

**The Energy Sustainability Dilemma:  
*Can Alternatives to Oil Bail Us Out?***

*ASPO USA World Oil Conference  
Houston, Texas, USA  
October 18, 2007*

**J. David Hughes**

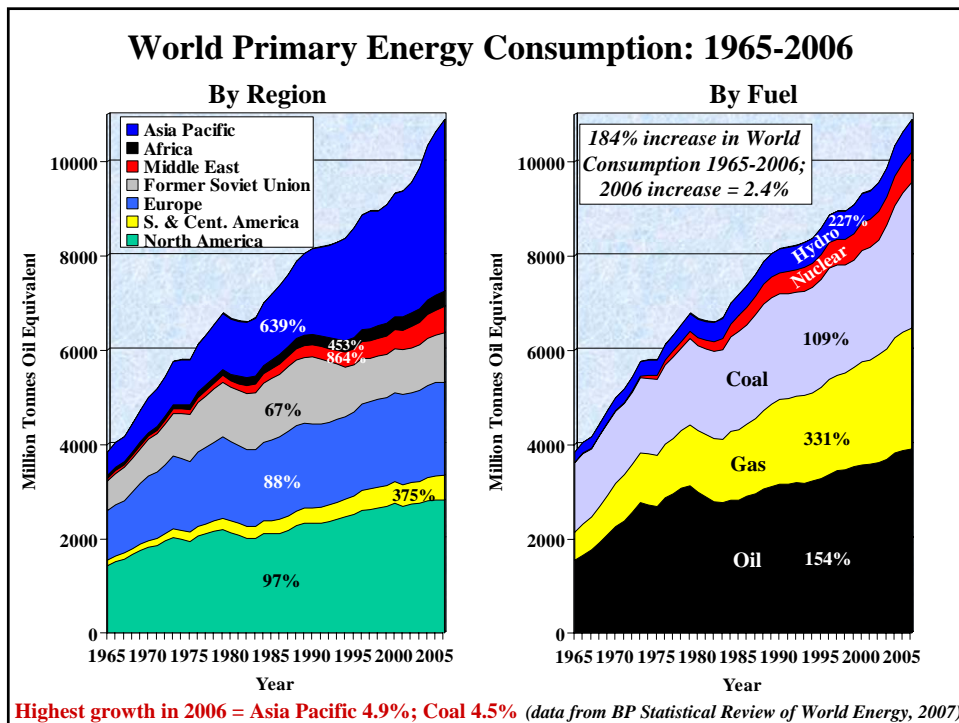
Geological Survey of Canada  
Canadian Gas Potential Committee

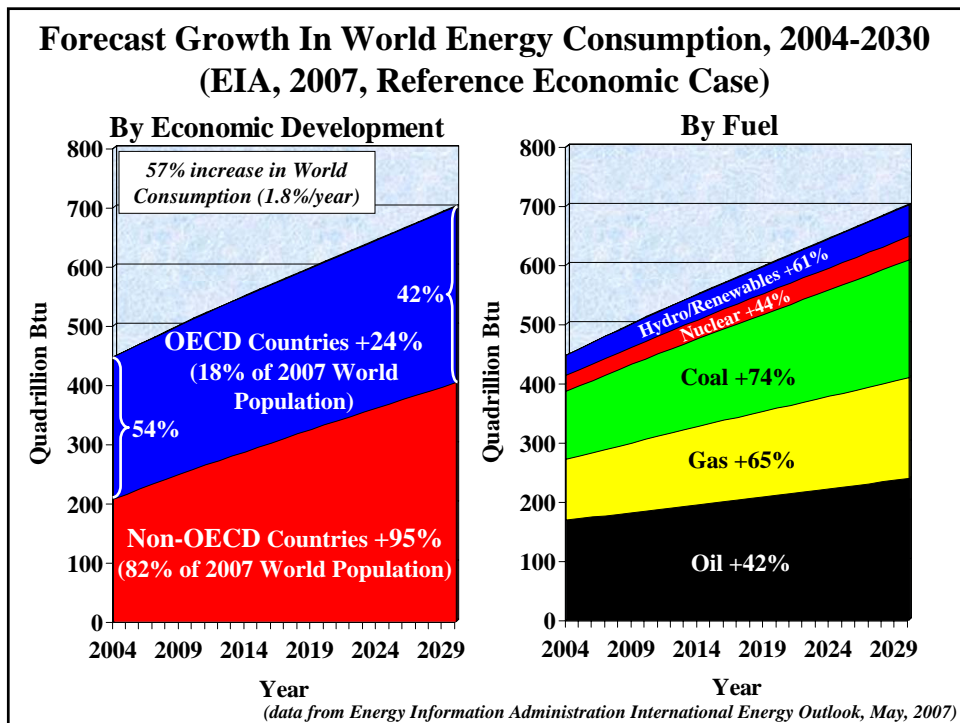
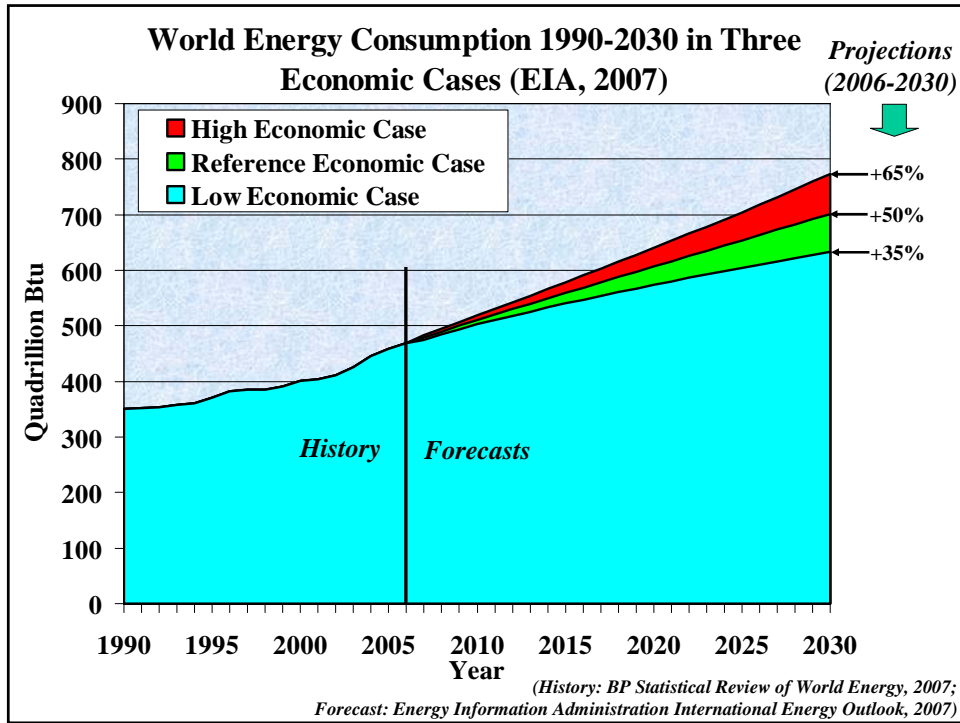
**Foreword**

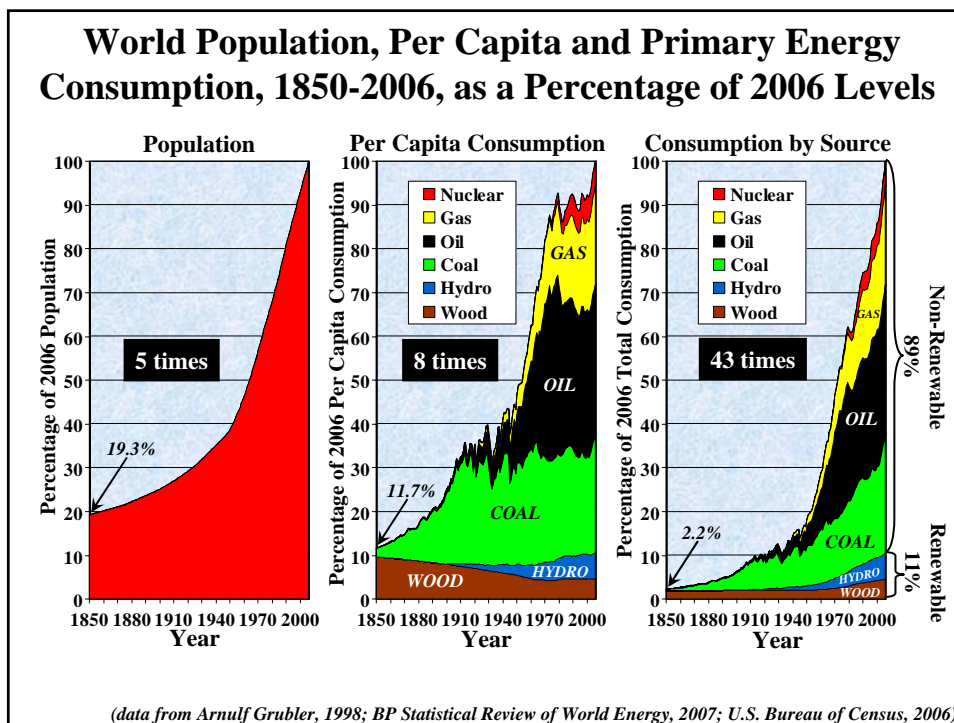
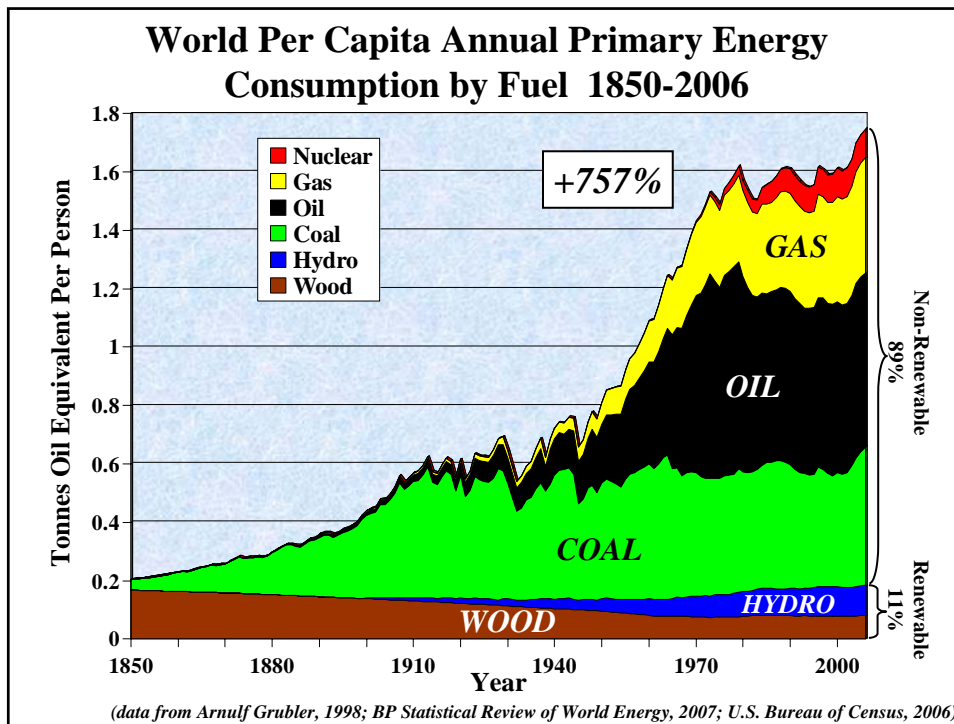
**Interpretations, conclusions and views drawn from the  
the data shown in the following analysis are strictly the  
responsibility of the author and are not attributable to  
any other individual or organization**

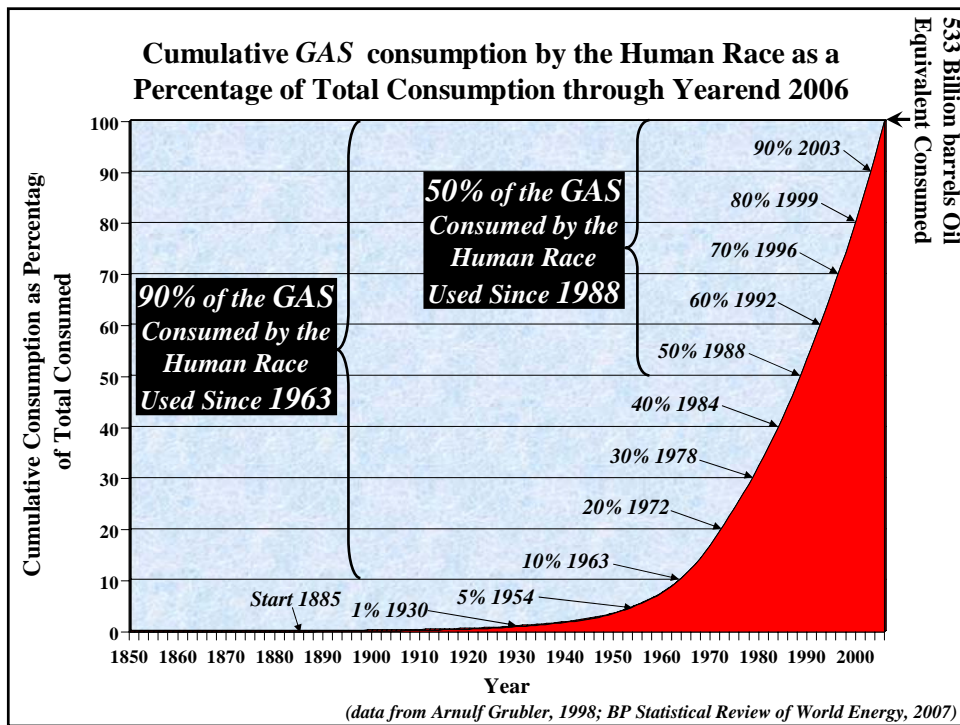
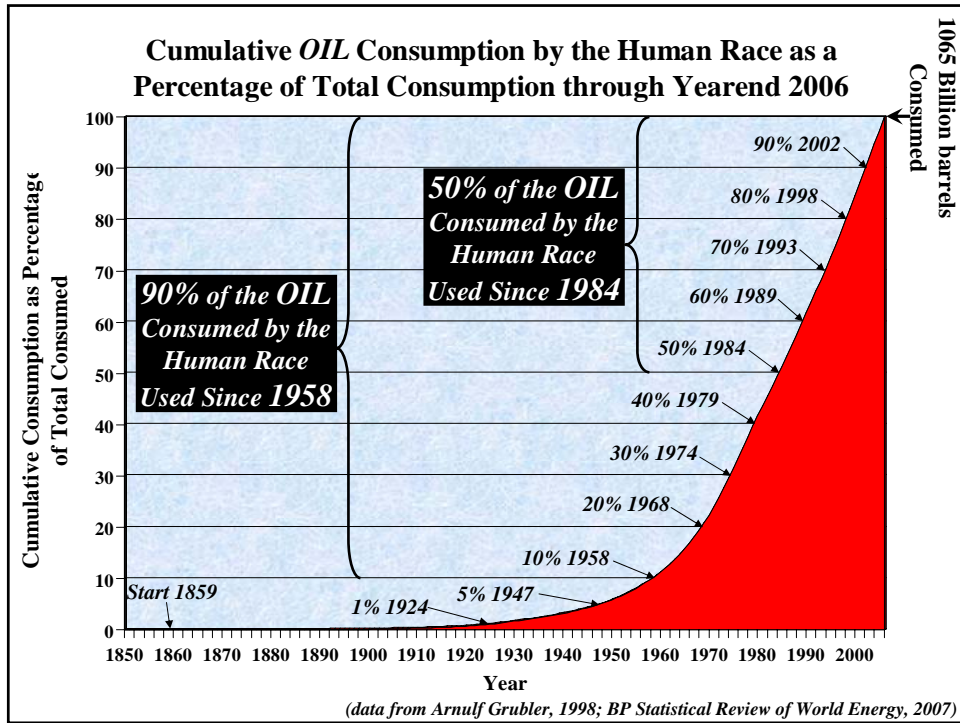
## Points to be covered:

