Energy Supply/Demand Trends and Forecasts: *Implications for a Sustainable Energy Future in Canada and the World (including Ontario)*

The Future of Coal in Ontario
Toronto, Ontario
May 10, 2007

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Natural Resources Canada
GEOLOGICAL SURVEY OF CANADA
CALGARY

Ressources naturelles Canada
COMMISSION GÉOLOGIQUE DU CANADA
CALGARY

Points to be covered:

- Global and North American Energy Overview – Trends from the Past and Forecasts of the Future:

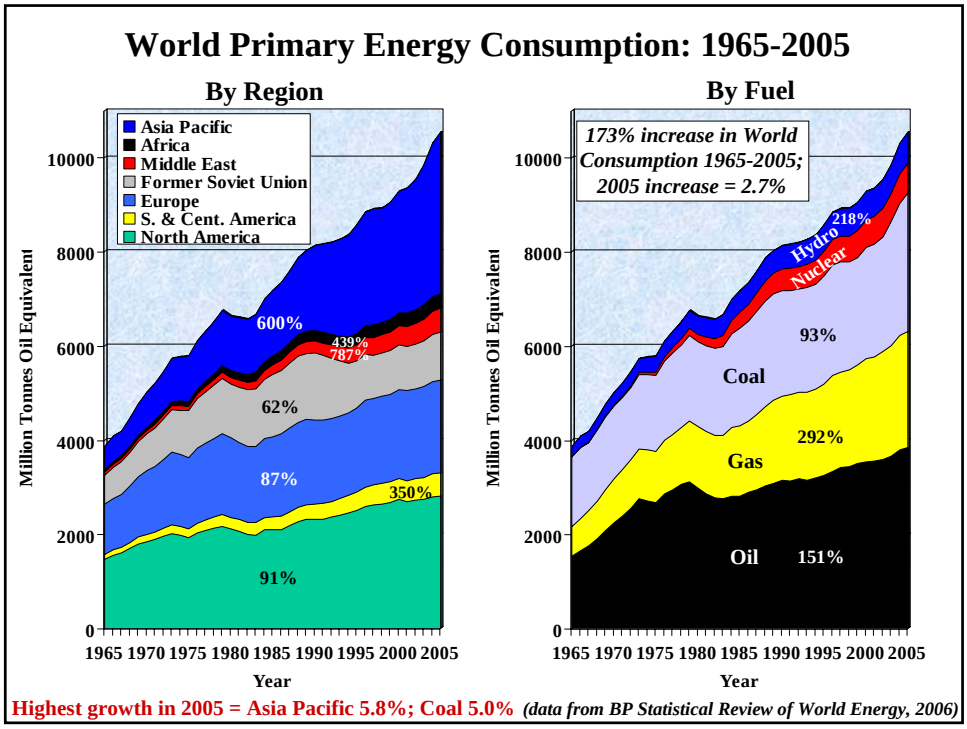
- ***Oil, Gas, Coal, Alternatives***
- ***Global and North American Energy Security Implications – Resources, Deliverability, Geopolitics***
- ***Electricity Past generation and forcasts of future generation by fuel with energy security implications (including Ontario)***

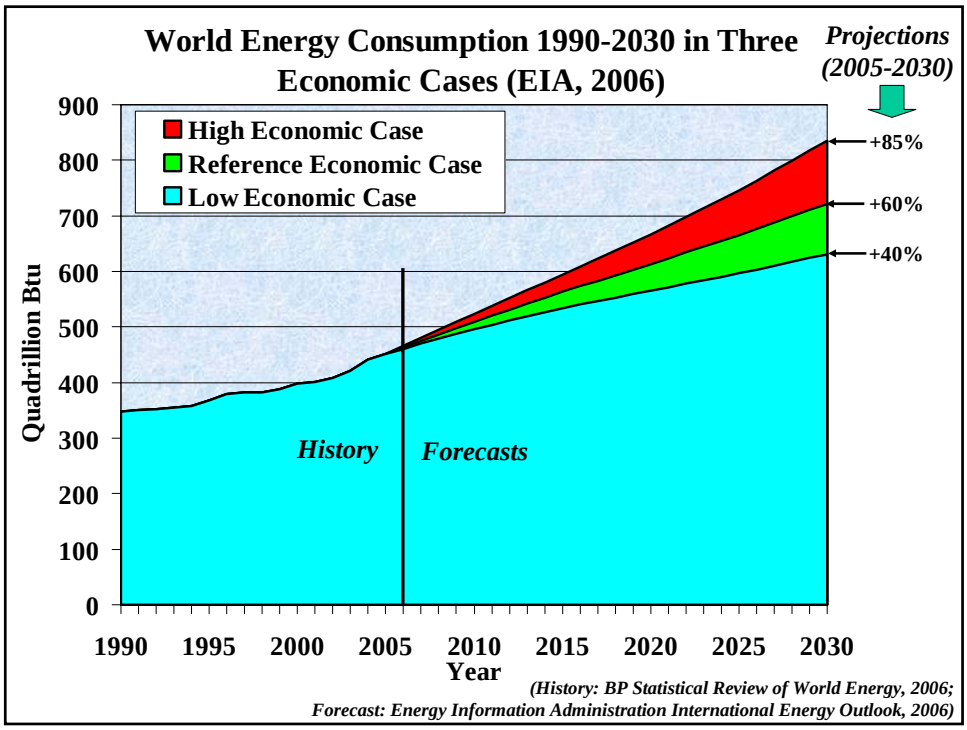
- Overriding Energy Challenges:

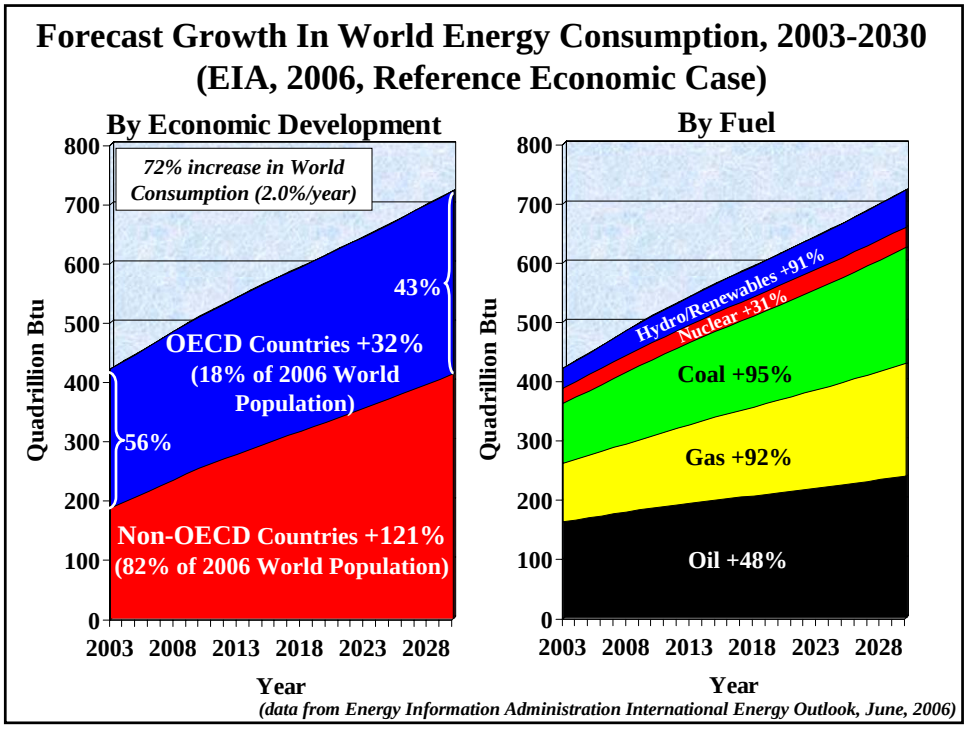
- ***Economic Well-being through "Infinite Growth" - Is This Possible?***
- ***Third World Aspirations of First World Consumption***

