Transportation Energy: Supply, Demand and the Future

Edward Beimborn
Center for Urban Transportation Studies
University of Wisconsin-Milwaukee
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Institute of Transportation Engineers
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The problem

- Transportation in nearly 100% dependant on petroleum as a source of energy.
- Global supply and demand trends will have a profound impact on the ability to use our transportation system and on economic activity.
- Alternatives are slow in development and implementation. Short term impacts are likely to be extreme and massively disruptive
- The ability to finance future transportation programs will be severely impacted.

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Demand

- Worldwide demand for petroleum is growing, particularly as related to economic trends in China, India, Eastern Europe and other developing areas.
  - China oil demand +104% by 2030, India +91%, Africa +105%, Central and South America +98 to 112%, US, Europe +22 to 34% (Exxon)
- Transportation energy demand in the U.S. has increased because of the greater use of less fuel efficient vehicles. – a transportation finance bonus

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Fuel Economy by Model Year

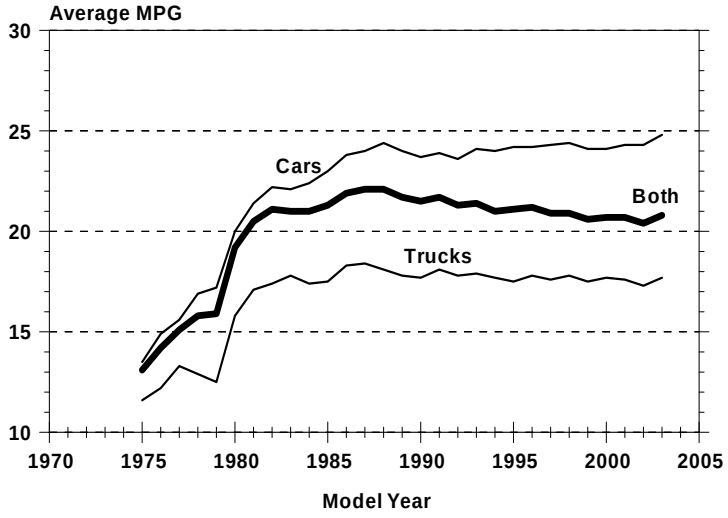

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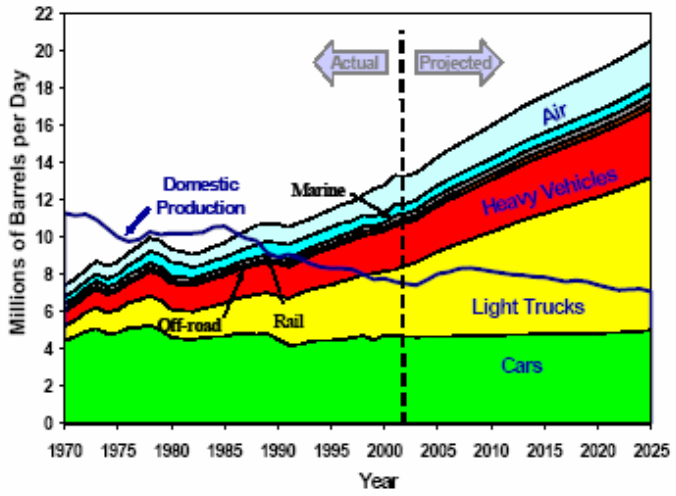
Figure 1.7. United States Petroleum Production and Consumption, 1970–2025



Source:
See Tables 1.12 and 2.5. Projections are from the Energy Information Administration, *Annual Energy Outlook 2004*, January 2004.

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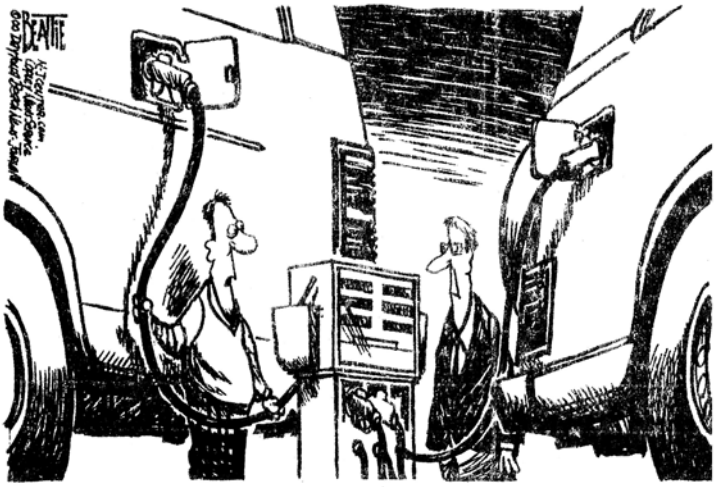
MONDAY, FEBRUARY 21, 2000 MILWAUKEE JOURNAL SENTINEL

Morning Mail, Milwaukee Journal Sentinel, P.O. Box 371, Milwaukee, Wis. 53201-0371. Fax us at (41



"I don't get it . . . gas prices going up again?!"