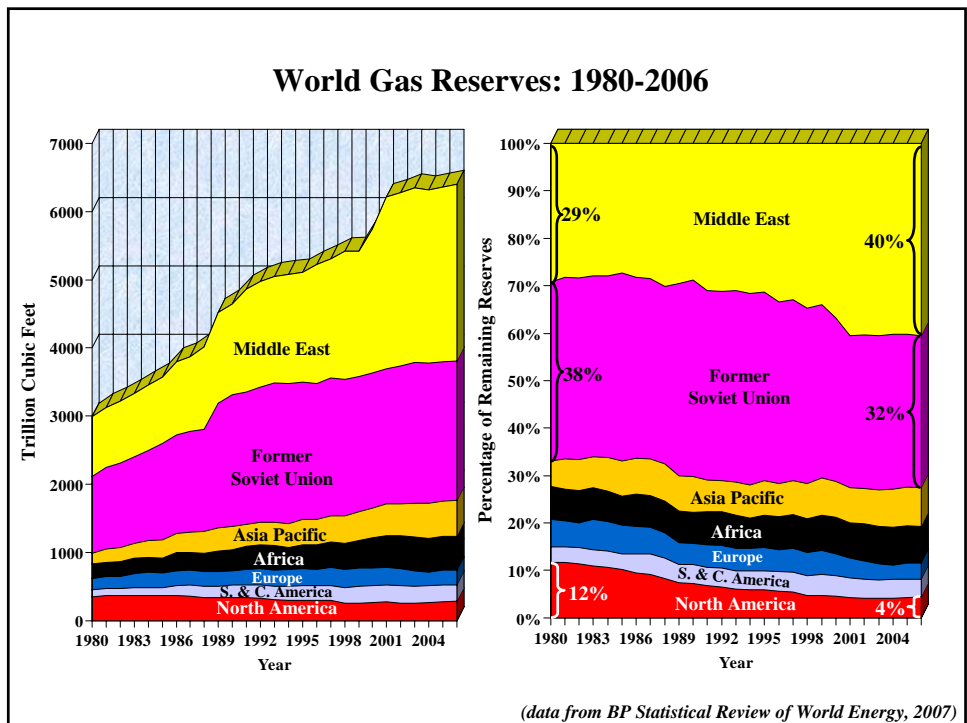
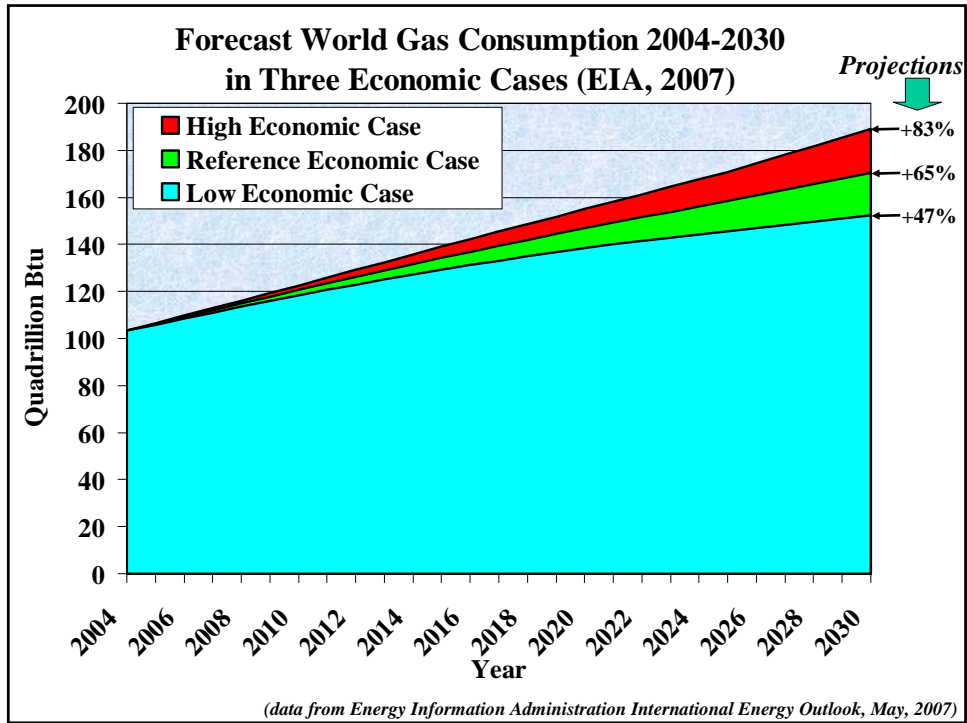
- **The ENERGY SUSTAINABILITY DILEMMA:**
  - History – *Where have we been and Where are we at?*
  - Forecasts - *Where are we Going and how likely is it that we'll get there?*
- **Alternatives to Oil:**
  - *Natural Gas – the clean burning miracle fuel*
  - *Coal – natural gas' dirty but abundant cousin*
- **Electricity:**
  - *Some issues in keeping the lights on*
- **Some thoughts on the way forward: *Why the ENERGY SUSTAINABILITY DILEMMA will likely trump CLIMATE CHANGE in terms of short- and medium-term socio-economic impact***

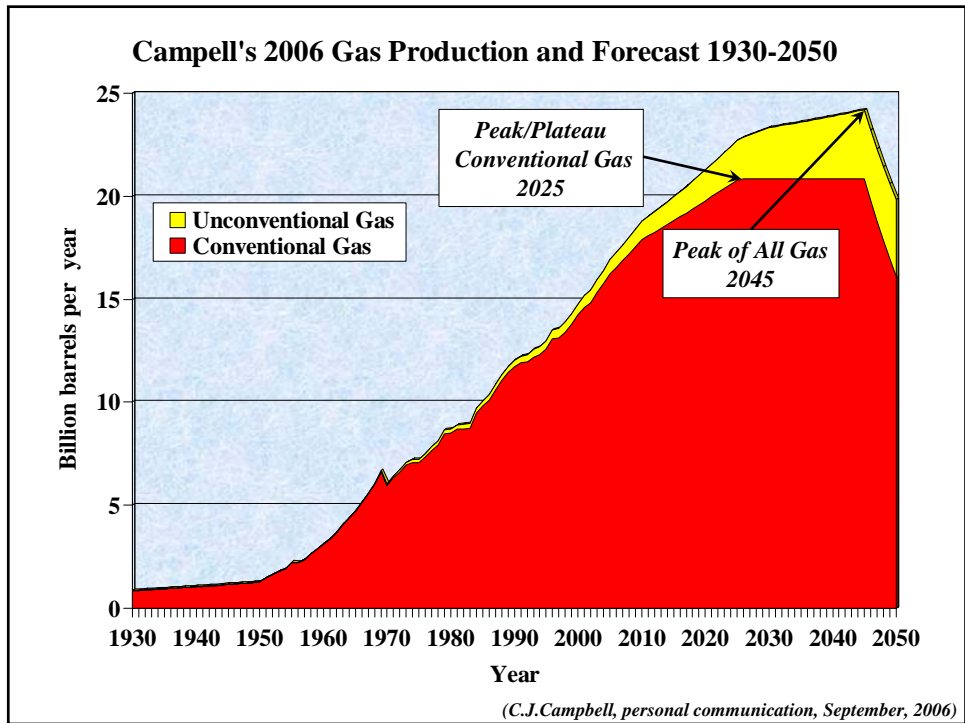
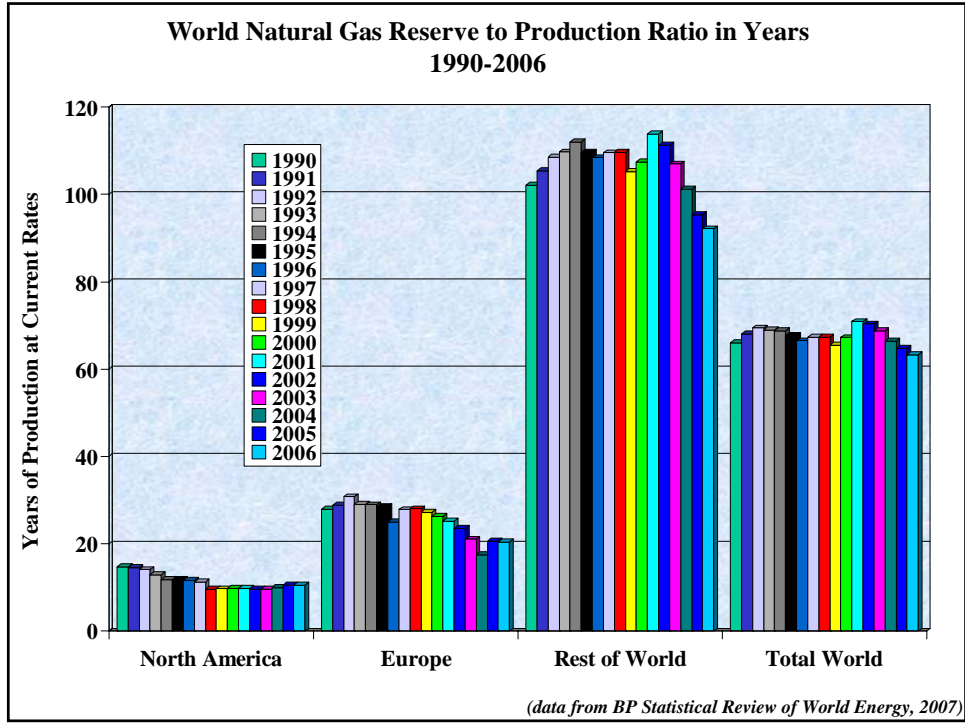


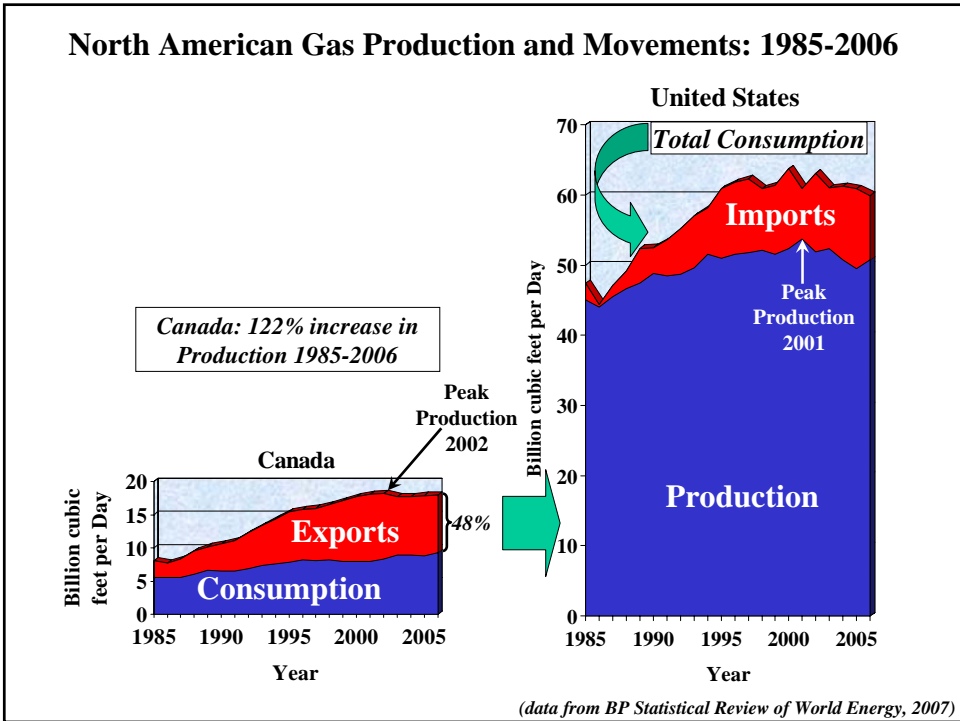
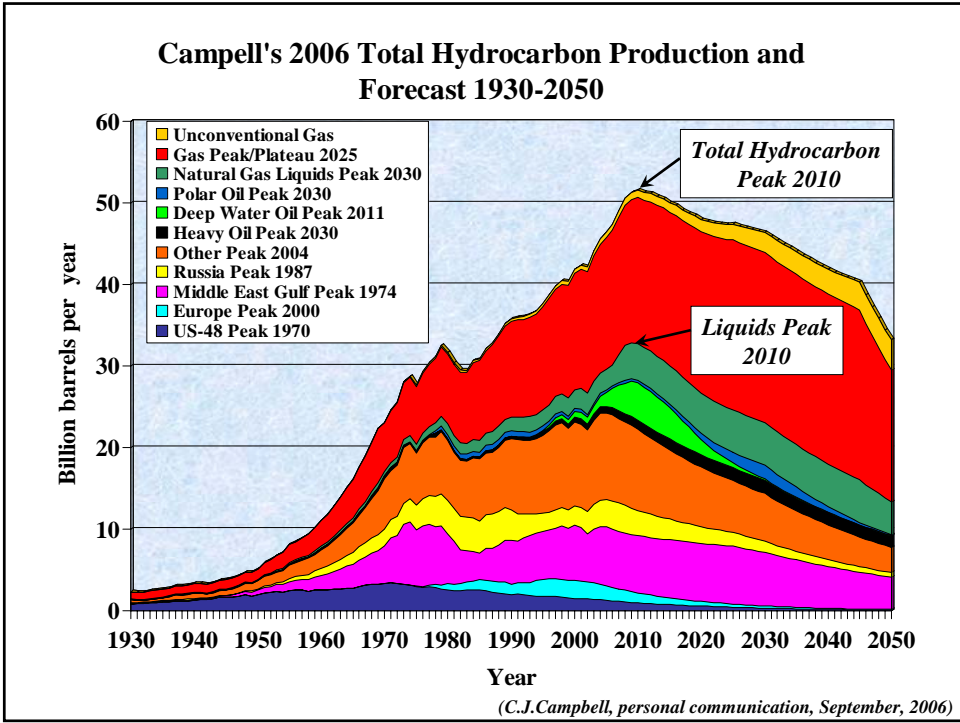