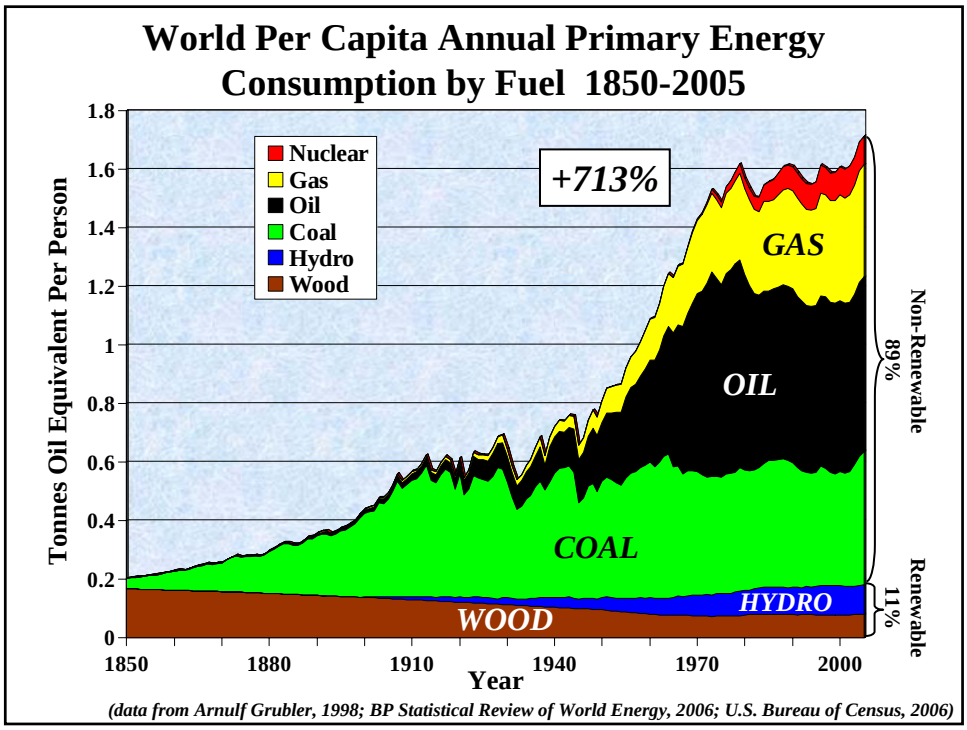
- The Hard Choices Going Forward to a more Sustainable Energy Future

- ***What does and doesn't make sense going forward***

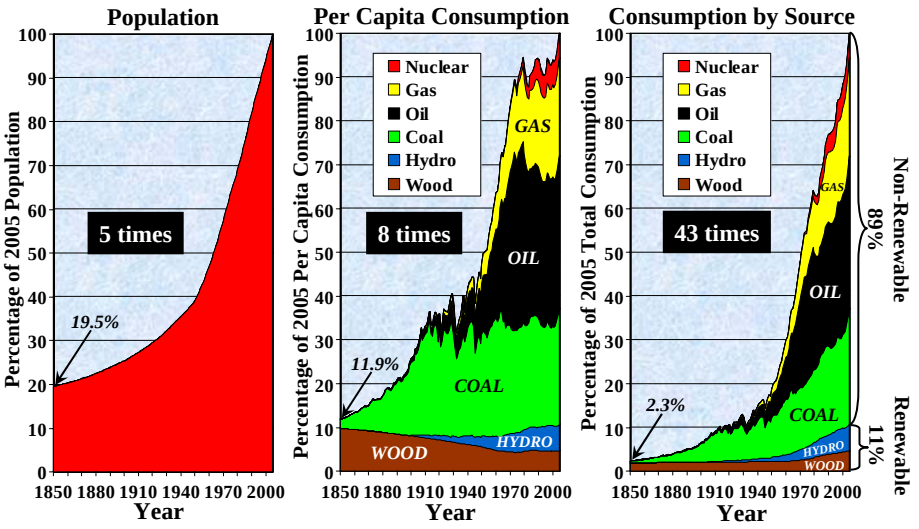

World Primary Energy Consumption: 1965-2005
By Region
By Fuel
Asia Pacific
Africa
Middle East
Former Soviet Union
Europe
S. & Cent. America
North America
Million Tonnes Oil Equivalent
10000
8000
6000
4000
2000
0
600%
439%
787%
62%
87%
350%
91%
1965 1970 1975 1980 1985 1990 1995 2000 2005
Year
173% increase in World Consumption 1965-2005; 2005 increase = 2.7%
218%
Hydro
Nuclear
93%
Coal
292%
Gas
Oil
151%
Highest growth in 2005 = Asia Pacific 5.8%; Coal 5.0%
(data from BP Statistical Review of World Energy, 2006)


World Energy Consumption 1990-2030 in Three Economic Cases (EIA, 2006)
Projections (2005-2030)
High Economic Case
Reference Economic Case
Low Economic Case
+85%
+60%
+40%
Quadrillion Btu
900
800
700
600
500
400
300
200
100
0
History
Forecasts
1990 1995 2000 2005 2010 2015 2020 2025 2030
Year
(History: BP Statistical Review of World Energy, 2006;
Forecast: Energy Information Administration International Energy Outlook, 2006)


Forecast Growth In World Energy Consumption, 2003-2030
(EIA, 2006, Reference Economic Case)
By Economic Development
By Fuel
72% increase in World Consumption (2.0%/year)
43%
OECD Countries +32%
(18% of 2006 World Population)
56%
Non-OECD Countries +121%
(82% of 2006 World Population)
Hydro/Renewables +91%
Nuclear +31%
Coal +95%
Gas +92%
Oil +48%
Quadrillion Btu
Year
2003 2008 2013 2018 2023 2028
0 100 200 300 400 500 600 700 800
(data from Energy Information Administration International Energy Outlook, June, 2006)


