only 15% higher than year 2000 levels

Strategy 6: Three Fuel Future: Gas, Liquid, and Electricity

- **Illustrates one possible path towards eliminating liquid fossil fuels in light vehicles by 2050**
- **New vehicle sales in 2050**
  - HEV ETOH: 35%
  - 3.2X EVs: 10%
  - 3.5X Fuel Cell H2: 55%
- **Results**
  - Energy use down 64%
  - Carbon emissions:
    - 80% < Base Case
    - 49% < 2000 levels
  - Oil use nearly eliminated (only used in ethanol blends)



Summary and Conclusions

- **Half of the world's oil resources will be consumed between 2010 and 2040; permanent decline in production begins**
- **Transportation energy demand by 2050:**
  - Expected to double in the U.S.
  - Anticipated to grow by a factor of five globally
- **If any of these strategies represent a desired end-state, actions must start soon because of the long lead times needed for a transportation transition**
- **Efficient vehicles are beneficial in any strategy; they are the equivalent of the discovery of major new oil fields**
- **Very high efficiency coupled with alternative fuels could reduce future oil use below current levels and restrain the growth of carbon emissions**
- **Transition from conventional oil is inevitable and consequences are important. Choices made or not made will be important.**

Next Steps in the Ongoing Analysis

- **Shortcomings Noted in Phase 1 of the DOE 2050 Study**
  - Lack of price feedbacks for the resource estimates
  - Costs for technologies and related infrastructure not addressed
  - Lack of consideration of North American and global interactions
- **Phase 2 Overview**
  - Conducted with Natural Resources Canada
  - Air and rail modes to be added; heavy truck included in Phase 1
  - Reference case and three future scenarios
  - Modeling of world energy resources and use
  - Use Champagne Model for U.S., Canada, and Mexico
  - Policy analysis will be included
  - Preliminary results from the models by October, 2001
  - Preliminary report by December, 2001