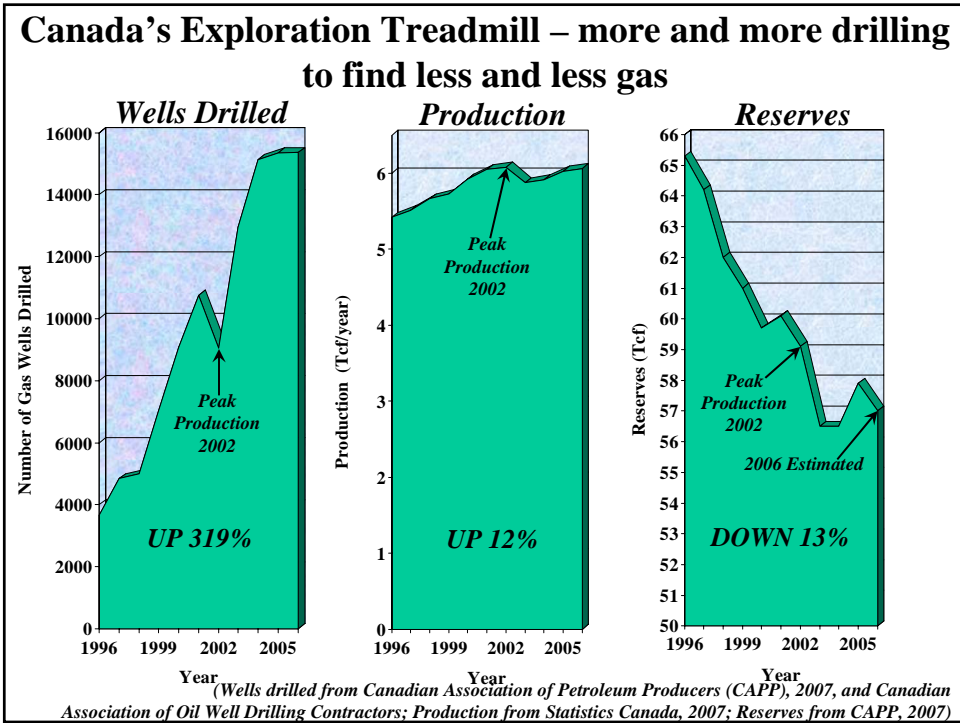
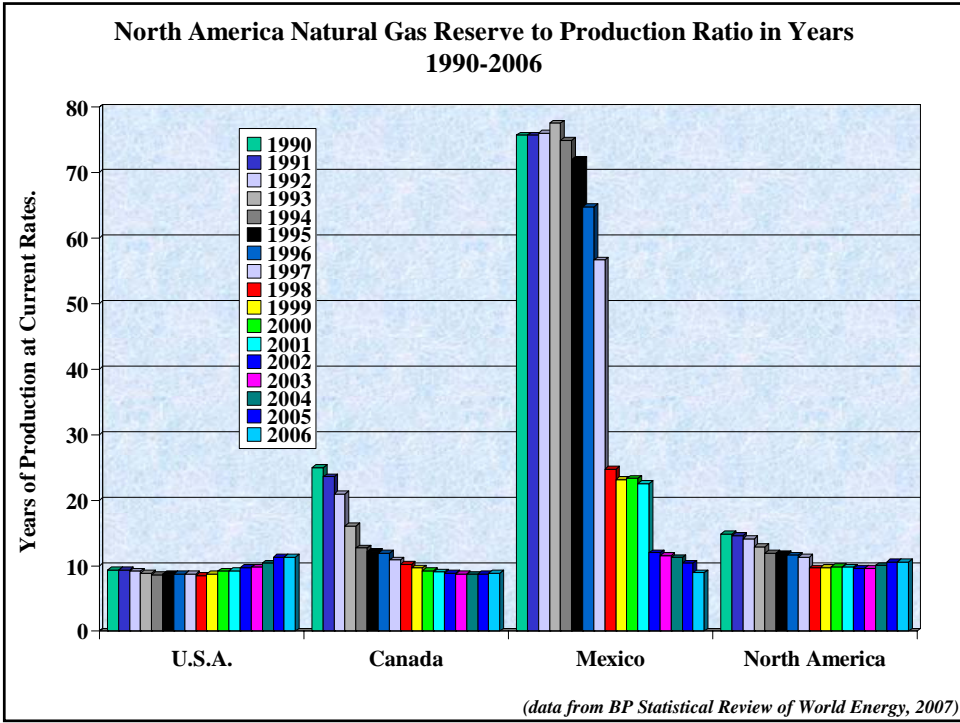


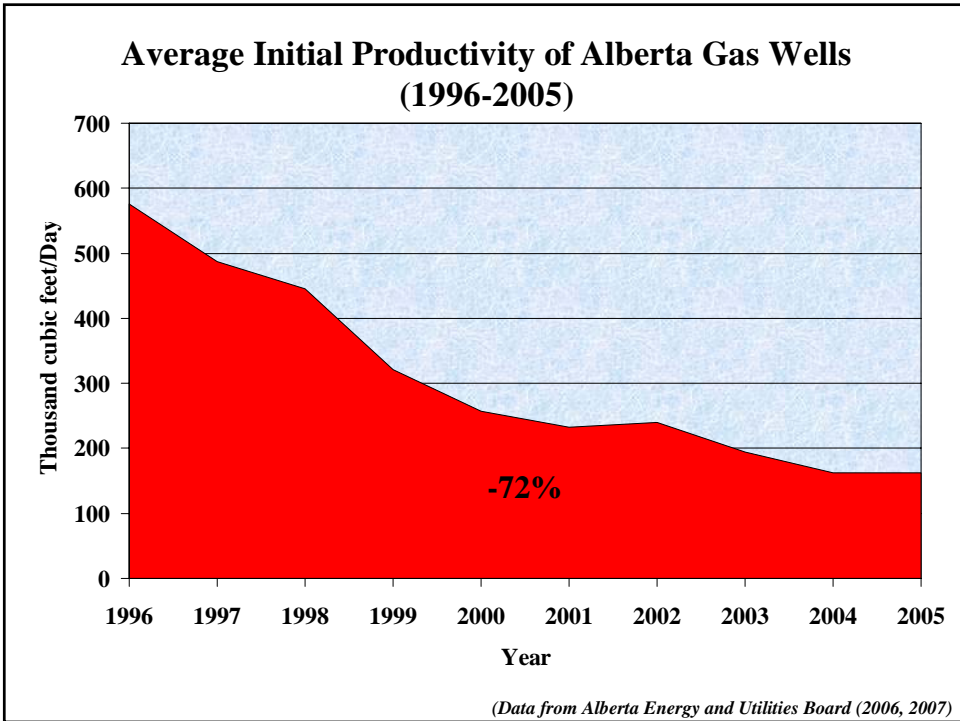
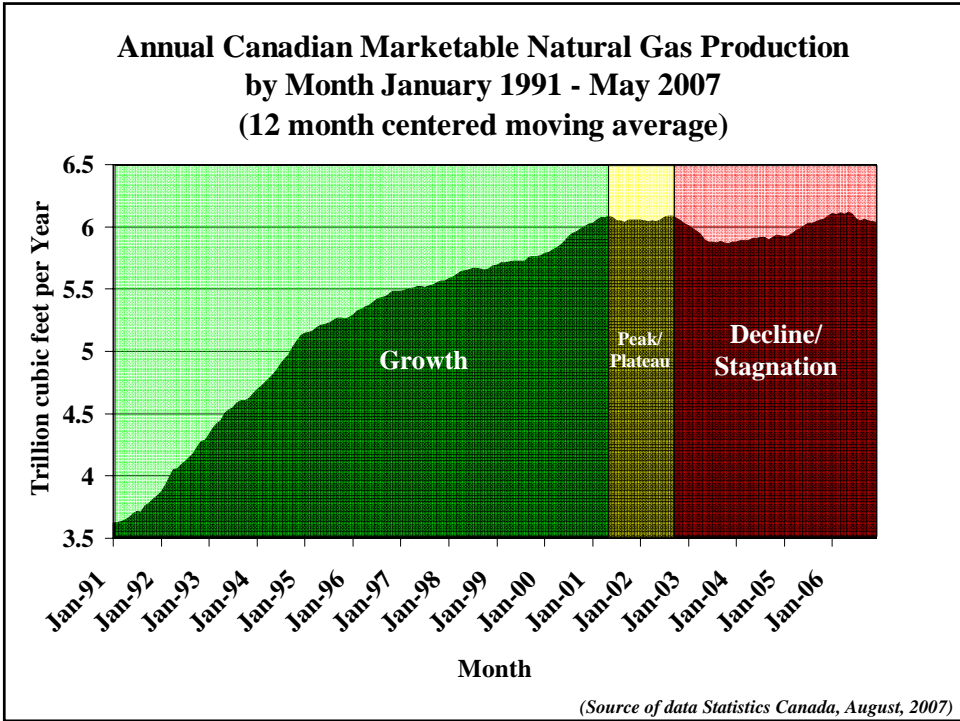


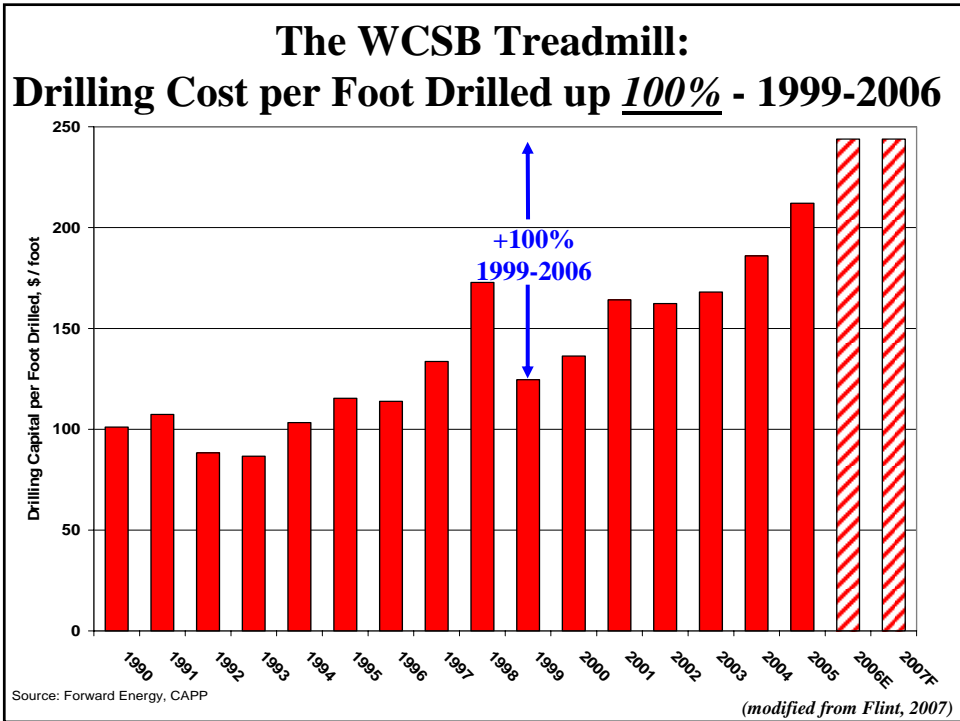
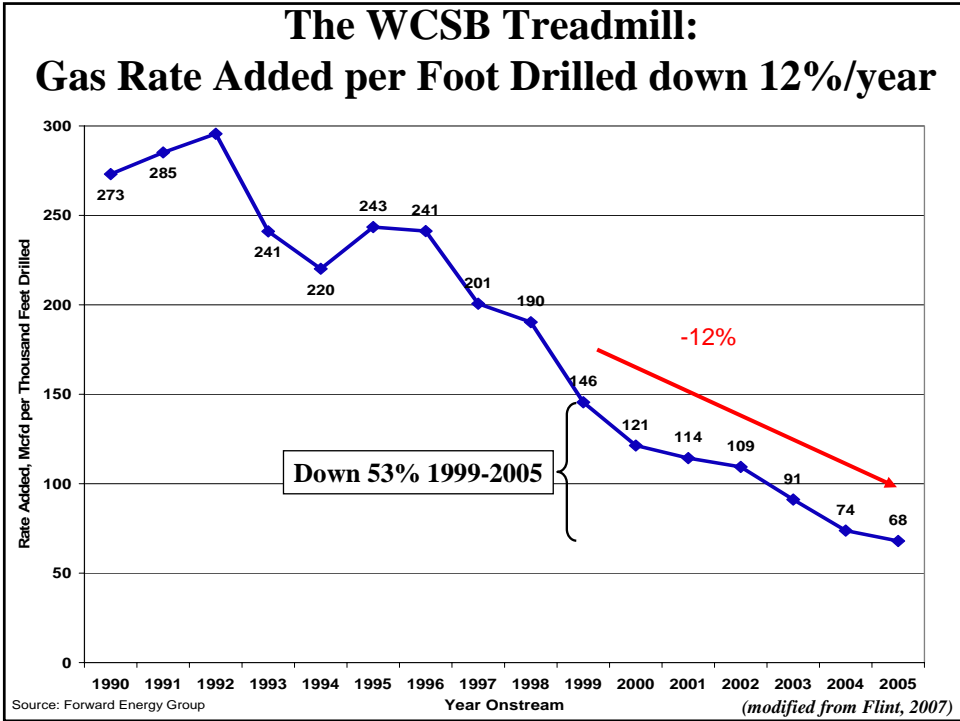


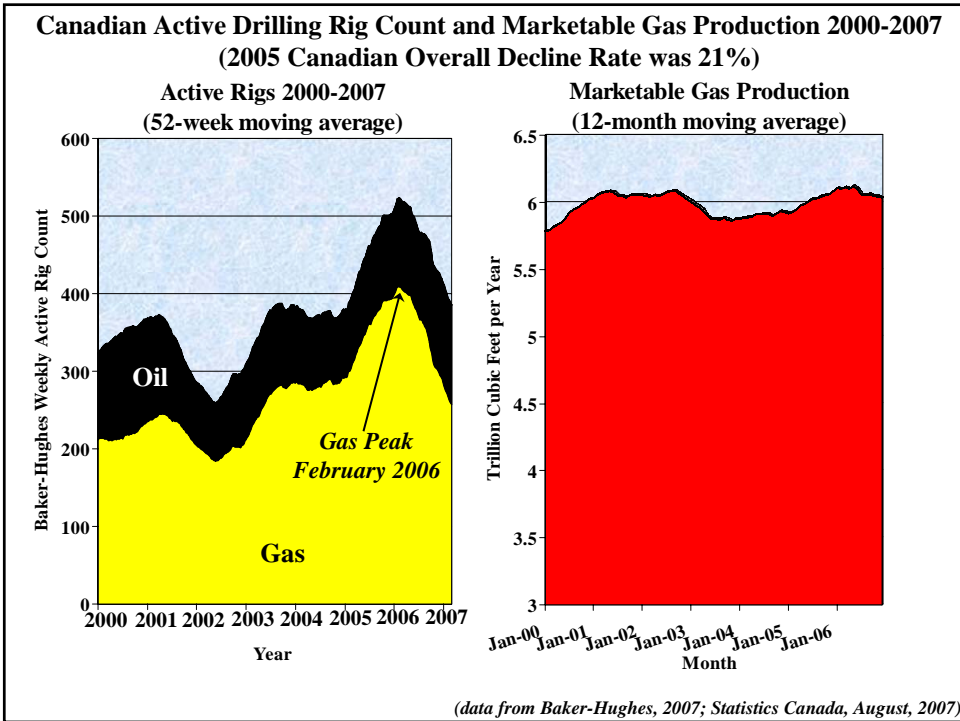
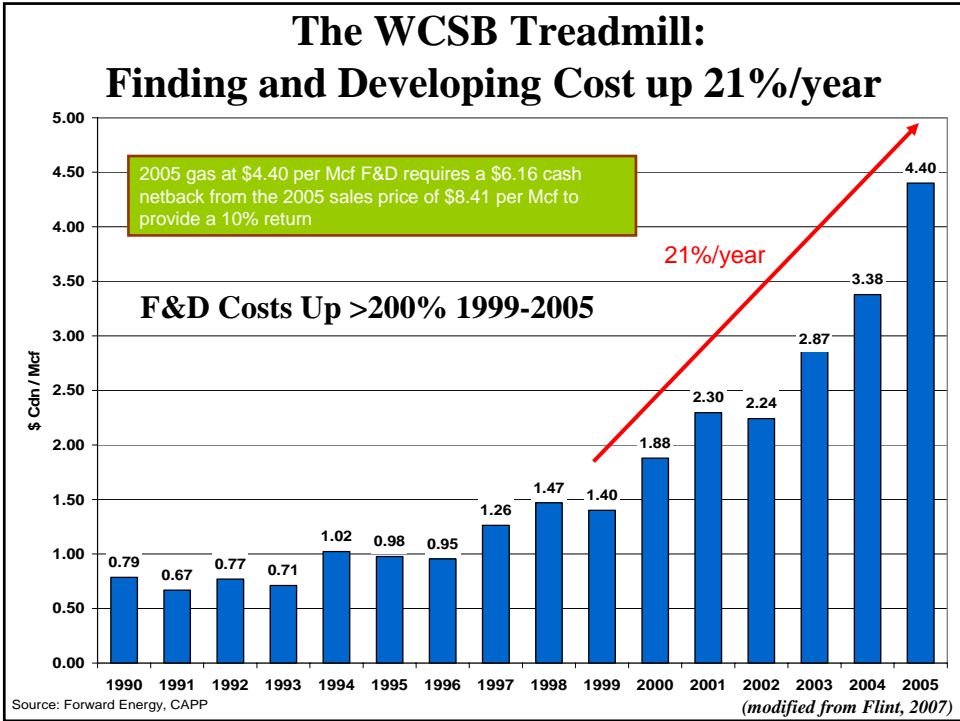