GUEST CARTOON BY BRUCE BEATTIE/DAYTONA BEACH NEWS-JOURNAL

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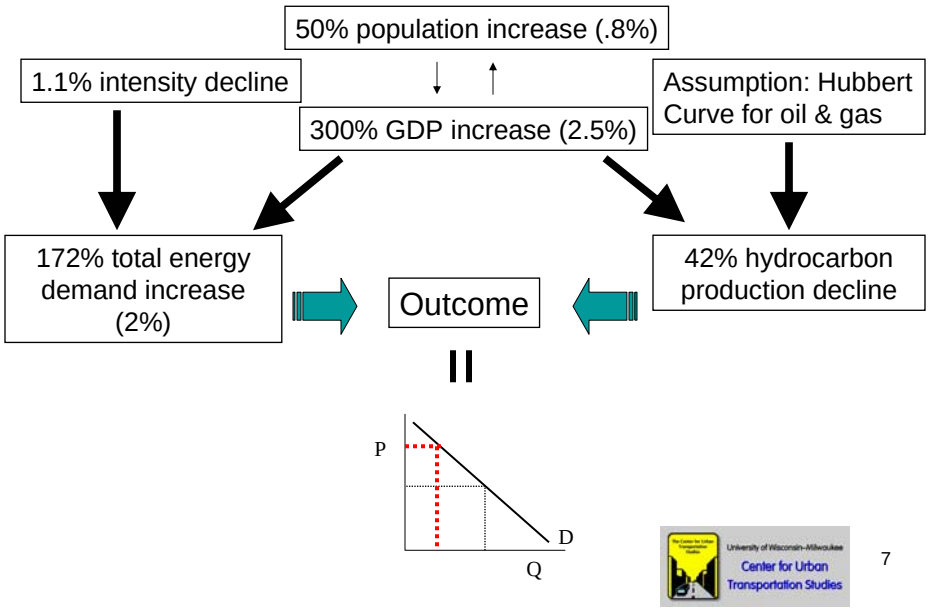
2000-2050 Energy Model



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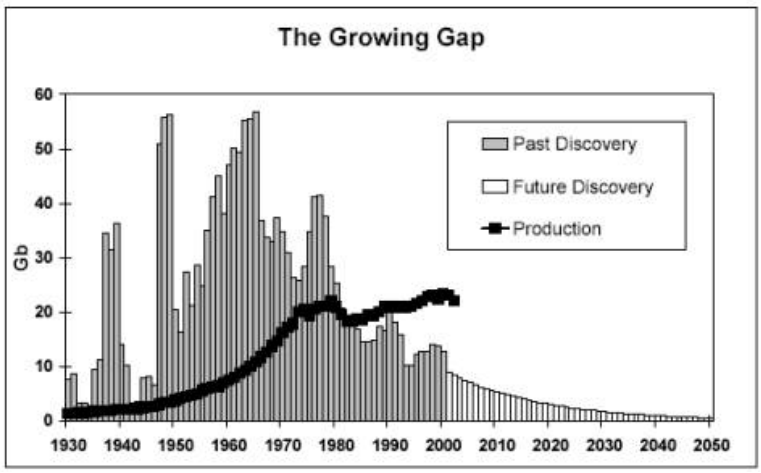
World Conventional Oil Production & Discoveries



OIL DEPLETION -THE HEART OF THE MATTER, C.J.Campbell, *The Association for the Study of Peak Oil and Gas*

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Supply

- Different predictions of the total global supply of petroleum and related products.
- Some believe we may have reached the global peak of production. (peak oil)
- Rates of discovery have slowed, there may be few places left to find petroleum
- Major oil companies have reduced estimates of reserves and reduced investment in finding new sources
- As easy sources are used up, the cost, risk and energy inputs for other sources will increase.

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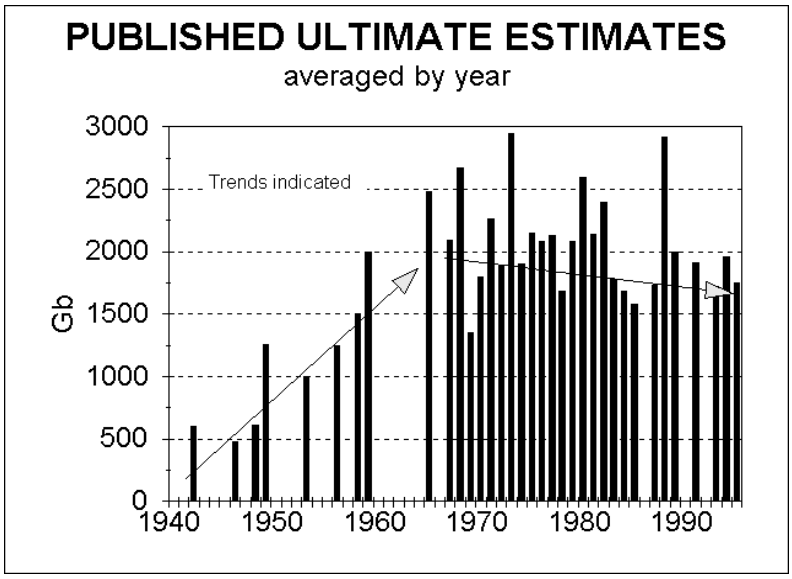