World Per Capita Annual Primary Energy Consumption by Fuel 1850-2005
Nuclear
Gas
Oil
Coal
Hydro
Wood
+713%
GAS
OIL
COAL
HYDRO
WOOD
Non-Renewable 89%
Renewable 11%
Tonnes Oil Equivalent Per Person
Year
1850 1880 1910 1940 1970 2000
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2006; U.S. Bureau of Census, 2006)

World Population, Per Capita and Primary Energy Consumption, 1850-2005, as a Percentage of 2005 Levels



(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2006; U.S. Bureau of Census, 2006)

Summary

- **Hydrocarbons provided 88% of the world's primary energy in 2005**

- **Forecasts suggest that 86.5% of a greatly expanded energy demand will continue to be provided by hydrocarbons in 2030**

- **Most of the balance of energy supply will be provided by large hydro and nuclear – sources with their own environmental problems**

- **The Question is: *IS THIS SUSTAINABLE?***

…… Lets look in more detail at oil, gas and coal

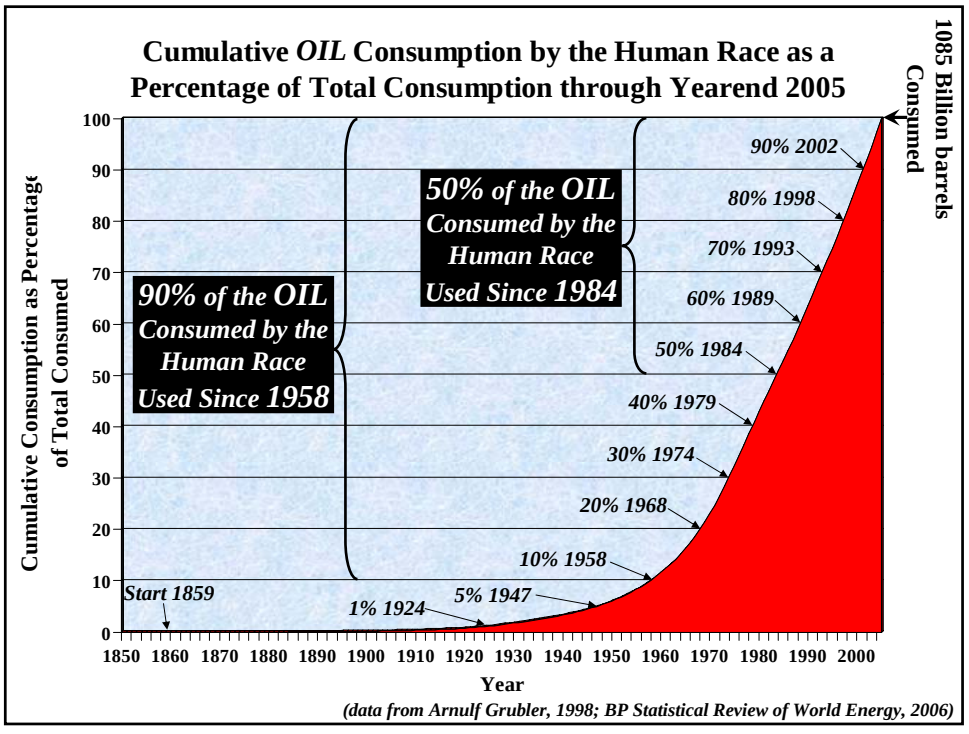
OIL

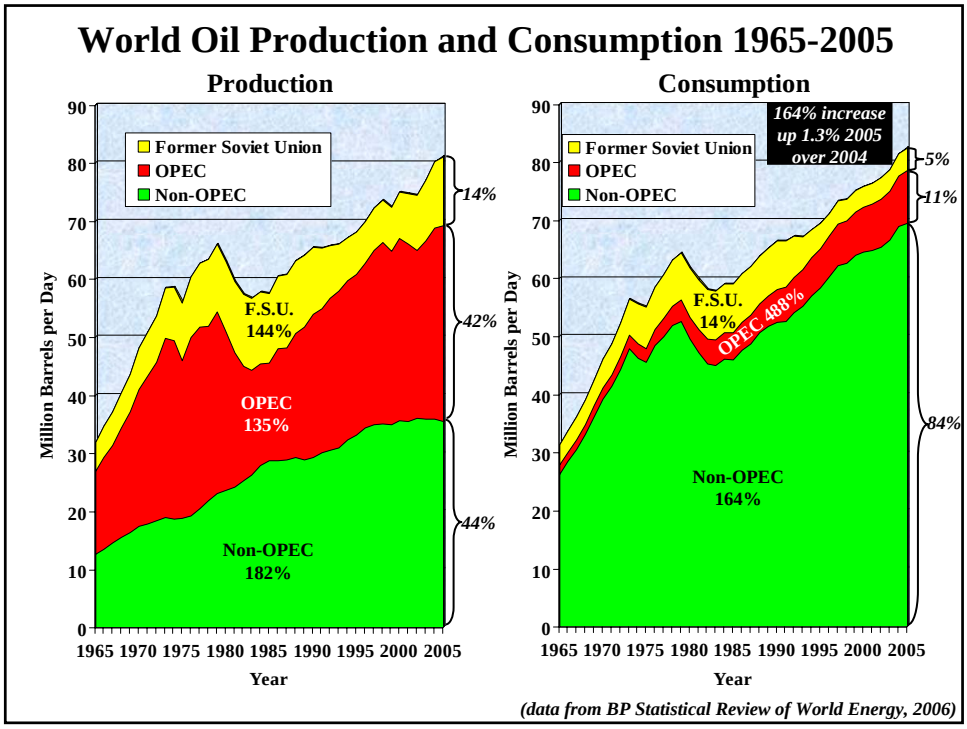
- The largest source of energy in the world *(36.4% of primary energy consumption in 2005)*

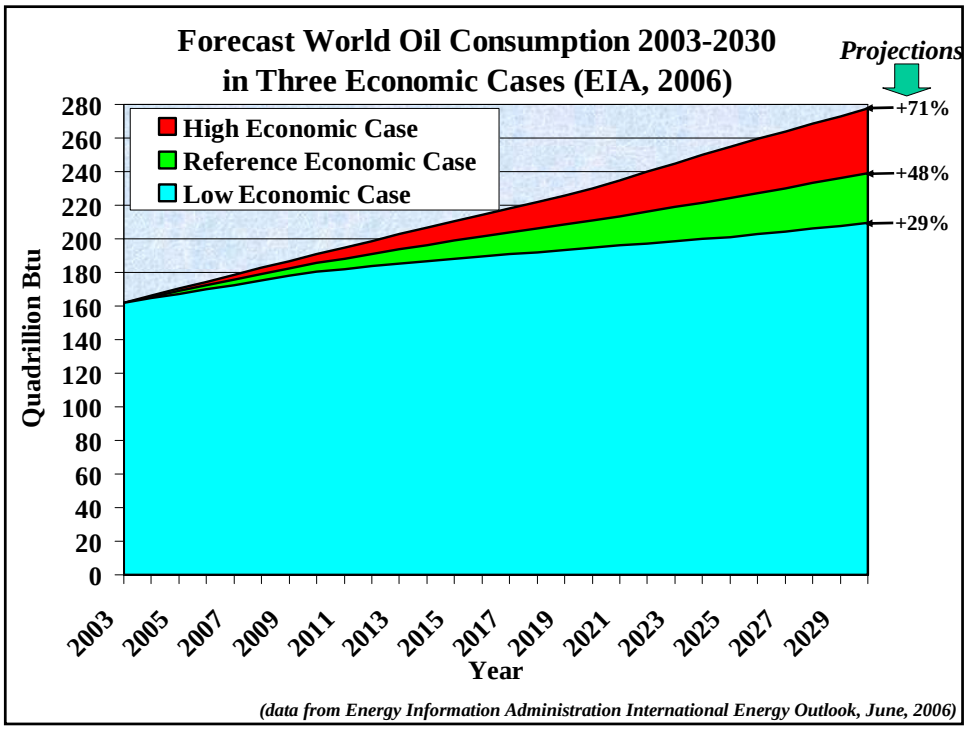
- The ultimate fuel for international trade – *easily moved by tanker and pipeline*