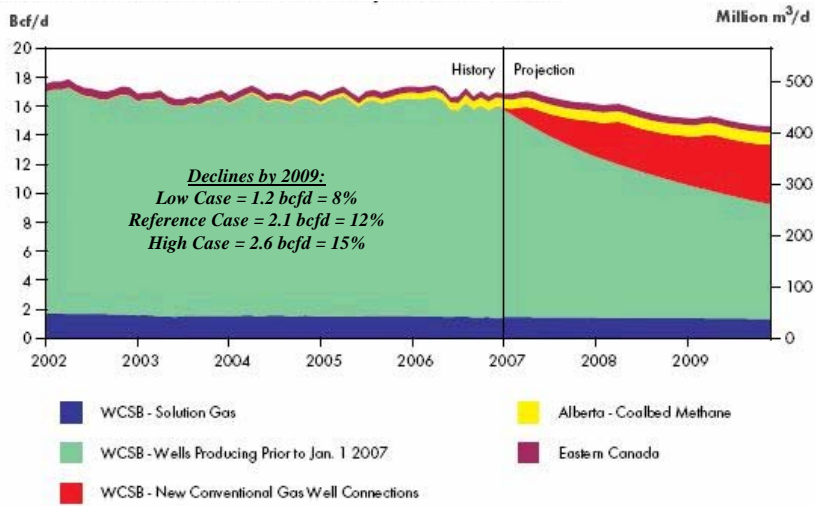






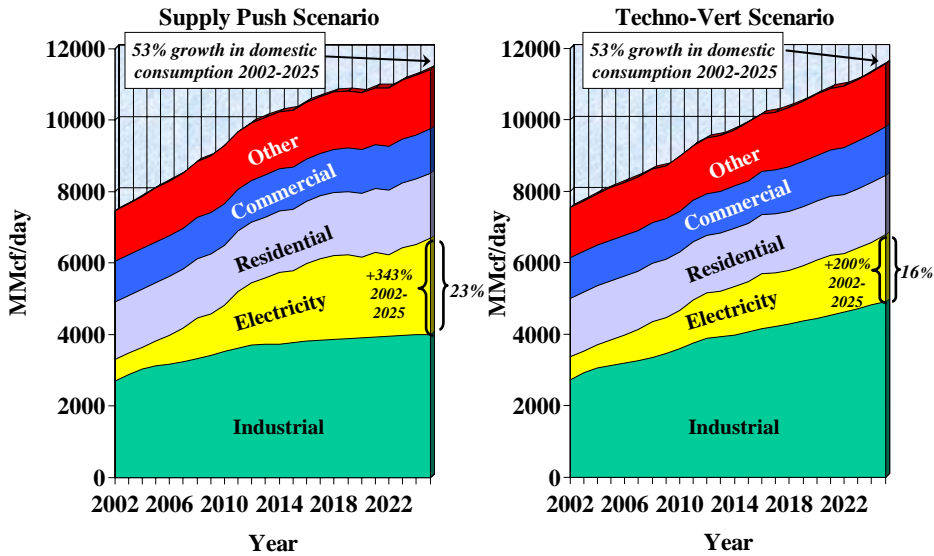


## National Energy Board Forecast for Canadian Gas Deliverability 2007-2010 – Reference Case

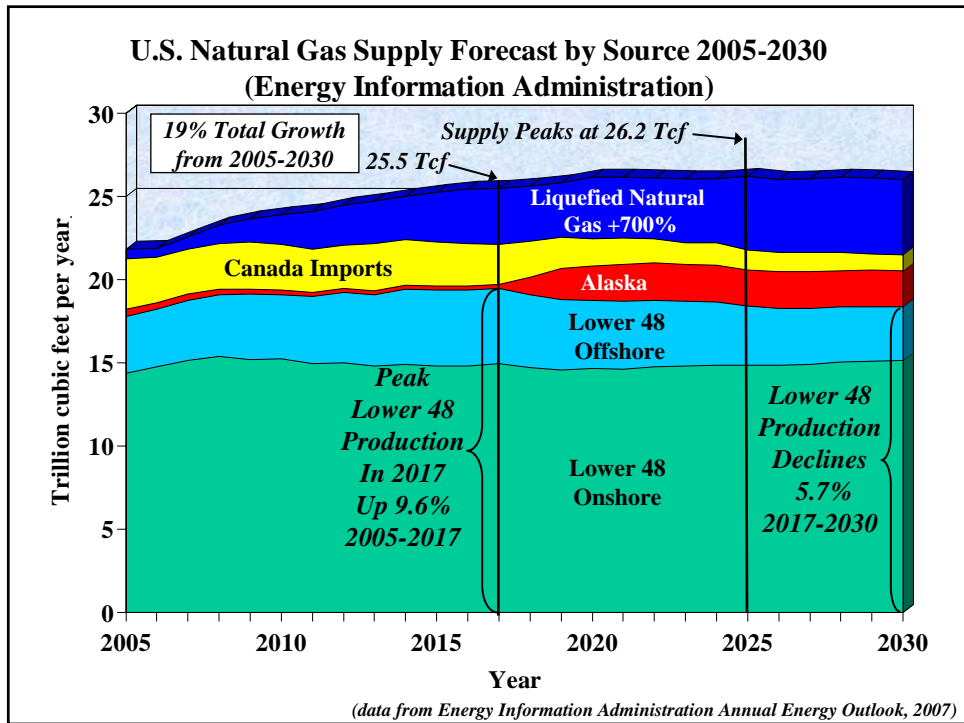
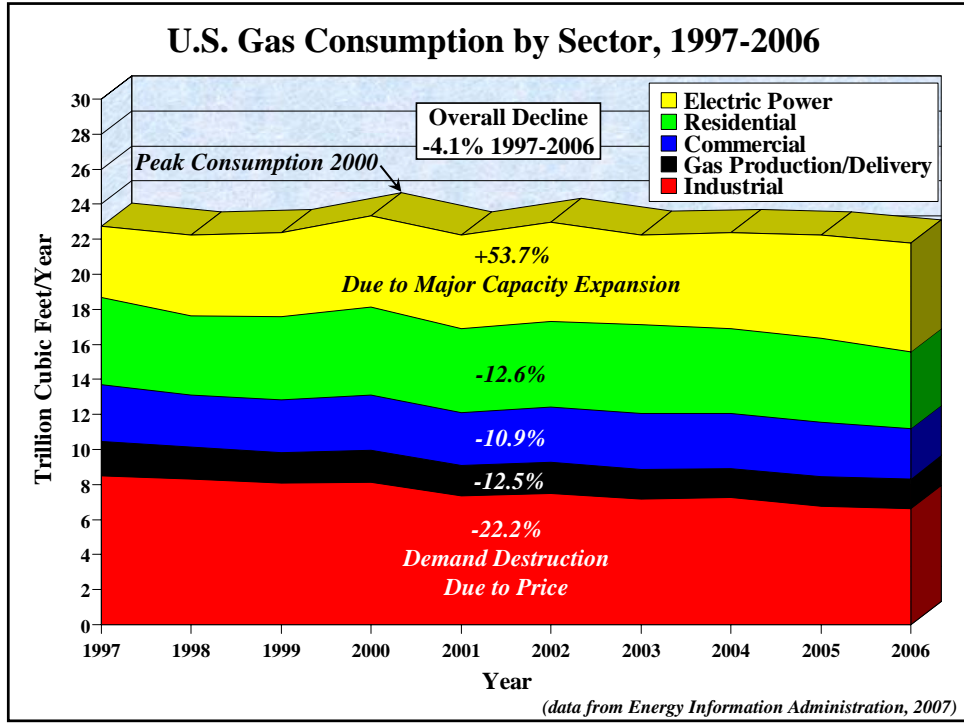


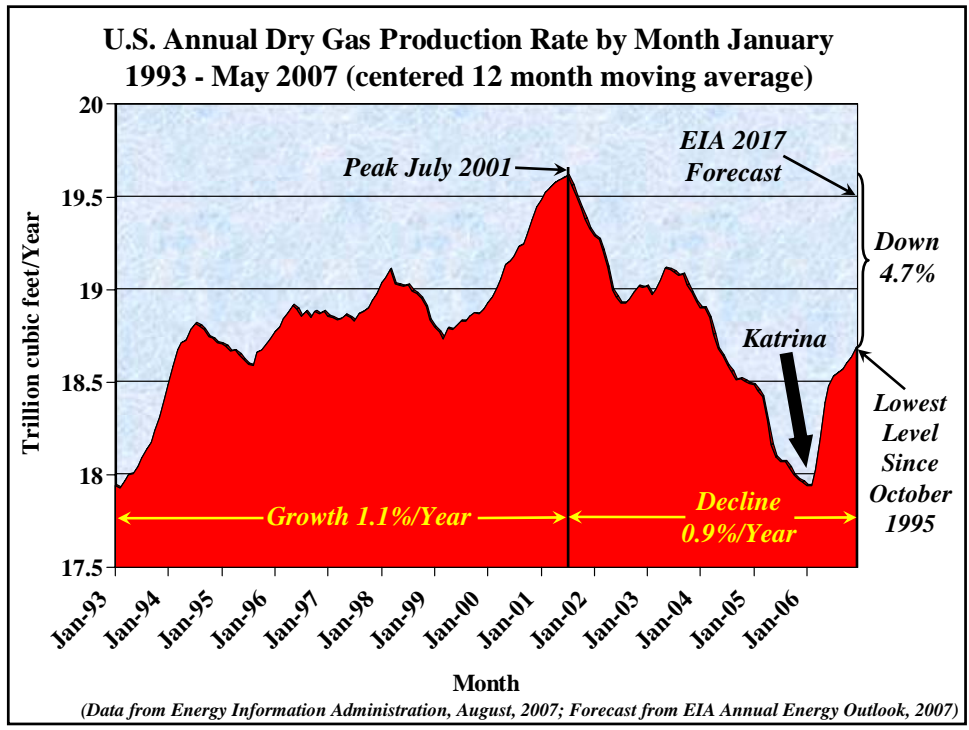
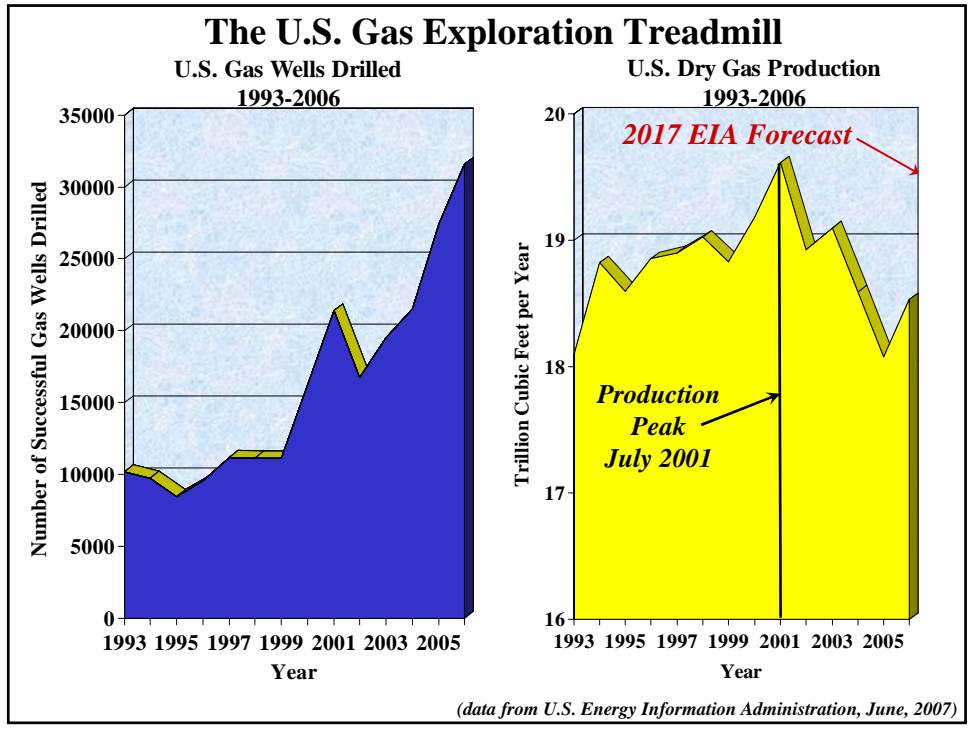
(from National Energy Board Reference Case, 2007)