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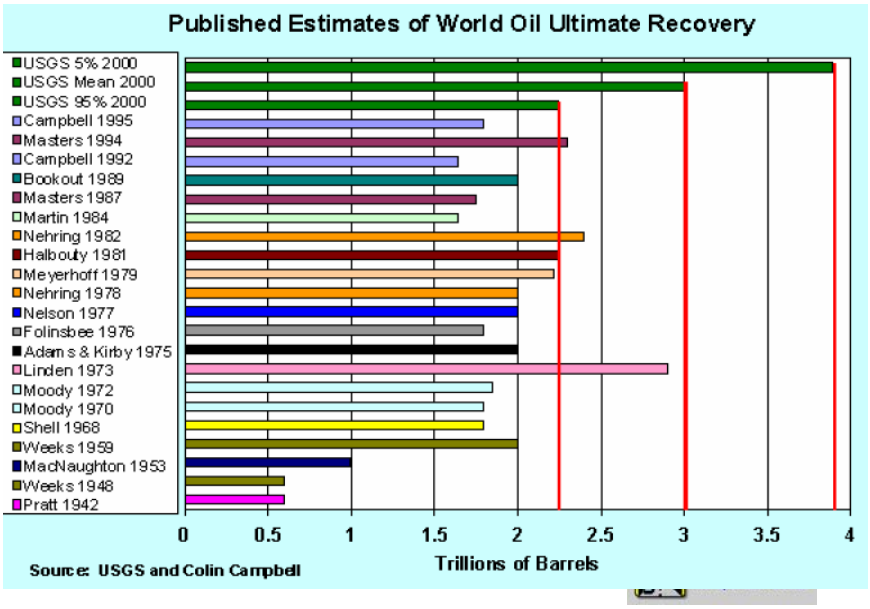
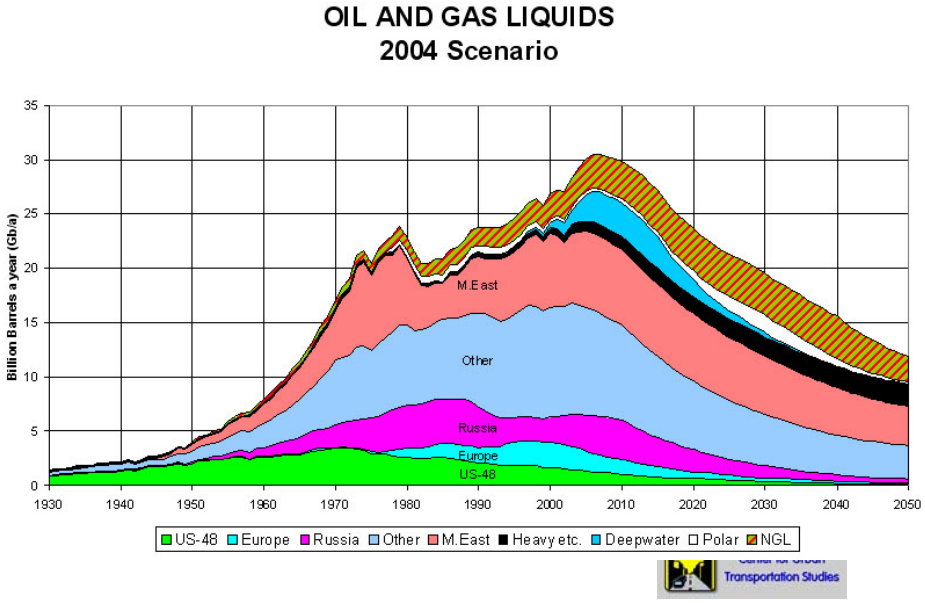
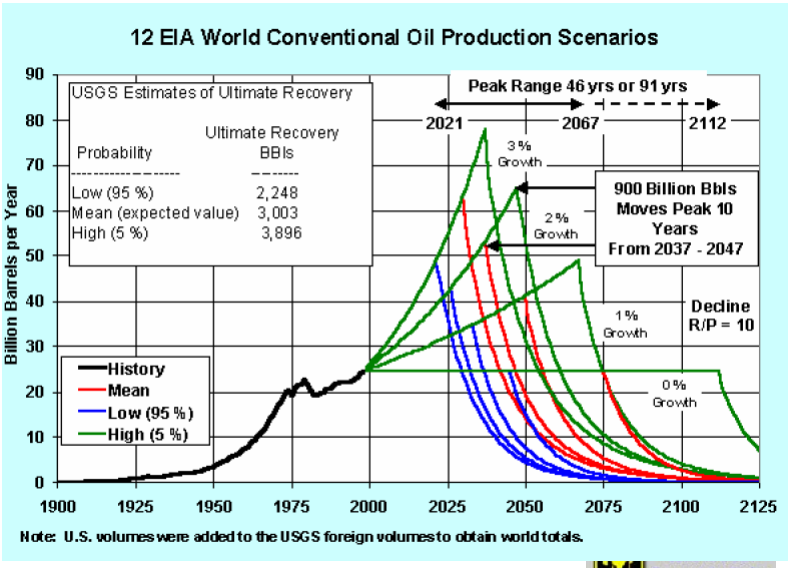
U.S. DOE, source:
http://tonto.eia.doe.gov/FTPROOT/features/longterm.pdf#search='oil%20supply