- Highly subject to Geopolitics – *the OPEC cartel has three quarters of remaining reserves and the only remaining spare production capacity – terrorism or natural disasters like Hurricanes Katrina and Rita can cause extreme price volatility*

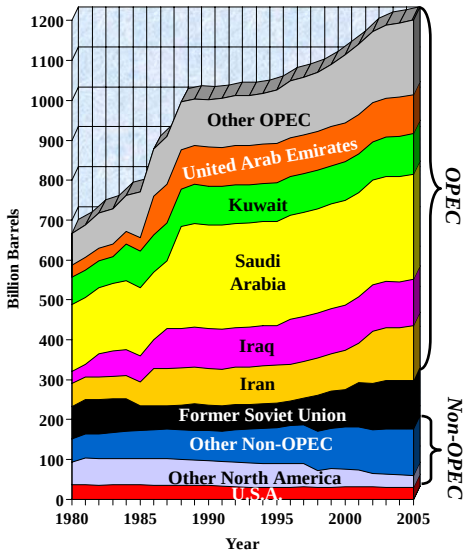
- Alternatives to oil have seen similar price spikes over the past several years *(natural gas, coal and uranium)*

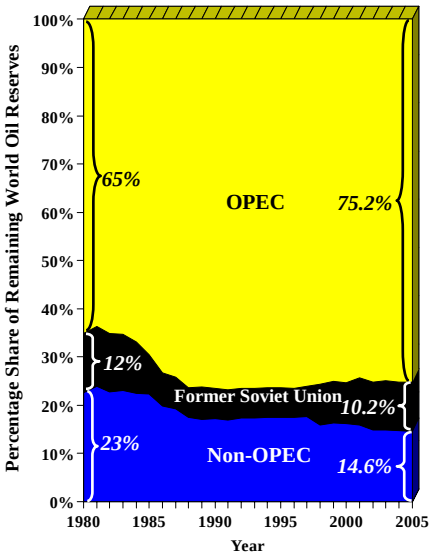



World Oil Production and Consumption 1965-2005
Production
Consumption
Former Soviet Union
OPEC
Non-OPEC
Million Barrels per Day
F.S.U.
144%
OPEC
135%
Non-OPEC
182%
14%
42%
44%
164% increase
up 1.3% 2005
over 2004
F.S.U.
14%
OPEC 488%
Non-OPEC
164%
5%
11%
84%
1965 1970 1975 1980 1985 1990 1995 2000 2005
Year
(data from BP Statistical Review of World Energy, 2006)


Forecast World Oil Consumption 2003-2030
in Three Economic Cases (EIA, 2006)
Projections
High Economic Case
Reference Economic Case
Low Economic Case
Quadrillion Btu
+71%
+48%
+29%
2003 2005 2007 2009 2011 2013 2015 2017 2019 2021 2023 2025 2027 2029
Year
(data from Energy Information Administration International Energy Outlook, June, 2006)

World Conventional Oil and Oil Sands* Reserves 1980-2005

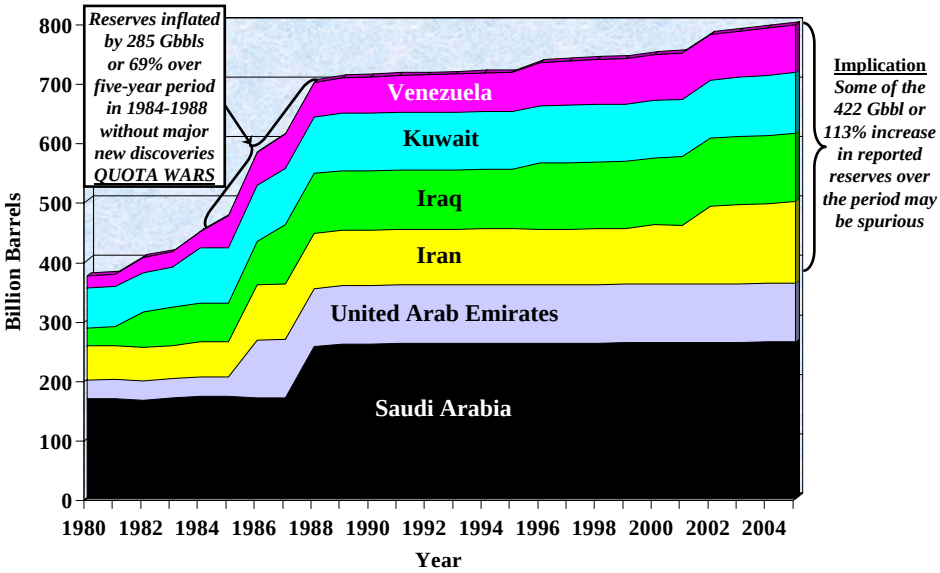




** Includes Oil Sands Reserves "Under Development"*

(data from BP Statistical Review of World Energy, 2006)

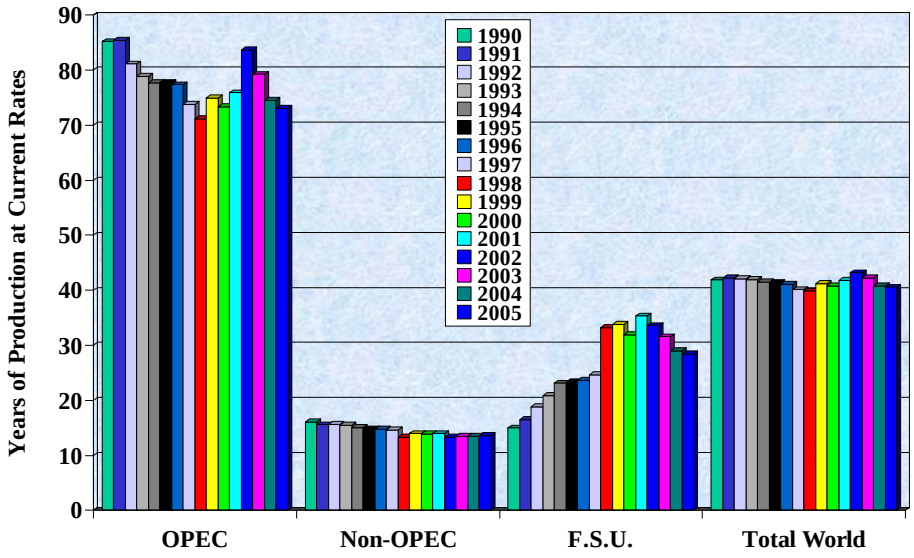
Oil Reserve Reporting in Selected OPEC Countries, 1980-2005, Representing 88% of 2005 OPEC Reserves and 66% of World Reserves