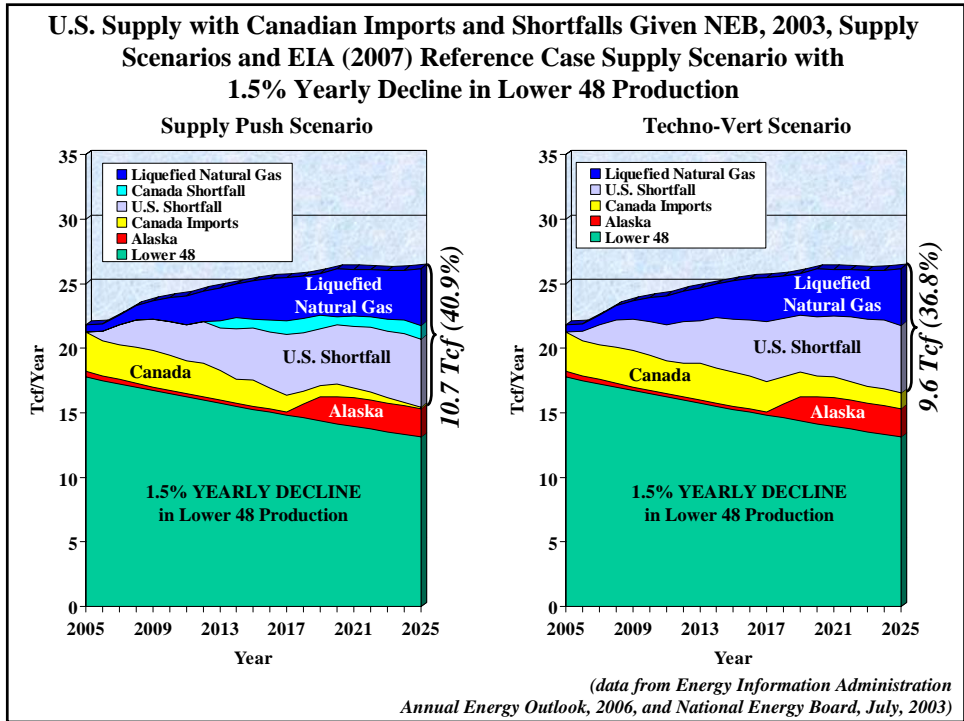
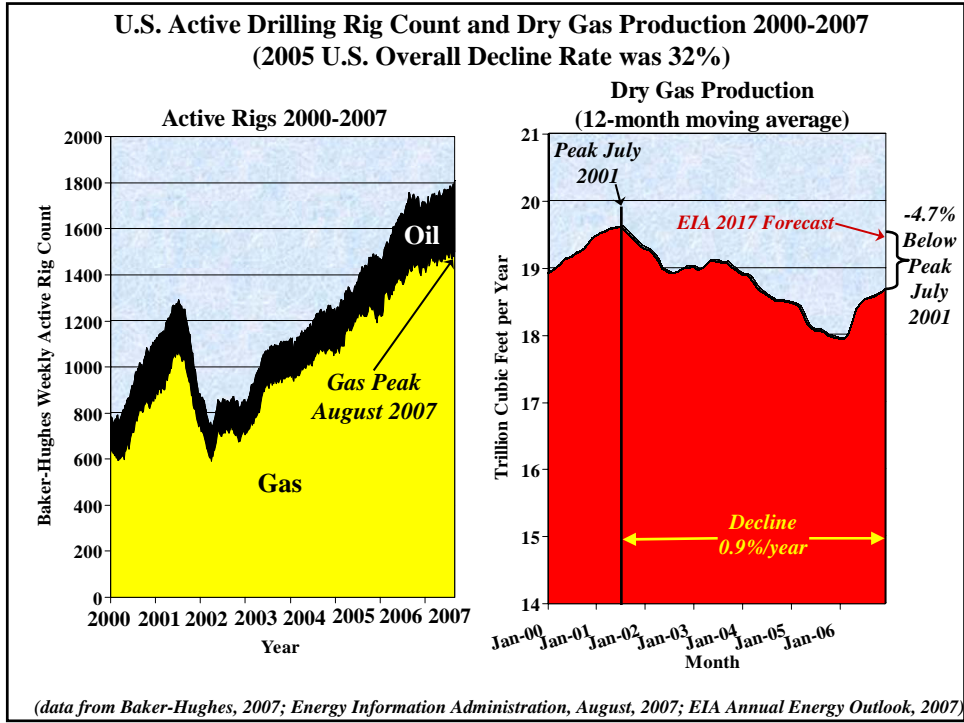
## NEB, 2003, Canadian Domestic Natural Gas Demand Scenarios by Sector, 2002-2025



(data from National Energy Board, July, 2003)

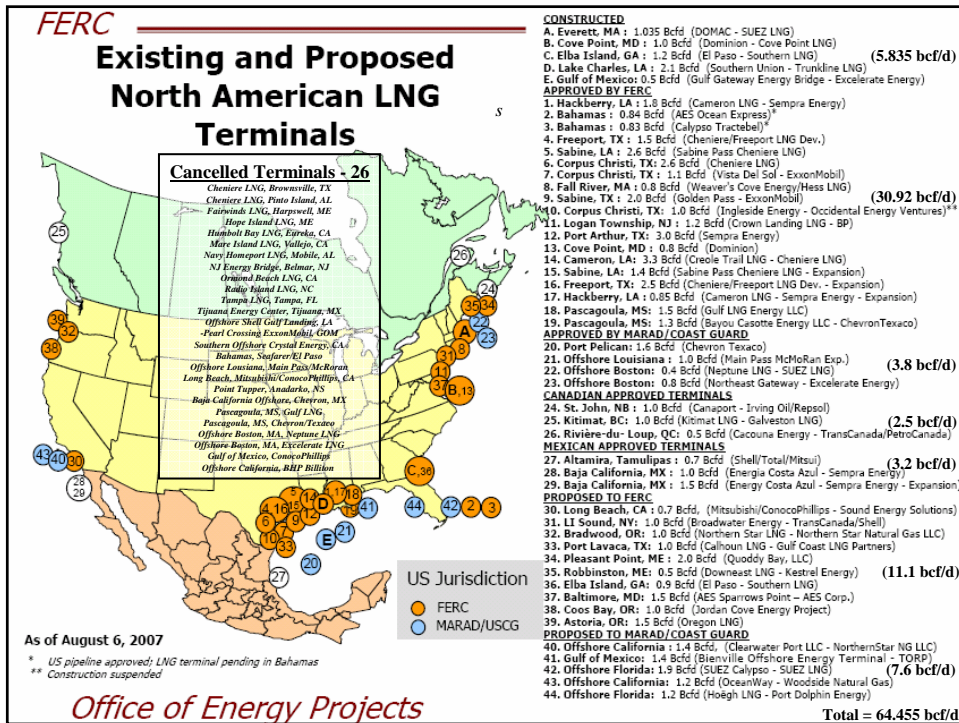
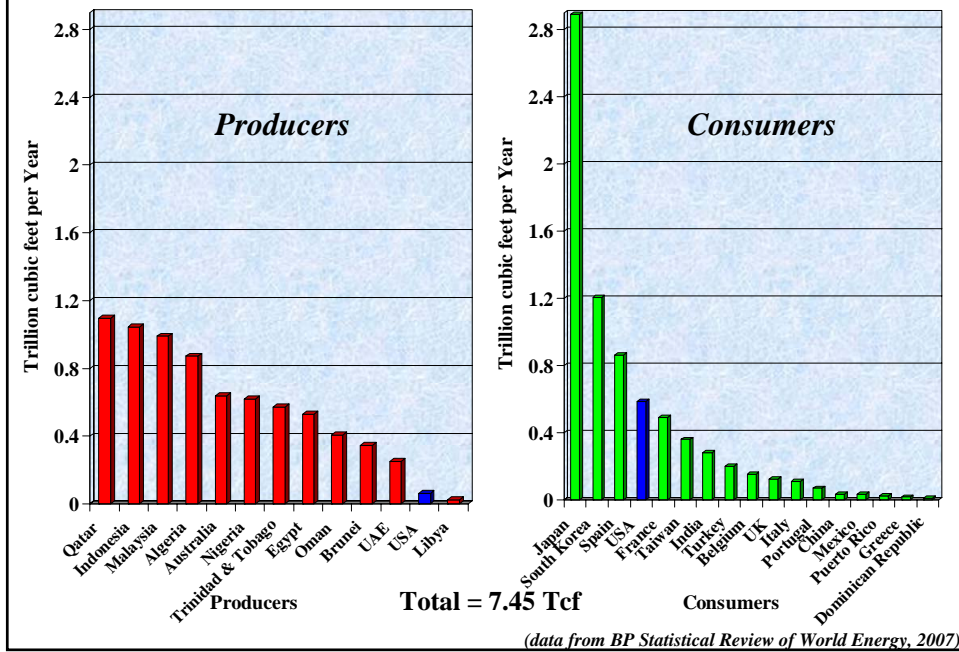




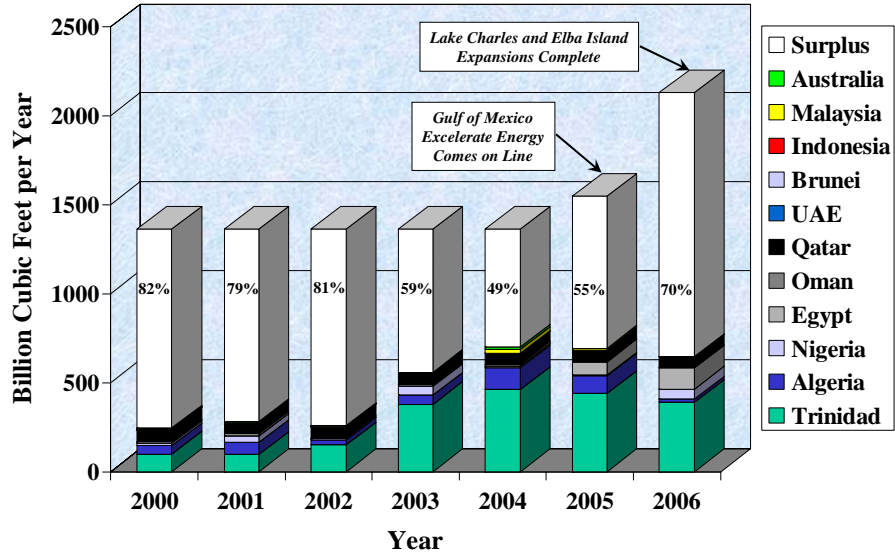




## LNG Producers and Consumers in 2006

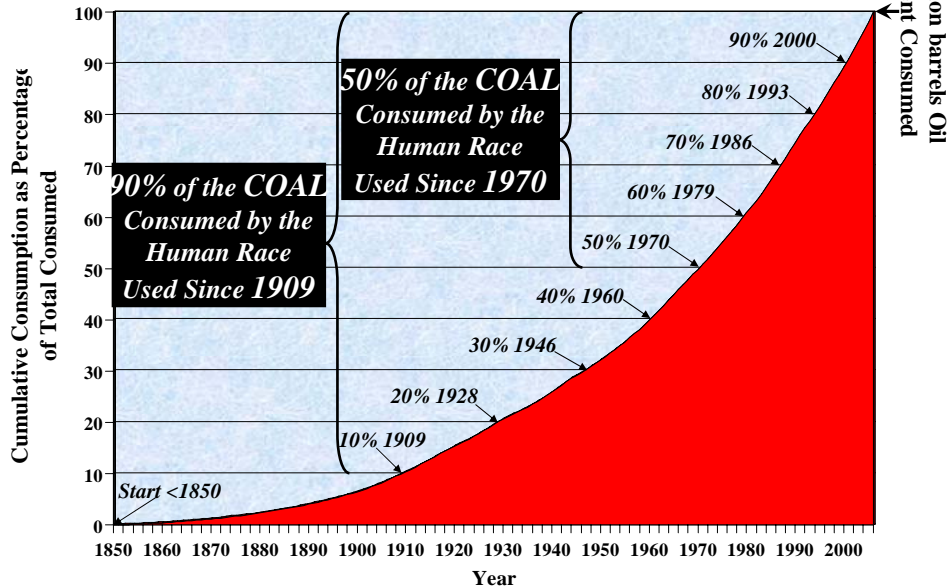


## LNG Imports and Surplus Capacity 2000-2006

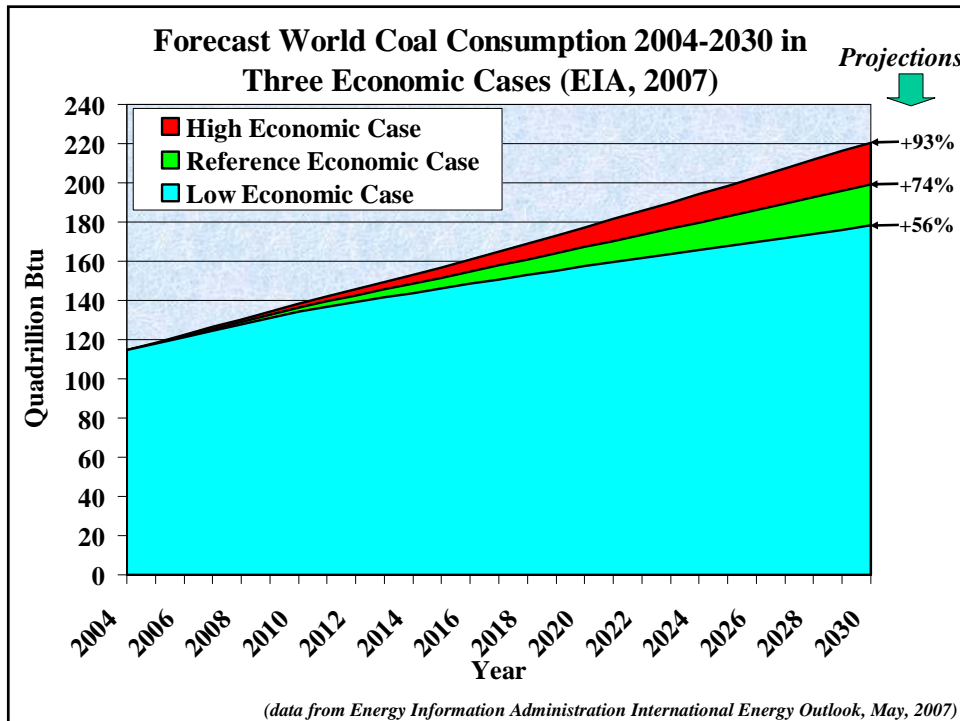
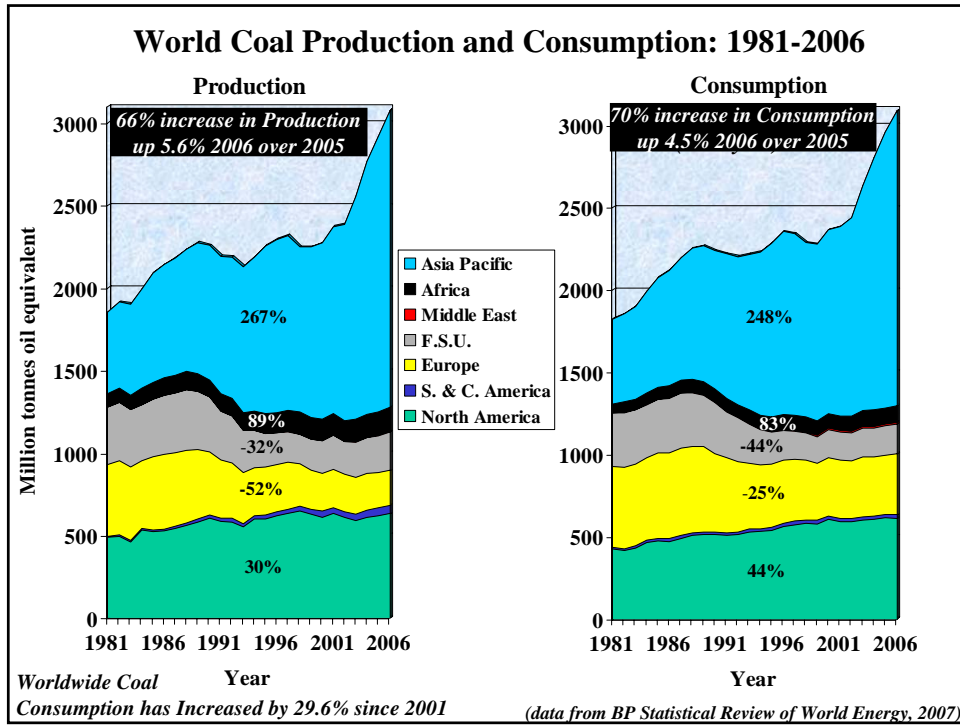