Campbell's prediction "the end of cheap oil"



U.S. DOE viewpoint,
source:http://tonto.eia.doe.gov/FTPROOT/features/longterm.pdf#search='oil%20supply'



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Sources of supply

- Many producing countries have moved past their peak production and are in a period of decline and are becoming net importers. (Oman, Indonesia, China, UK, Iran?)
- Exceptions are in the middle east (Saudi Arabia, Iraq, Kuwait, Abu Daubi)
- No matter when we reach the peak, most of the world, including the U.S. will be highly dependant on sources from a few foreign locations.
- Who gets the money?

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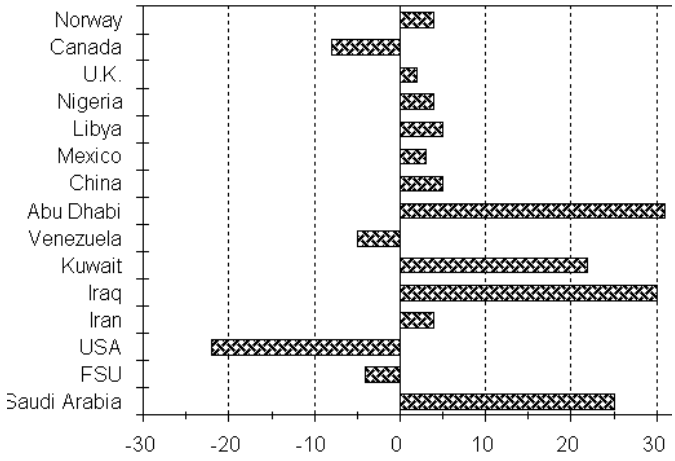
Time to Depletion Midpoint

source: http://www.hubbertpeak.com/summary.htm



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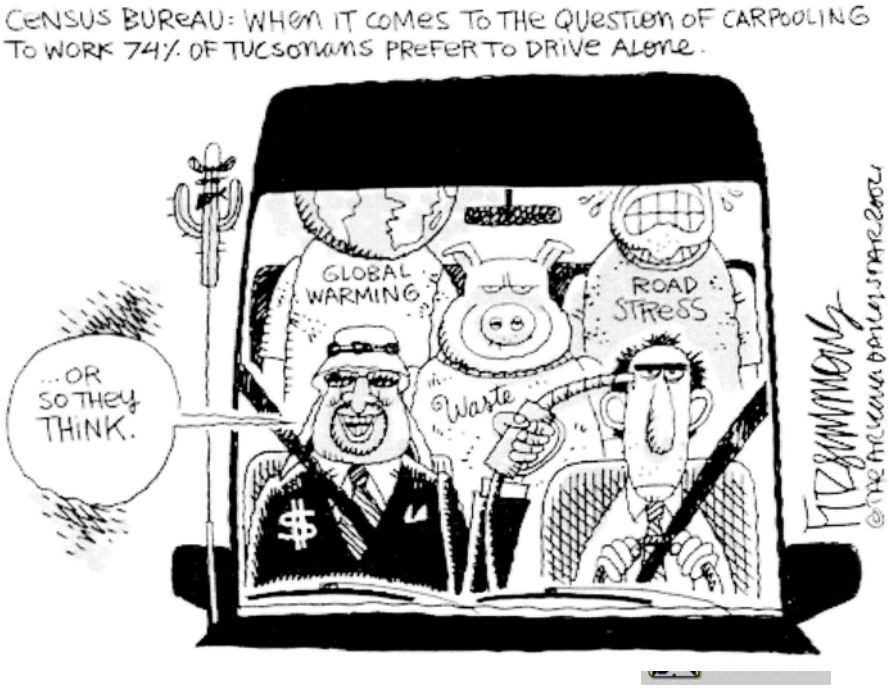
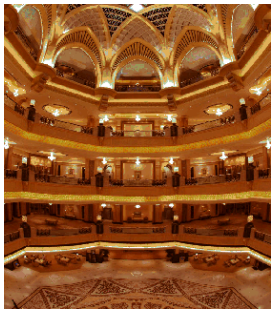


Where does the Money go?