These Countries also Produced 181.6 Billion Barrels over the Period

(data from BP Statistical Review of World Energy, 2006)

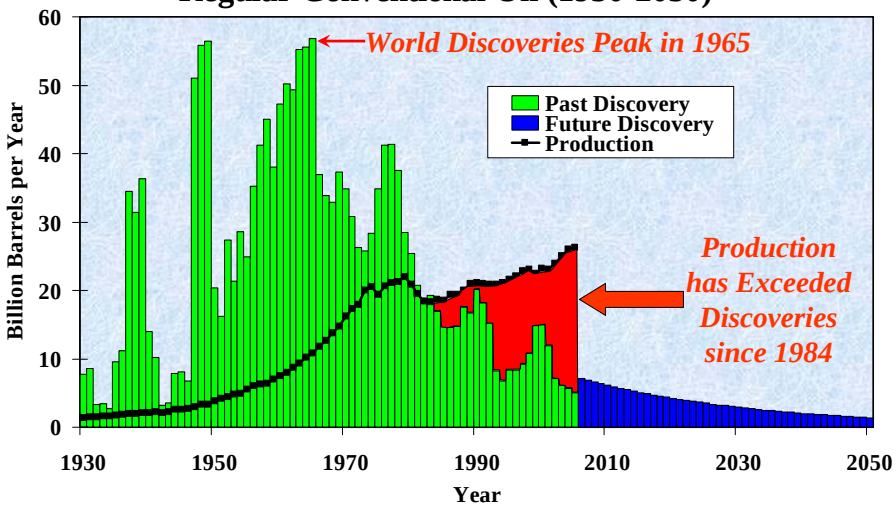
World Oil Reserve to Production Ratio in Years Including Oil Sands* and Possibly Spurious post-1984 OPEC Reserves



** Includes Oil Sands Reserves "Under Development"*

(data from BP Statistical Review of World Energy, 2006)

The Growing Gap between Production and Discovery of Regular Conventional Oil (1930-2050)



Past discoveries have been backdated with revisions from ExxonMobil (2002) to reflect "Reserve Growth"

(from Campbell, personal communication, September 2006)

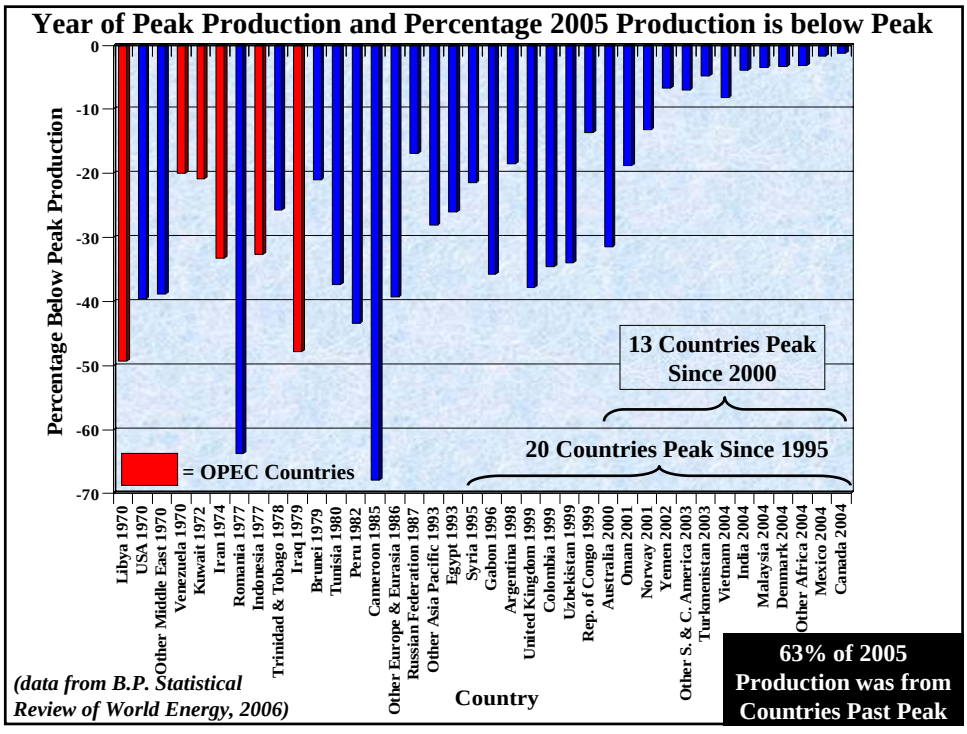
World Oil Production Peak

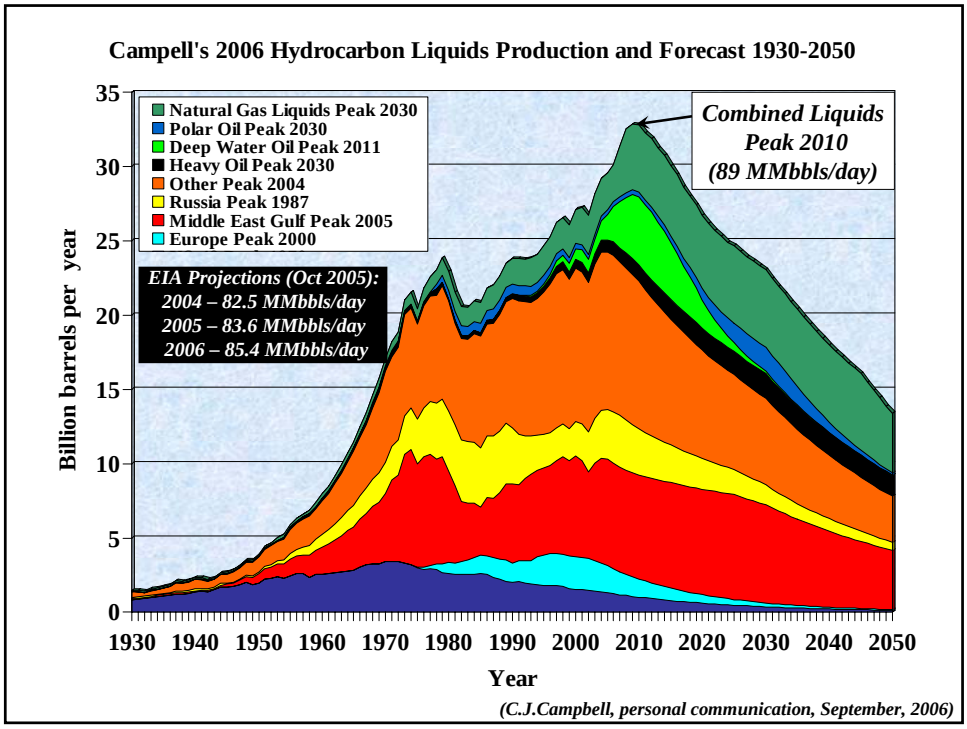
WHEN?