(data from Energy Information Administration September, 2007)

## Cumulative COAL Consumption by the Human Race as a Percentage of Total Consumption through Yearend 2006

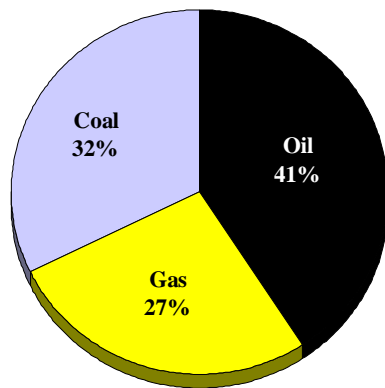


(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2007)

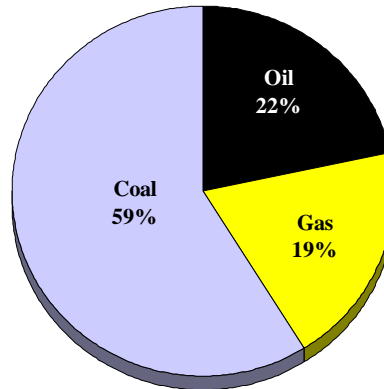


## World Hydrocarbon Consumption in 2006 Versus Remaining Hydrocarbon Energy Reserves

Consumption in 2006



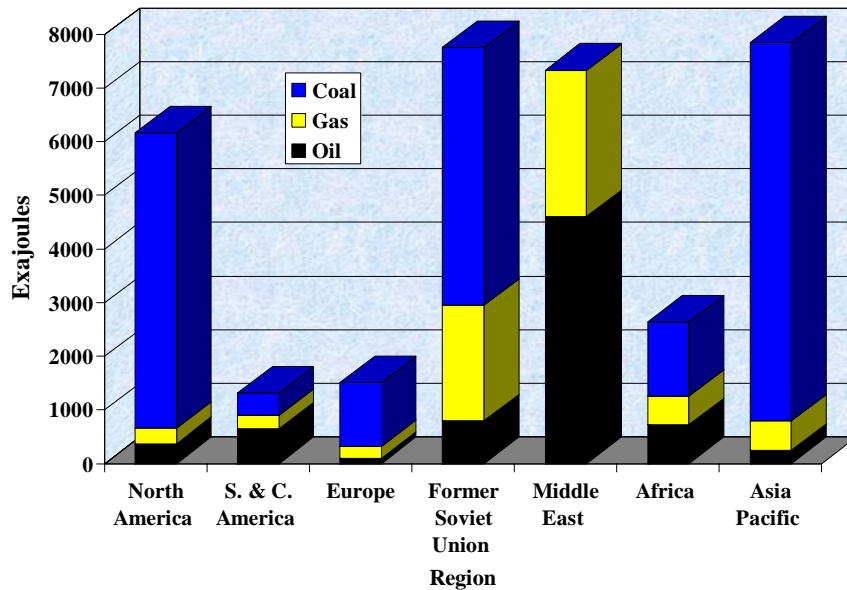
Remaining Reserves  
by Energy Content



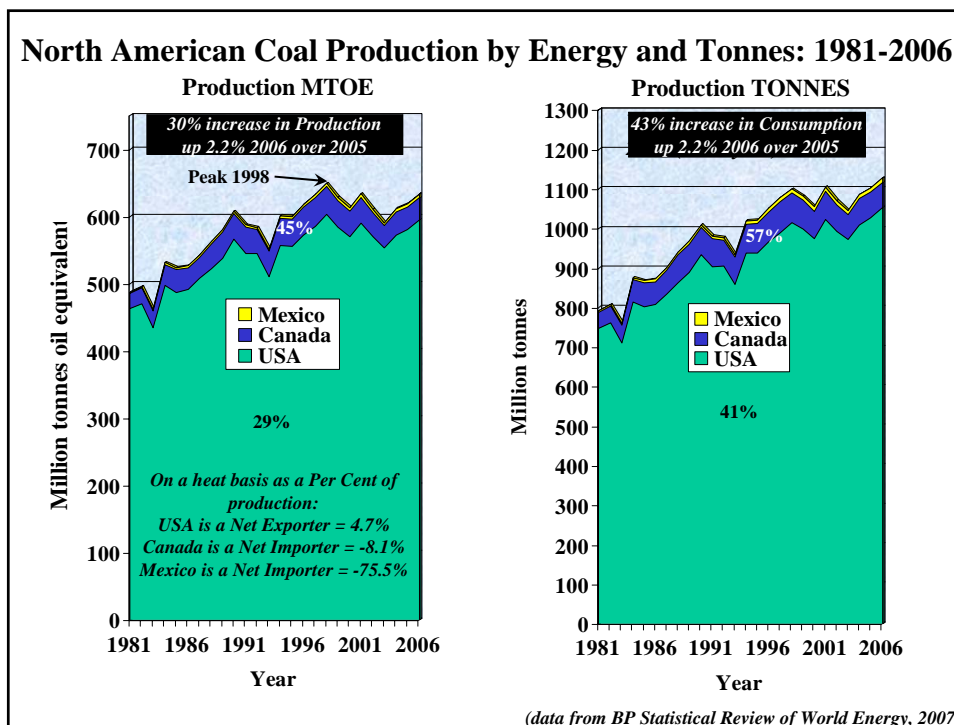
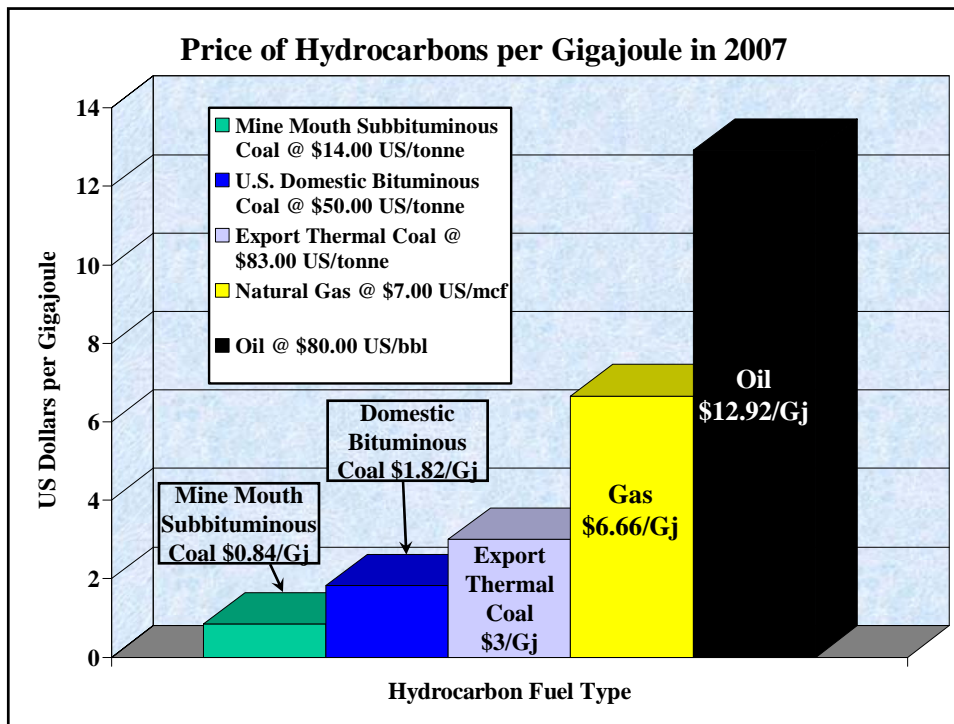
By Energy Content

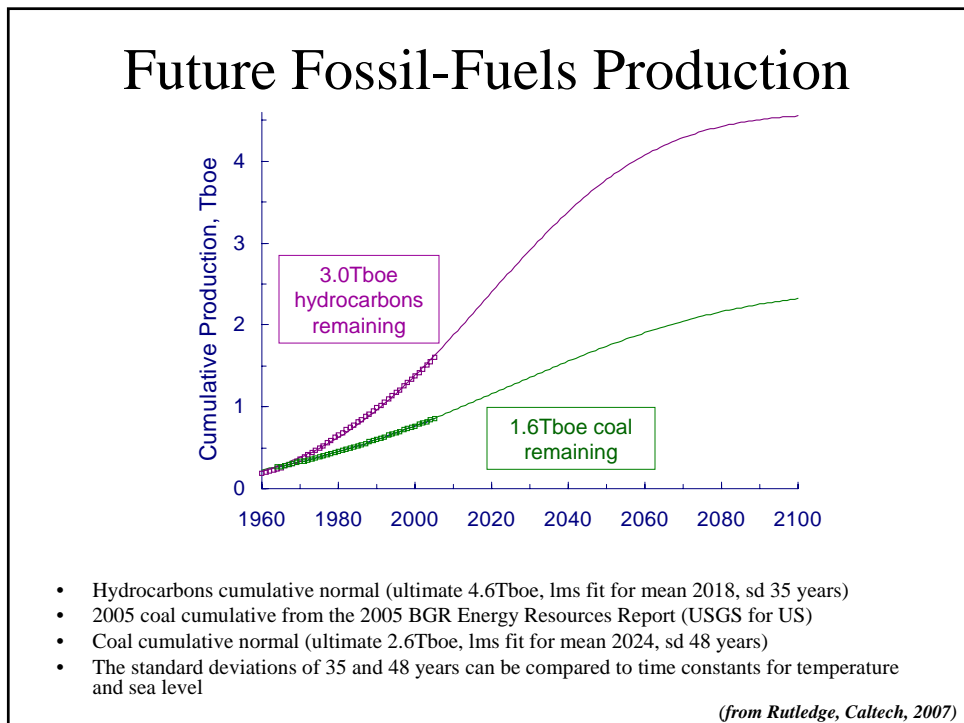
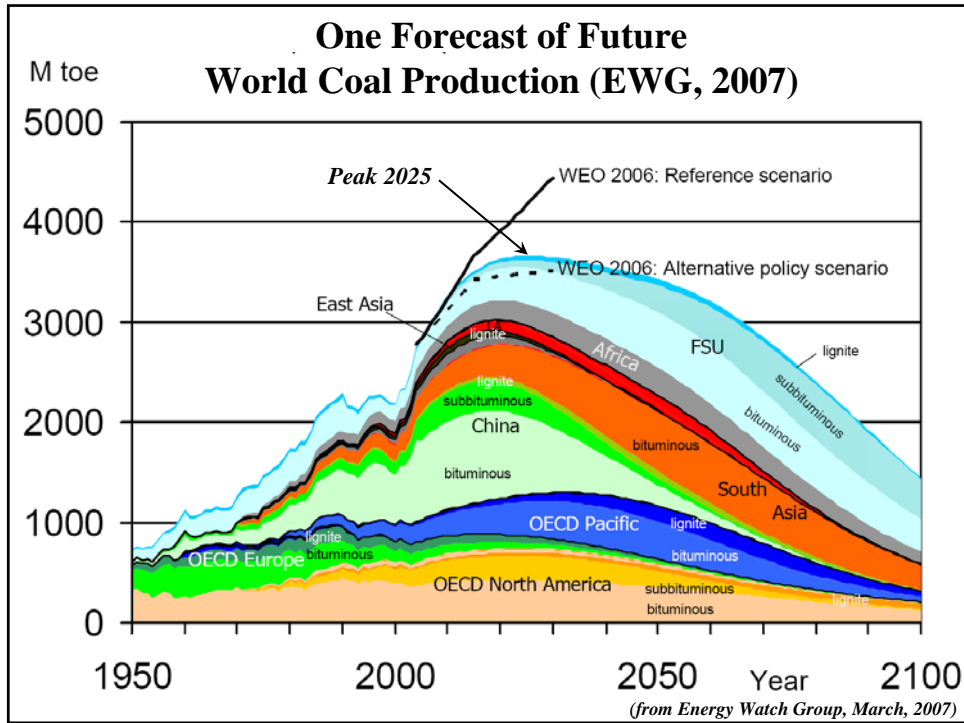
*(data from BP Statistical Review of World Energy, 2007)*

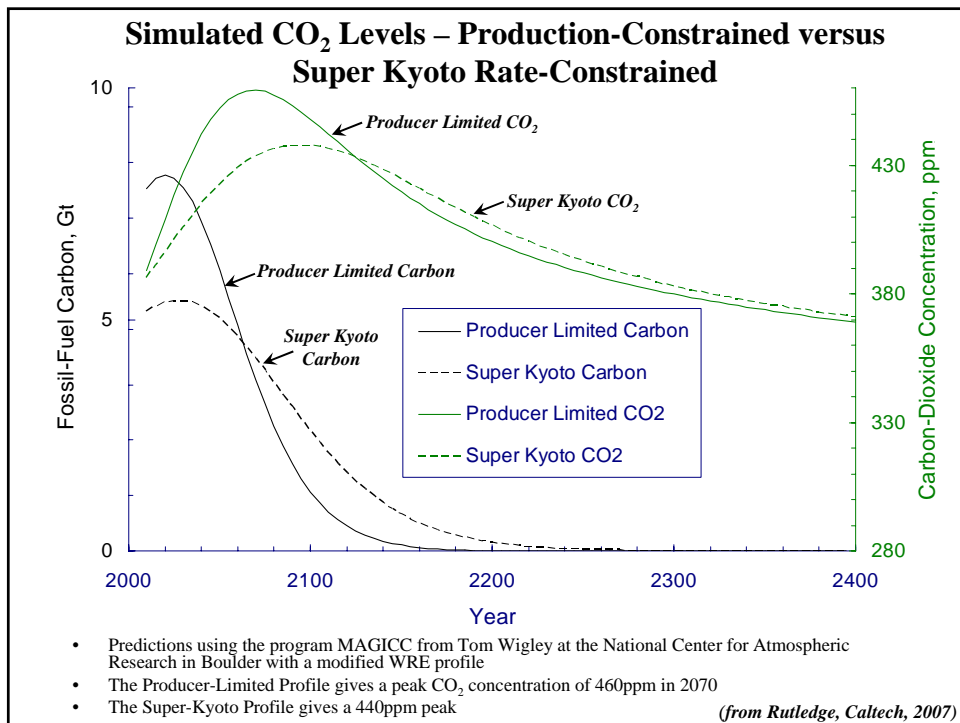
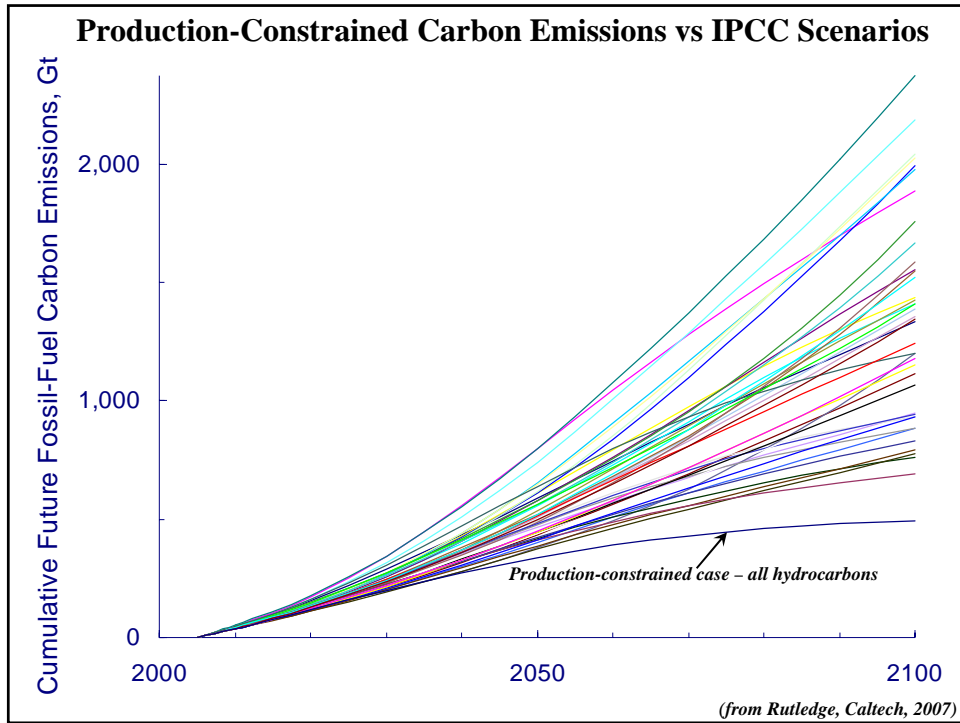
## World Remaining Recoverable Hydrocarbon Reserves by Energy Content (2006)