(Emirates Palace Hotel and Conference Center, Abu Daubi)



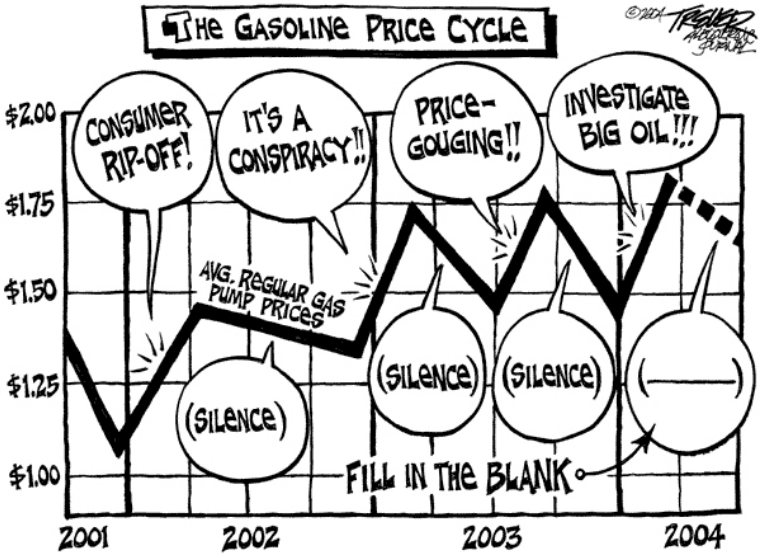
Some Quotes

- "Simply put, the era of easy access to energy is over. In part, this is because we are experiencing the convergence of geological difficulty with geopolitical instability... [W]e are seeing the beginnings of a bidding war for Mideast supplies between East and West.“ David J. O'Reilly Chairman and CEO, ChevronTexaco
- “The supply side is limited, We are reaching the limits of the planet very soon” Dr. Ali Samsam Bakhtiari, Senior Planner, National Iranian Oil Company
- “By some estimates, there will be an average of two-percent annual growth in global oil demand over the years ahead, along with, **conservatively**, a three-percent natural decline in production from existing reserves. That means by 2010 we will need on the order of an additional 50 million barrels a day.” Vice President Cheney

The Future??

Prices

- We are operating on a very thin, thin edge to balance supply and demand.
- The current system is not sustainable
- The result will be a series of major oil price shocks with rapidly increasing prices with a high potential for conflict over remaining resources.
- Short term effects are likely to be very sever with few options. “over a barrel”
- Highly visible prices
- Prices will rise and fall, but are likely to generally continue upwards.



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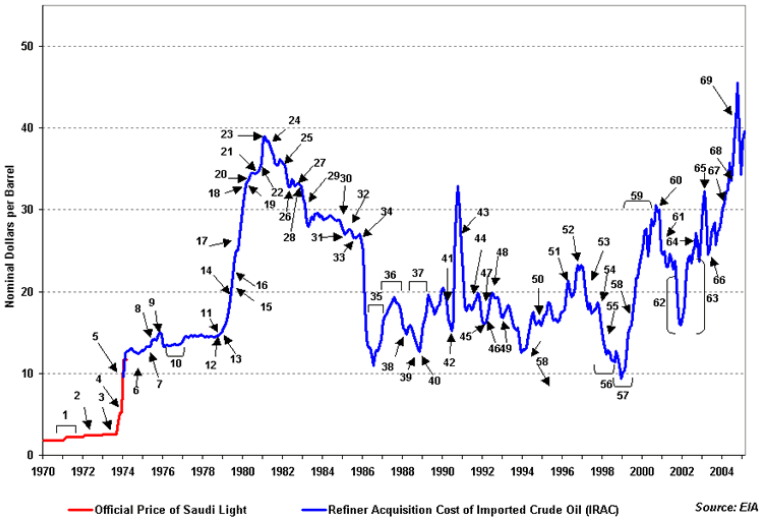
Crude Oil Price Trends:
Source: http://www.eia.doe.gov/emeu/cabs/chron.html