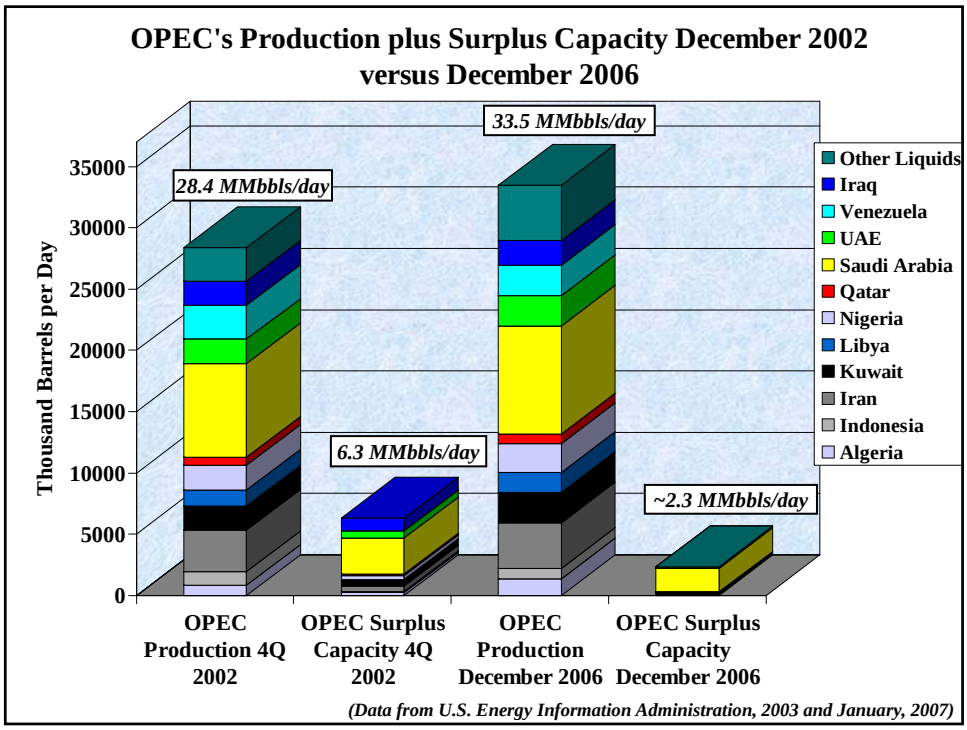
- Debatable, because of the variables, ***BUT IT IS HIGHLY LIKELY TO HAPPEN***

DEPENDS ON:

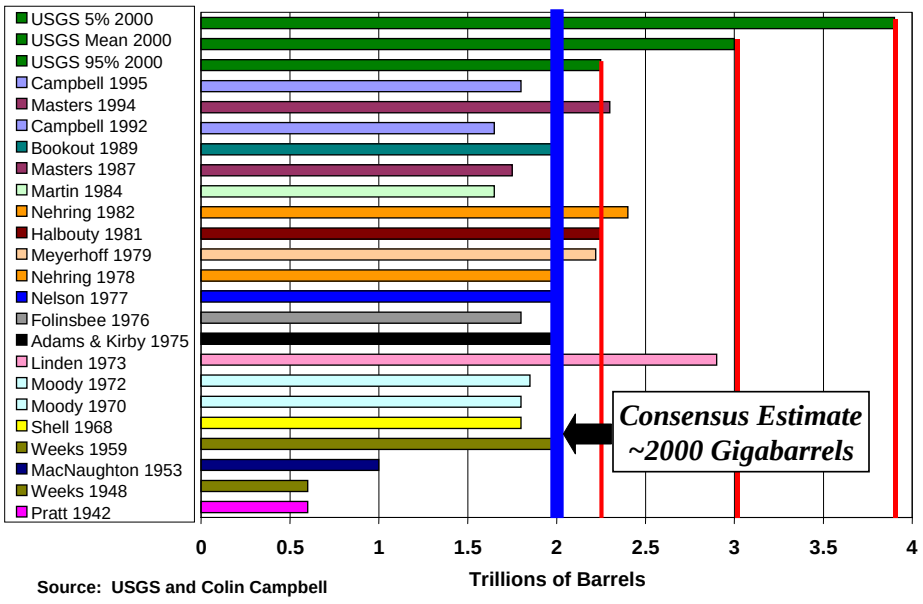
- **ULTIMATE RECOVERABLE RESERVES** *- a function of:*
  - **Mother Nature's Endowment** *(total discovered and undiscovered resources)*
  - **Technology and Price** *(determines economics)*
  - **Reserve Appreciation (Growth) in known pools** *(through more drilling, better technology and higher prices)*
- **RATE OF CONSUMPTION** *- a function of:*
  - **Price** *(controls economic growth and encourages/discourages conservation)*
  - **Infrastructure** *for production*
  - **Depletion rates** *of producing pools*




Campell's 2006 Hydrocarbon Liquids Production and Forecast 1930-2050
Natural Gas Liquids Peak 2030
Polar Oil Peak 2030
Deep Water Oil Peak 2011
Heavy Oil Peak 2030
Other Peak 2004
Russia Peak 1987
Middle East Gulf Peak 2005
Europe Peak 2000
Combined Liquids Peak 2010 (89 MMbbls/day)
EIA Projections (Oct 2005):
2004 – 82.5 MMbbls/day
2005 – 83.6 MMbbls/day
2006 – 85.4 MMbbls/day
Billion barrels per year
0
5
10
15
20
25
30
35
1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050
Year
(C.J.Campbell, personal communication, September, 2006)


OPEC's Production plus Surplus Capacity December 2002 versus December 2006
28.4 MMbbls/day
6.3 MMbbls/day
33.5 MMbbls/day
~2.3 MMbbls/day
Other Liquids
Iraq
Venezuela
UAE
Saudi Arabia
Qatar
Nigeria
Libya
Kuwait
Iran
Indonesia
Algeria
Thousand Barrels per Day
0
5000
10000
15000
20000
25000
30000
35000
OPEC Production 4Q 2002
OPEC Surplus Capacity 4Q 2002
OPEC Production December 2006
OPEC Surplus Capacity December 2006
(Data from U.S. Energy Information Administration, 2003 and January, 2007)