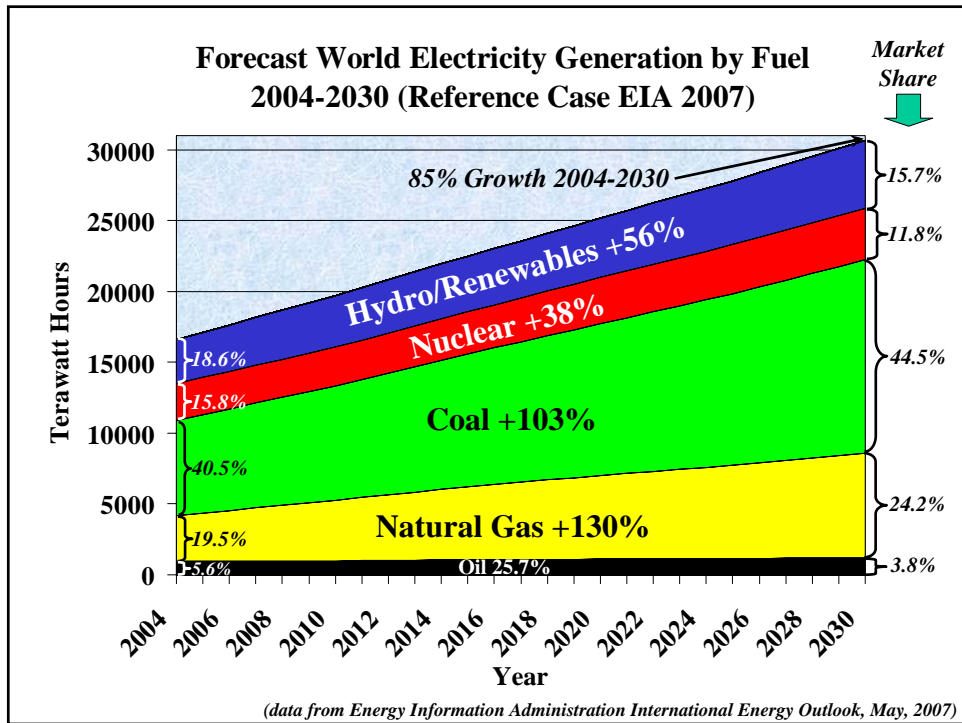
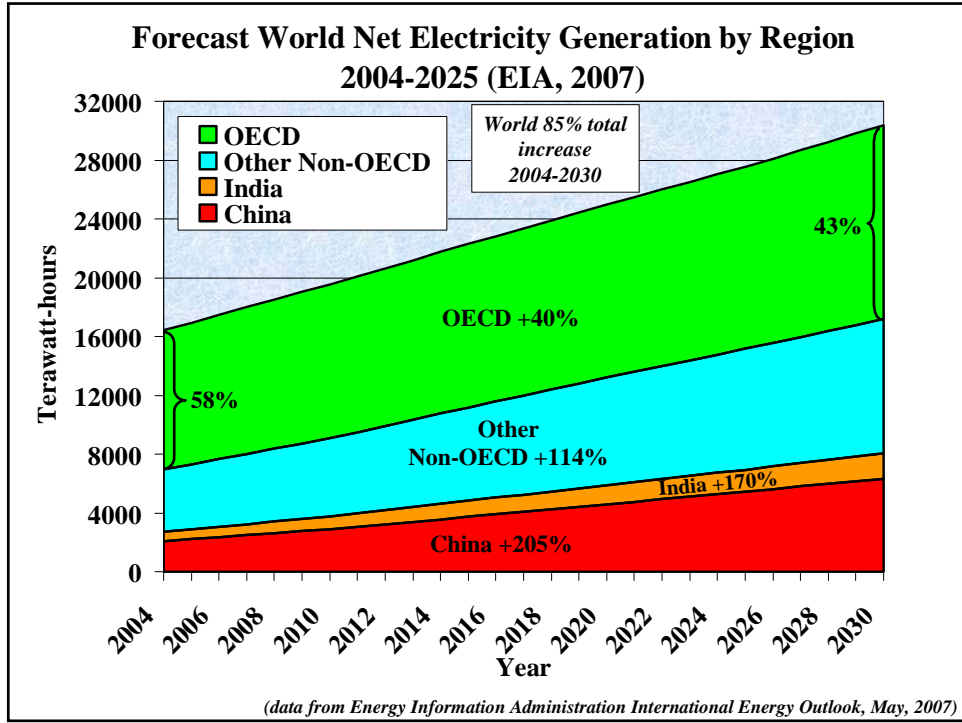


*(data from BP Statistical Review of World Energy, 2007)*

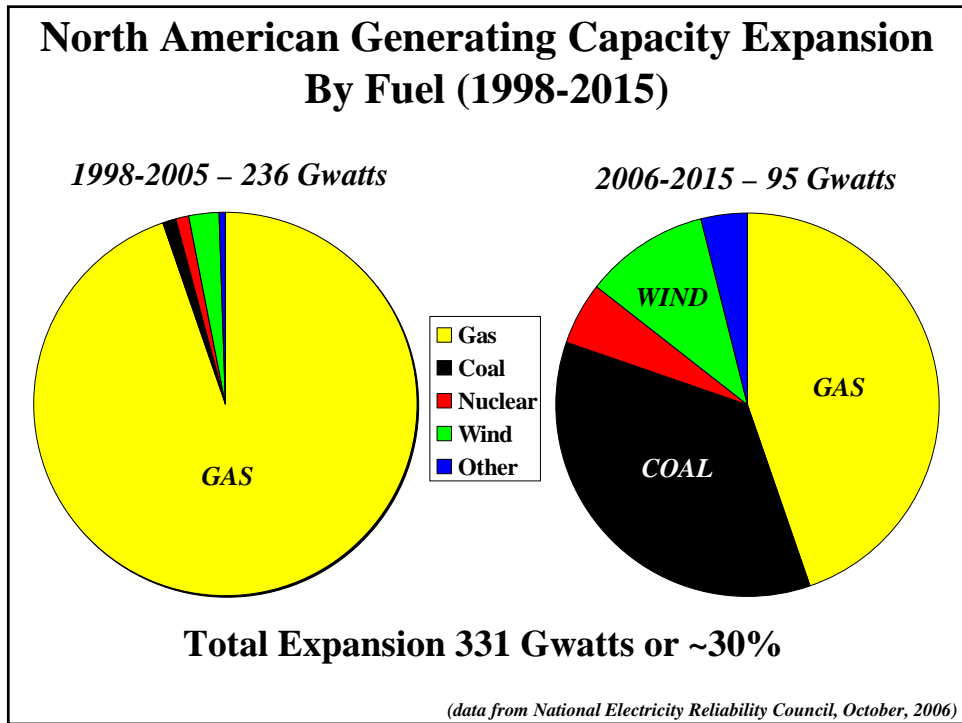
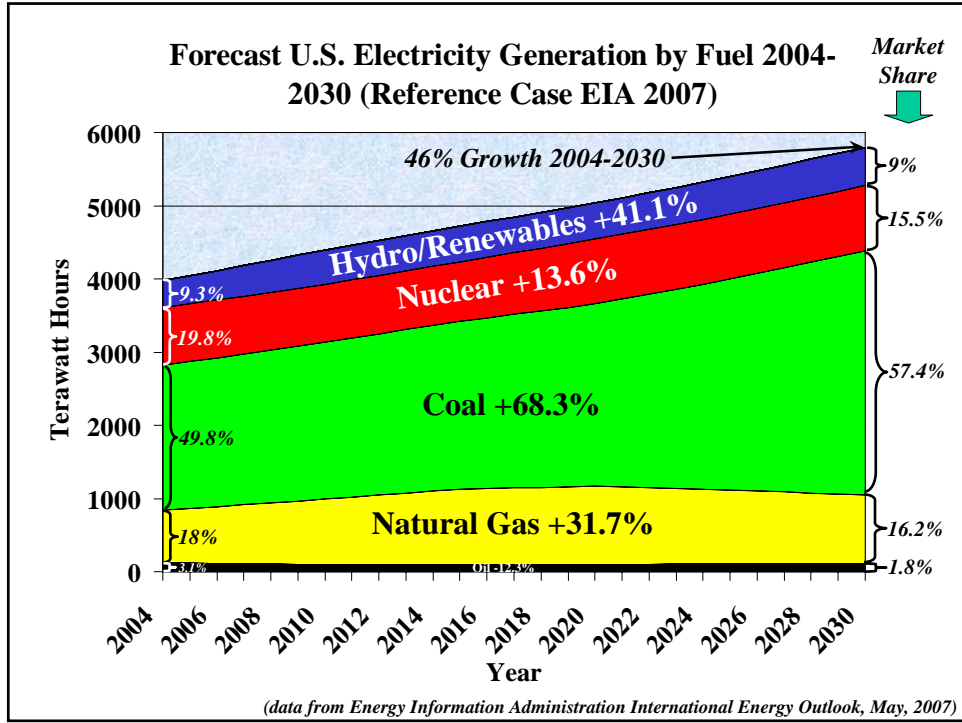






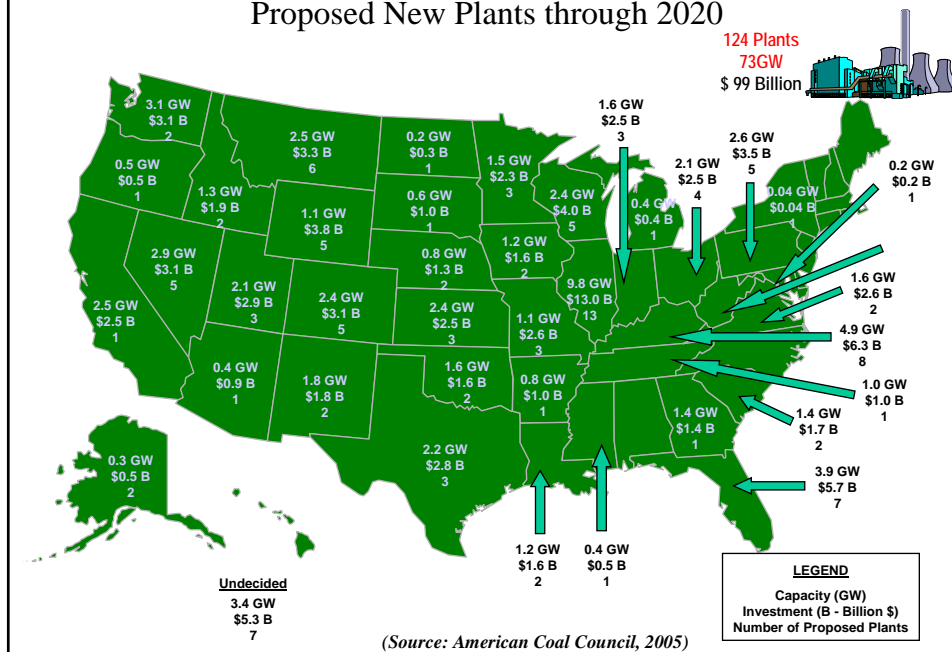






## Coal's Resurgence in U.S. Electric Power Generation

Proposed New Plants through 2020

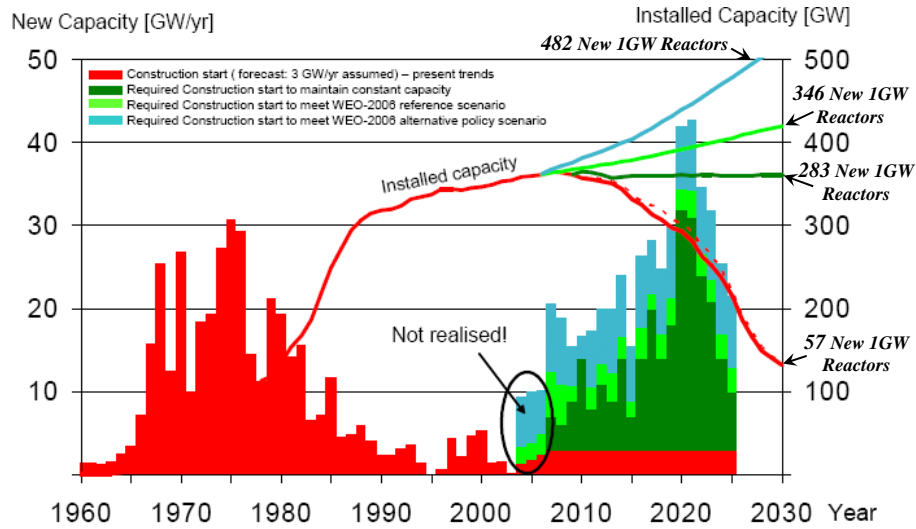


## WHAT ABOUT "CLEAN COAL"?

- Higher efficiency generation with new technologies can reduce CO<sub>2</sub> emissions by 25% given existing technologies – more in future, coupled with 99+% reduction in particulates, 99% in SO<sub>x</sub>, 90% in NO<sub>x</sub> and 90% in mercury
- The most efficient current technology is ultrasupercritical combustion at 43.5% - compared to 34% for a 60's era subcritical plant.
- Demark is a world leader in ultrasupercritical plants and utilizes them in district-heating applications with combined efficiencies exceeding 60% (which is better than combined-cycle gas).
- If we burn coal we must do so utilizing the best technologies to minimize emissions coupled with a very aggressive conservation and efficiency program.