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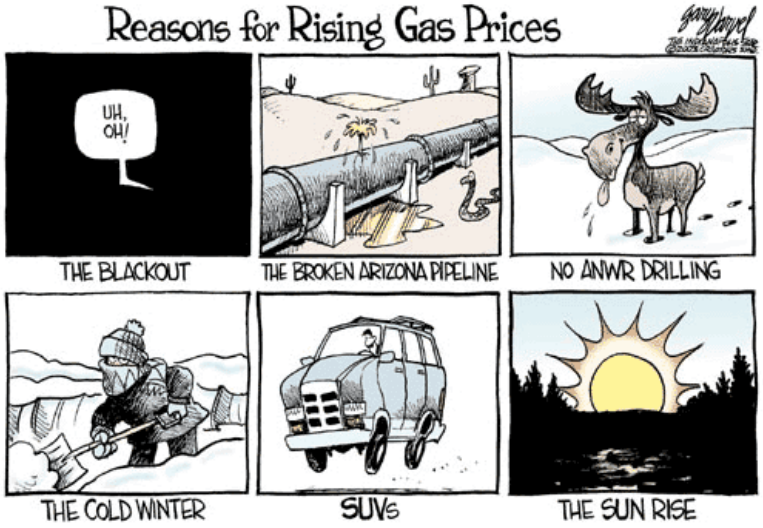

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The Future

- No easy long term solution, a combination of thousands of actions
  - Price increases
  - Conservation
  - Alternative Fuels
  - New sources
  - Economic impacts

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Can Conservation Solve the Problem?

- More efficient vehicles, price pressures and general conservation can delay the problem, but are not enough.
- “You can only turn off the lights once”
- Price increases will force more conservation
- More conservation of fuels means less revenue for transportation purposes.

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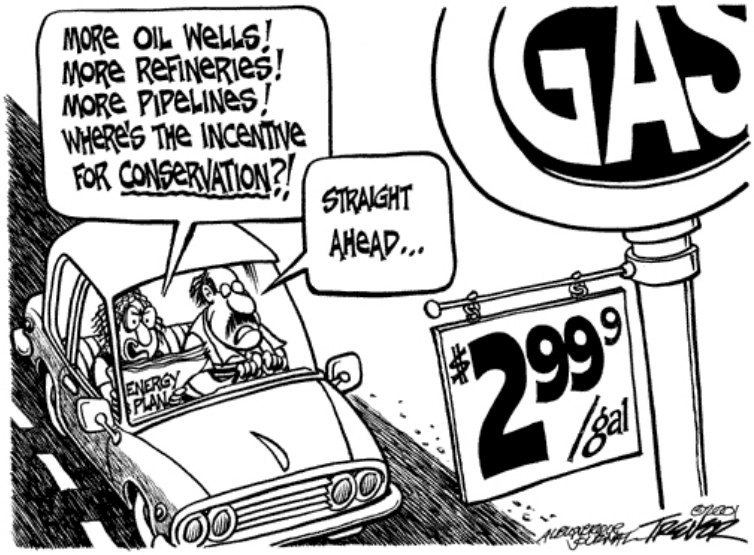

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The Future

- Can Technology and Alternative Fuels solve the problems?
  - Possibly, in the long run, but it will take a long lead time to happen
    - Technology development - 6-15 years
    - Infrastructure deployment -10-15 years
    - Market penetration occurs along with above
    - Fleet turnover – 12 years
    - Total 20-40 years for full effect to be felt

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Alternative Fuels

- An ideal fuel has
  - high energy content per unit of volume – (vehicle range),
  - is easily converted to useful transport energy,
  - is easily transported,
  - doesn't take more energy to produce than it returns as a useful fuel (positive EROEI),
  - has low emissions and
  - has an existing infrastructure
- (Gasoline or Diesel fuel)

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Alternatives

- Natural gas
- Liquid Petroleum gas (LPG/Propane)
- Compressed or liquid natural gas
- Methanol
- Ethanol
- Electricity
- Hydrogen
- Bio-diesel

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Alternative fuels

- Most require substantial energy to produce.
  - Hydrogen from natural gas or electricity
  - Methanol, ethanol need fuel, fertilizer and heat from fossil fuels
  - Electricity as a source to convert fuels, generally uses coal, natural gas or nuclear fuels

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More about alternatives

- U.S. Department of Energy provides comparisons of fuel alternative and their characteristics:
  - source, Intensity, physical state, environmental factors, security impacts, availability, infrastructure, safety
- See:
  - http://www.eere.energy.gov/afdc/altfuel/fuel_properties.html