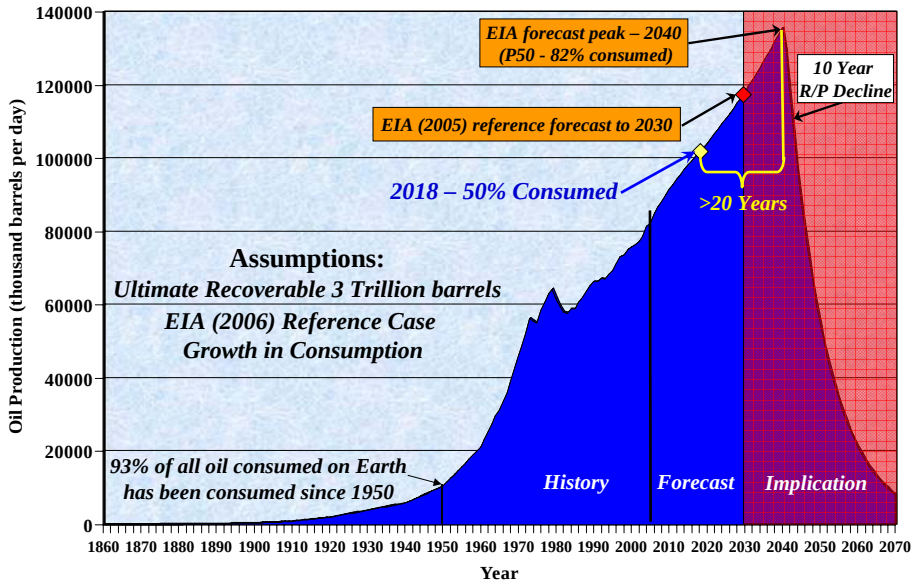
Published Estimates of Conventional World Oil Ultimate Recovery



Source: USGS and Colin Campbell

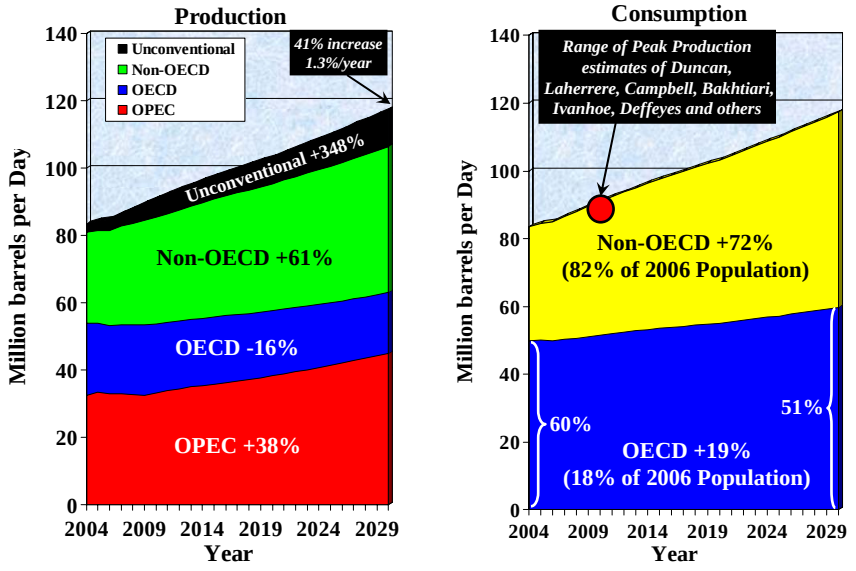
(from Wood, USGS, 2000)

Forecast of World Peak Oil Production Using EIA Methodology Assuming USGS (2000) P50 Ultimate Recoverable of 3003 Billion Barrels and 1.4% Yearly Growth in Consumption



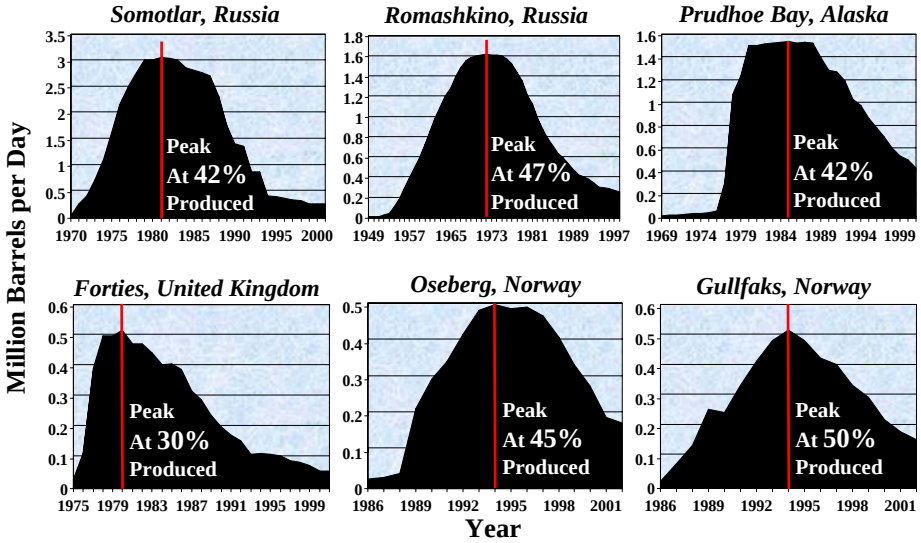
(Source of data: BP Statistical Review of World Energy, 2006; Wood, USGS, 2000; EIA IEO, 2006)

EIA World Oil Production and Consumption Forecast 2004-2030 (Reference Economic Case)



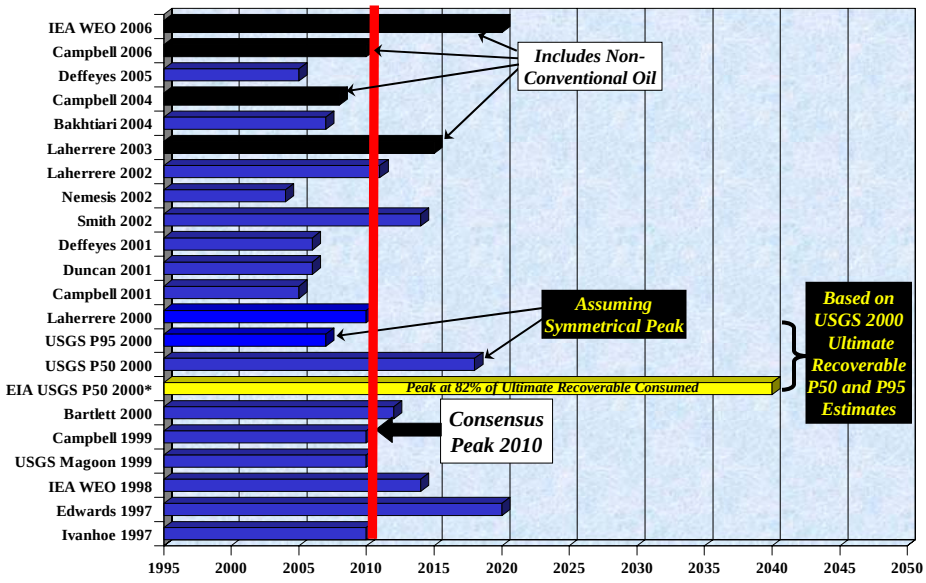
(data from Energy Information Administration Annual Energy Outlook 2007, December, 2006)