# WHAT ABOUT "NUCLEAR"?

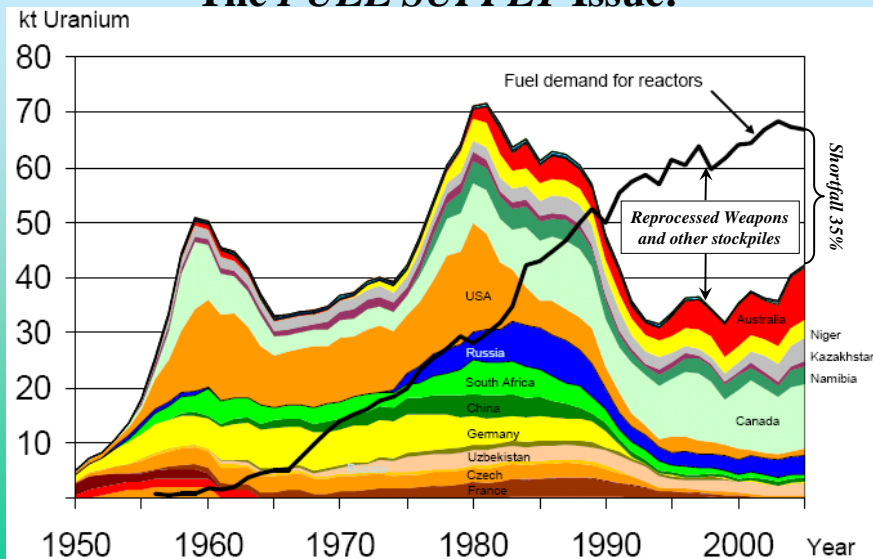
## Generation Capacity at Current Construction Levels and Levels Required to Maintain and/or Increase Nuclear Capacity by 2025



(adapted from Energy Watch Group, Paper EWG Series No. 1/2006, (2006); data from IAEA, (2006))

# WHAT ABOUT "NUCLEAR"?

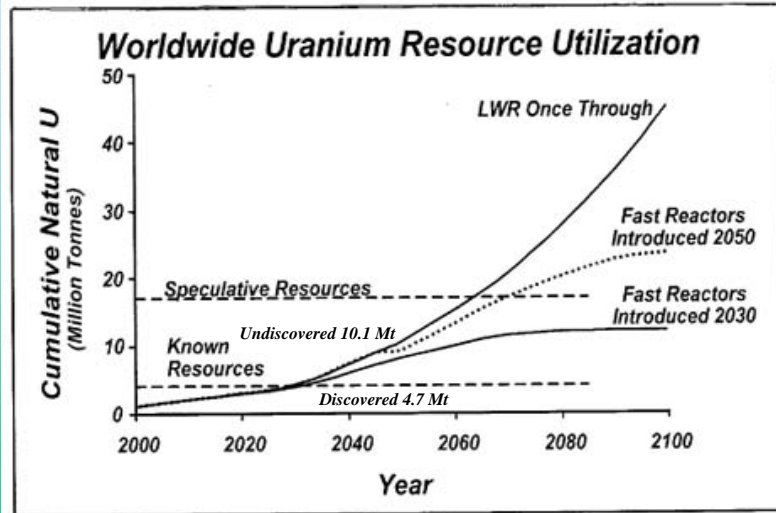
## The FUEL SUPPLY Issue:



(adapted from Energy Watch Group, Paper EWG Series No. 1/2006, (2006))

# WHAT ABOUT “NUCLEAR”?

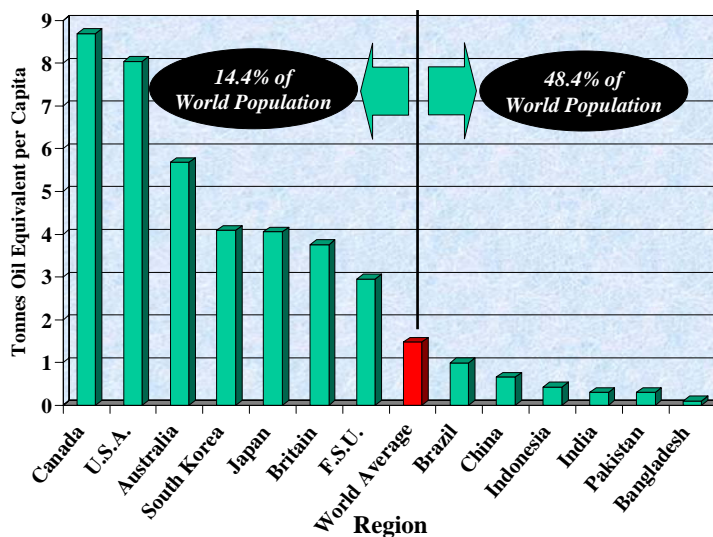
## The FUEL SUPPLY Issue:



(from Busby, September 2007, Sanders Research, based on Nuclear Energy Agency “Redbook” (2006) - <\$130kg/U)

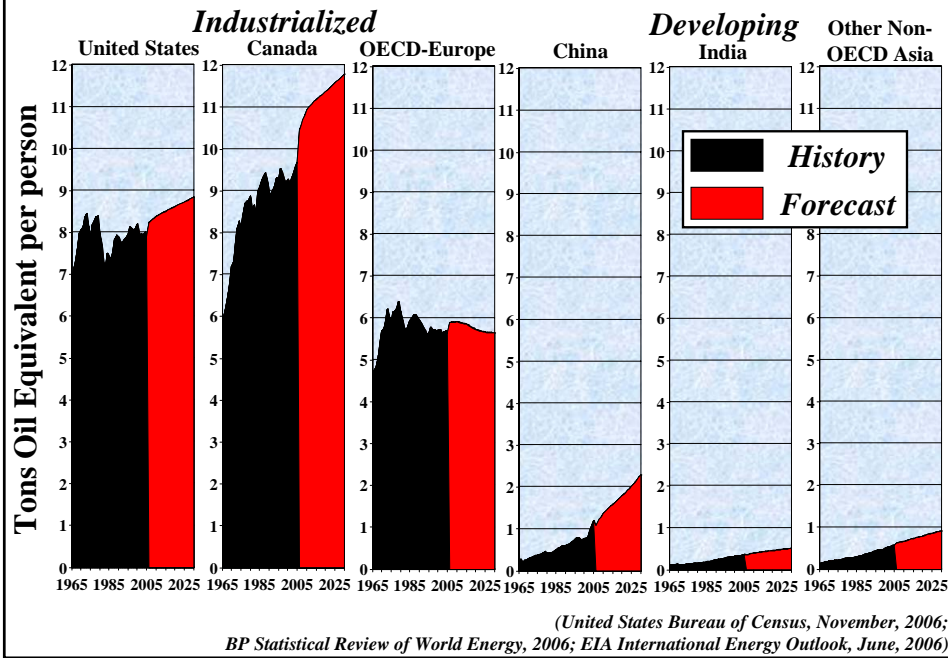
## There is a Great Inequity in Energy Consumption Worldwide

Primary Per Capita Energy Consumption of Selected Countries in 2001

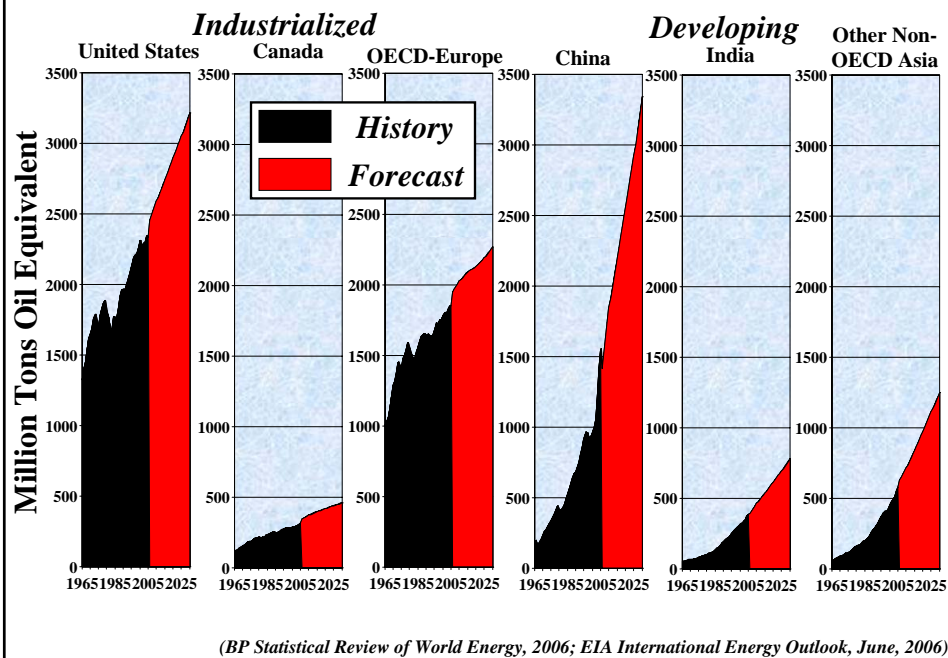


(data from BP Statistical Review of World Energy, 2002, and United Nations World Database, 2002)

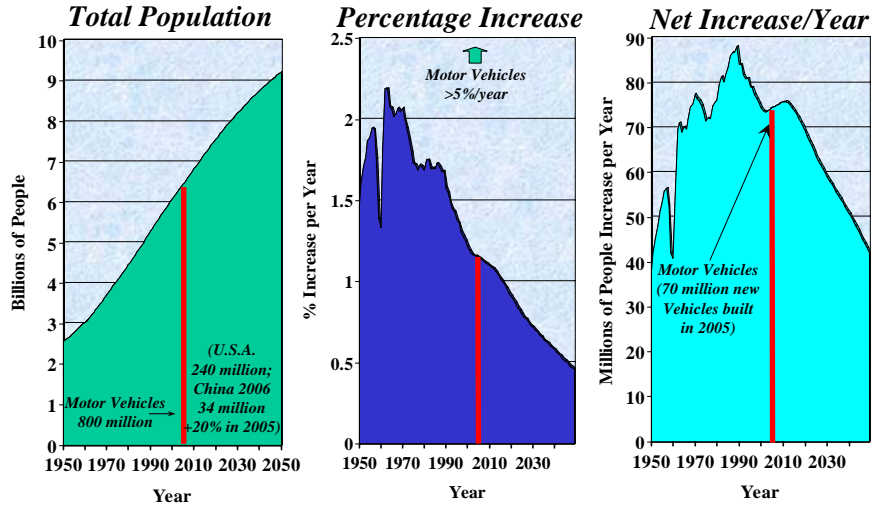
## Per Capita Consumption – History and Forecast (1965-2030)



## Total Consumption – History and Forecast (1965-2030)

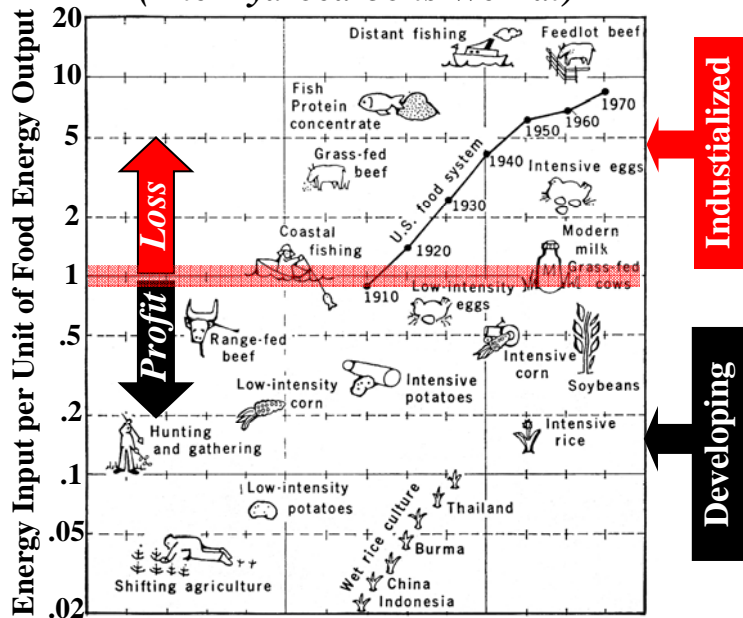


## World Population Increase 1950-2050



(U.S. Bureau of Census, 2005; Hirsch, 2005;  
 Globe and Mail February 17, 2006; Vancouver Sun, July 22, 2006; National Post September 16, 2006)

## Trends in Energy Investment for Food Production (The Hydrocarbons We Eat)



(Adapted from Science, April 19, 1974)

## Summary

- The five-fold expansion of global population since 1850 has been made possible by non-renewable fuels, the consumption of which pervades all aspects of society – food, transportation, communication etc.
- The eight-fold expansion of global per capita energy consumption since 1850 has been entirely a result of consumption of non-renewable energy
- Despite the hype, renewable energy technologies are EXTREMELY UNLIKELY to be able to replace non-renewable energy in existing energy demand forecasts – a sustainable future lies in radically reducing and rethinking energy consumption
- Natural gas is unfortunately, as with oil and coal an irreplaceable one-time resource
- North America is on an Exploration Treadmill with respect to conventional gas and new supplies from unconventional sources are only serving to slow the rates of decline
- LNG will help offset these declines but North America will be in competition with other countries who also see LNG as a solution

## Summary

- Research on new sources such as tight gas, shale gas, gas hydrates etc. must continue but it would be a huge mistake to assume these sources will be there as an excuse to perpetuate business-as-usual based on what we know so far
- Coal represents the most abundant remaining hydrocarbon resource in North America and is forecast to be the largest source of generation by far in both the World and the US through 2030 – but must utilize the latest technologies preferably with heat capture and utilization
- Even maintaining nuclear's contribution to the World's electricity generation mix implies a major program of repowering, decommissioning and replacing the aging nuclear fleet
- The US (and later Canada) will become increasingly more vulnerable to the vagaries of imported supplies, not just for oil and natural gas, but for the products produced from them - petrochemicals, fertilizers etc.
- There are some crucial decisions to be made with respect to the future energy security of North America and the World - the future represents a huge challenge and these decisions must be made objectively without ruling out any incremental contribution to demand reduction or supply - we will likely need them all

**Despite the Proponents of Infinite Growth  
and the Ability of the Markets and Technology  
to Overcome all Obstacles there is One  
Supreme Overriding Principle:**

***ENERGY CONSUMPTION CANNOT  
EXCEED ENERGY SUPPLY***

***Therefore the reality of **FINITE** nonrenewable  
energy resources will force a transition to a  
sustainable energy future.***

***The Only Question Is:  
HOW WILL THIS TRANSITION OCCUR?***



***Thank you***

**Contact Coordinates:  
Dave Hughes  
dhughes @ nrcan.gc.ca  
403 292-7117**



# 2007 Houston World Oil Conference

Proceedings



*Energy Action for a Healthy Economy  
and a Clean Environment*

- [Conference Program](#)
- [Conference DVD](#)
- [Video Highlights](#)
- [Peak Oil Review](#)
- [ASPO-USA](#)