	Gasoline	No. 2 Diesel	Biodiesel	CNG	Electricity	Ethanol (E85)	Hydrogen	LNG	Liquefied Petroleum Gas (LPG)	Methanol (M85)
Chemical Structure	C_4 to C_{12}	C_{10} to C_{20}	Methyl esters of C_{16}-C_{18} fatty acids	CH_4	N/A	CH_3CH_2OH	H_2	CH_4	C_3H_8	CH_3OH
Cetane number	5 to 20	40 to 55	46 to 60	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Octane number	86 to 94	8 to 15	~25	120+	N/A	100	130+	120+	104	100
Main fuel source	Crude Oil	Crude Oil	Soy bean oil, waste cooking oil, animal fats, and rapeseed oil	Underground reserves	Coal, however, nuclear, natural gas, hydroelectric, and renewable resources can also be used.	Corn, Grains, or agricultural waste	Natural Gas, Methanol, and other energy sources	Underground reserves	A by-product of petroleum refining or natural gas processing	Natural gas, coal, or, woody biomass
Energy Content per Gallon	109,000 - 125,000 Btu	128,000 - 130,000 Btu	117,000 - 120,000 Btu (compared to diesel #2)	33,000 - 38,000 Btu @ 3000 psi; 38,000 - 44,000 @ 3600 psi	N/A	~ 80,000 Btu	Gas: ~6,500 Btu @ 3,000 psi; ~16,000 Btu @ 10,000 psi Liquid: ~30,000 psi	~73,500 Btu	~84,000 Btu	56,000 - 66,000 Btu
Energy Ratio Compared to Gasoline			1.1 to 1 or 90% (relative to diesel)	3.94 to 1 or 25% at 3000 psi; 3.0 to 1 @ 3600 psi		1.42 to 1 or 70%		1.55 to 1 or 66%	1.36 to 1 or 74%	1.75 to 1 or 57%
Physical State	Liquid	Liquid	Liquid	Compressed Gas	N/A	Liquid	Compressed Gas or Liquid	Liquid	Liquid	Liquid
Types of vehicles available today	All types of vehicle classes.	Many types of vehicles classes.	Any vehicle that runs on diesel today—no modifications are needed for up to 5% blends. Many engines also compatible with up to 20% blends.	Many types of vehicle classes.	Neighborhood Electric Vehicles, Bicycles, Light-duty vehicles, medium and heavy duty trucks and buses.	Light-duty vehicles, medium and heavy-duty trucks and buses - these vehicles are flexible fuel vehicles that can be fueled with E85 (ethanol), gasoline, or any combination of the two fuels.	No vehicles are available for commercial sale yet, but some vehicles are being leased for demonstration purposes.	Medium and heavy-duty trucks and buses.	Light-duty vehicles, which can be fueled with propane or gasoline, medium and heavy-duty trucks and buses that run on propane.	Mostly Heavy-duty buses are available.
Available Vehicles to purchase	See your local car/truck dealership	See your local car/truck dealership	Visit the Vehicle Buyer's Guide (http://www.cities.doe.gov/vbg/) to learn more about light and heavy-duty alternative fuel vehicles available.							
Vehicle Conversion Information	N/A	N/A	Visit the AFDC Web Site's Conversion page (http://www.afdc.doe.gov/afv/conversion.shtml) to learn more.							

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Environmental Impacts of Burning the Fuel	Produces harmful emissions; however, gasoline and gasoline vehicles are rapidly improving and emissions are being reduced.	Produces harmful emissions; however, diesel and diesel vehicles are rapidly improving and emissions are being reduced especially with after-treatment devices.	Reduces particulate matter and global warming gas emissions compared to conventional diesel; however, NO_x emissions may be increased.	CNG vehicles can demonstrate a reduction in ozone-forming emissions compared to some conventional fuels; however, HC emissions may be increased.	EVs have zero tailpipe emissions; however, some amount of emissions can be contributed to power generation.	E-85 vehicles can demonstrate a 25% reduction in ozone-forming emissions compared to reformulated gasoline.	Zero regulated emissions for fuel cell-powered vehicles, and only NO_x emissions possible for internal combustion engines operating on hydrogen.	LNG vehicles can demonstrate a reduction in ozone-forming emissions compared to some conventional fuels; however, HC emissions may be increased.	LPG vehicles can demonstrate a 60% reduction in ozone-forming emissions compared to reformulated gasoline.	M-85 vehicles can demonstrate a 40% reduction in ozone-forming emissions compared to reformulated gasoline.
Energy Security Impacts	Manufactured using mostly imported oil, which is not an energy secure option.	Manufactured using imported oil, which is not an energy secure option.	Biodiesel is domestically produced and has a fossil energy ratio of 3.3 to 1, which means that its fossil energy inputs are similar to those of petroleum.	CNG is domestically produced. The United States has vast natural gas reserves.	Electricity is generated mainly through coal fired power plants. Coal is the United States' most plentiful fossil energy resource and coal is our most economical and price stable fossil fuel.	Ethanol is produced domestically and it is renewable.	Hydrogen can help reduce U.S. dependence on foreign oil by being produced from renewable resources.	LNG is domestically produced and its typically costs less than gasoline and diesel fuels.	LPG is the most widely available alternative fuel with an estimated 3,400 refueling sites nationwide. The disadvantage of LPG is that 45% of the fuel in the U.S. is derived from oil.	Methanol can be domestically produced from renewable resources.
Fuel Availability	Available at all fueling stations.	Available at select fueling stations.	Available in bulk from an increasing number of suppliers. There are 22 states that have some biodiesel stations available to the public.	More than 1,100 CNG stations can be found across the country. California has the highest concentration of CNG stations. Home fueling will be available in the fall of 2005.	Most homes, government facilities, fleet garages, and businesses have adequate electrical capacity for charging, but, special hookup or upgrades may be required. More than 600 electric charging stations are available in California and Arizona.	Most of the E-85 fueling stations are located in the Midwest, but in all, approximately 150 stations are available in 23 states.	There are only a small number of hydrogen stations across the country. Most are available for private use only.	Public LNG stations are limited (only 35 nationally), LNG is available through several suppliers of cryogenic liquids.	LPG is the most accessible alternative fuel in the U.S. There are more than 3,300 stations nation wide.	Methanol remains a qualified alternative fuel as defined by EPAct, but it is not commonly used.
AFV Fueling Station Locations	N/A	N/A	Visit the AFDC Web Site's AFV Fueling Station Locator (http://www.afdc.doe.gov/refueling_mapsite.shtml) to search for stations near you.							
Infrastructure Information	N/A	N/A	Visit the AFDC Web Site's "Infrastructure Development Information and Resources Page".							

Maintenance Issues			Hoses and seals may be affected with higher-percent blends, lubricity is improved over that of conventional diesel fuel.	High-pressure tanks require periodic inspection and certification.	Service requirements are expected to be reduced. No tune-ups, oil changes, timing belts, water pumps, radiators, or fuel injectors are required. However, the batteries must be replaced every 3-6 years.	Special lubricants may be required. Practices are very similar, if not identical, to those for conventionally fueled operations.	When hydrogen is used in fuel cell applications, maintenance should be very minimal.	High-pressure tanks require periodic inspection and certification.	Some fleets report service lives that are 2-3 years longer, as well as extended intervals between required maintenance.	Special lubricants must be used as directed by the supplier and M-85-compatible replacement parts must be used.
Safety (Without exception, all alternative fuel vehicles must meet today's OEM safety standards)	Gasoline is a relatively safe fuel since people have learned to use it safely. Gasoline is not biodegradable though, so a spill could pollute soil and water.	Diesel is a relatively safe fuel since people have learned to use it safely. Diesel is not biodegradable though, so a spill could pollute soil and water.	Less toxic and more biodegradable than conventional fuel, can be transported, delivered, and stored using the same equipment as for diesel fuel.	Pressurized tanks have been designed to withstand severe impact, high external temperatures, and automotive environmental exposure.	OEM EVs meet all the same vehicle safety standards as conventional vehicles.	Ethanol can form an explosive vapor in fuel tanks. In accidents; however, ethanol is less dangerous than gasoline because its low evaporation speed keeps alcohol concentration in the air low and non explosive.	Hydrogen has an excellent industrial safety record; codes and standards for consumer vehicle use are under development.	Cryogenic fuels require special handling procedures and equipment to properly store and dispense.	Adequate ventilation is important for fueling an LPG vehicle due to increased flammability of LPG. LPG tanks are 20 times more puncture resistant than gasoline tanks and can withstand high impact.	Methanol can form an explosive vapor in fuel tanks. In accidents; however, methanol is less dangerous than gasoline because its low evaporation speed keeps alcohol concentration in the air low and non explosive.
Average Cost/gge	You can get average costs for all fuel types through the Alternative Fuel Price Report (www.afdc.doe.gov/documents/pricereport/pricereports.html)									

Contingency Planning for the near term

- Conservation is not enough and there is not adequate time to develop and deploy alternatives
- “If it could happen, it will happen” So, what strategies should be used when it does happen?
- Prepare for the worst, hope for the best
- Must plan for the crisis in advance because there is no time to plan for it when it does actually happen.
- Goal: To increase the ability to respond to an energy shortfall through an adjustment of demand without causing severe problems for households, or the economy.

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Question of Allocation & Conservation

Who gets the scarce resources and how is that decision made?

- Who is vulnerable to price swings and availability issues?
- What essentials do these groups need?
- At what stage are these essentials provided?
- Prioritize policies based on effectiveness (work trips, short trips, long trips, etc.)
- Implement contingency plan

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Conclusions

- The current system is not sustainable
- Energy issues will dominate the future of transportation and the economy
- Failure to act early will lead to more severe consequences
- Contingency planning is essential
- Transportation finance will be radically affected by future energy factors
- To do project planning or development without a thorough knowledge of future energy situations is a waste of time
- Become knowledgeable about the issue

Web sites

- Millions of web sites on Google or Yahoo
- http://www.hubbertpeak.com/index.asp
- www.eia.doe.gov
- http://www.eere.energy.gov/afdc/
- http://www.oilanalytics.org/netentop.html
- http://tonto.eia.doe.gov/FTPROOT/features/longterm.pdf#search='oil%20supply'
- http://www.peakoil.net/
- http://www.drydipstick.com/