Peaking Profiles of Giant and Super Giant Fields at 30-50% of Total Production Suggests Peaking of World Production at 82% of Ultimate Recoverable Consumed is Wishful Thinking



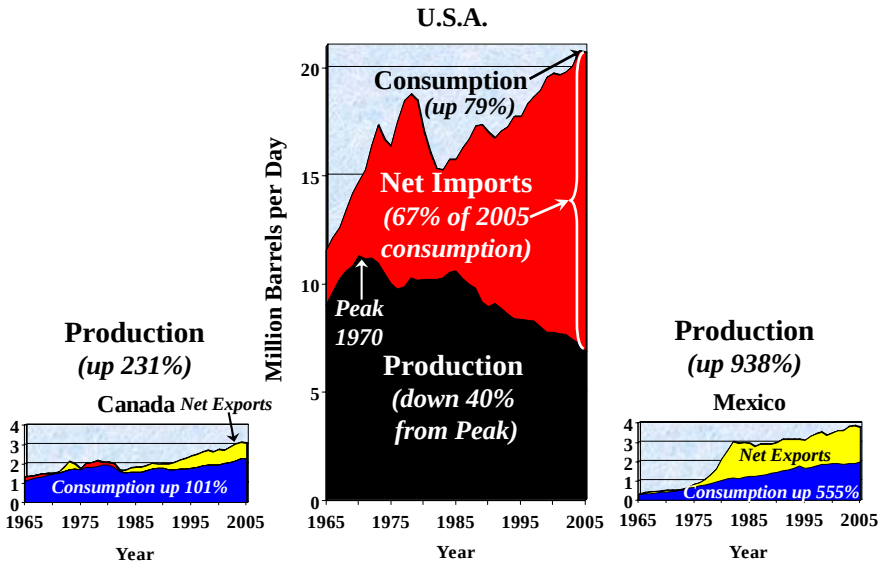
(data from Simmons, "The Saudi Arabia Oil Miracle", February, 2004)

Post 1997 Estimates of the Time of Peak World Oil Production



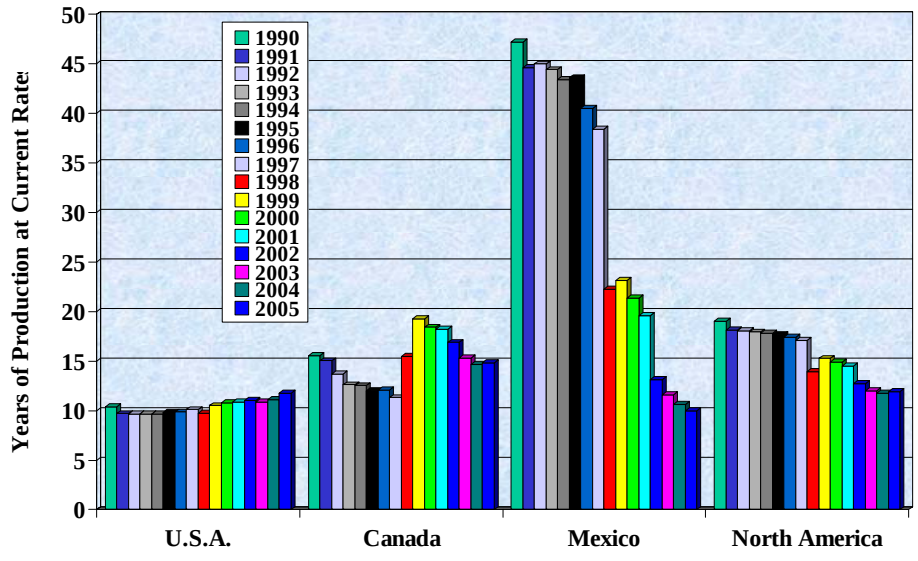
(Source Bentley, 2002; Wood, USGS, 2000;
**EIA IEO, 2006, reference case demand growth*
of 1.4%/year and USGS P50 2000 estimate and peaking at World R/P of 10 years; Oil and Gas Journal, 2004; and others)

North American Oil Consumption and Movements: 1965-2005



(data from BP Statistical Review of World Energy, 2006)

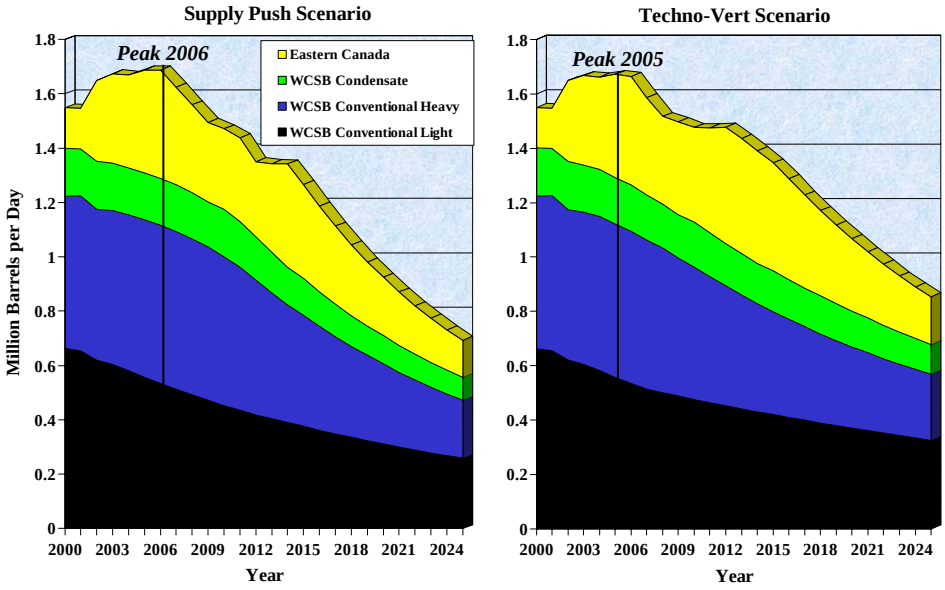
North America Reserve to Production Ratio in Years Including Oil Sands* 1990-2005



** Includes Oil Sands Reserves "Under Development"*

(data from BP Statistical Review of World Energy, 2006)

Canada Scenarios of Oil Production Excluding Oil Sands (NEB, 2003)



(data from National Energy Board, July, 2003)

Yes, But We've Got the
OIL SANDS – More Oil than Saudi Arabia!

- **The Oil Sands cannot significantly offset declines in world production because of the lead times and capital investment required.** Massive expansions in the Oil Sands and Venezuelan Orinoco extra-heavy oil belt could increase combined production from 1.74 million barrels per day at present to as much as six million barrels per day by 2025, which is only 5% of EIA forecast World Demand in 2025.

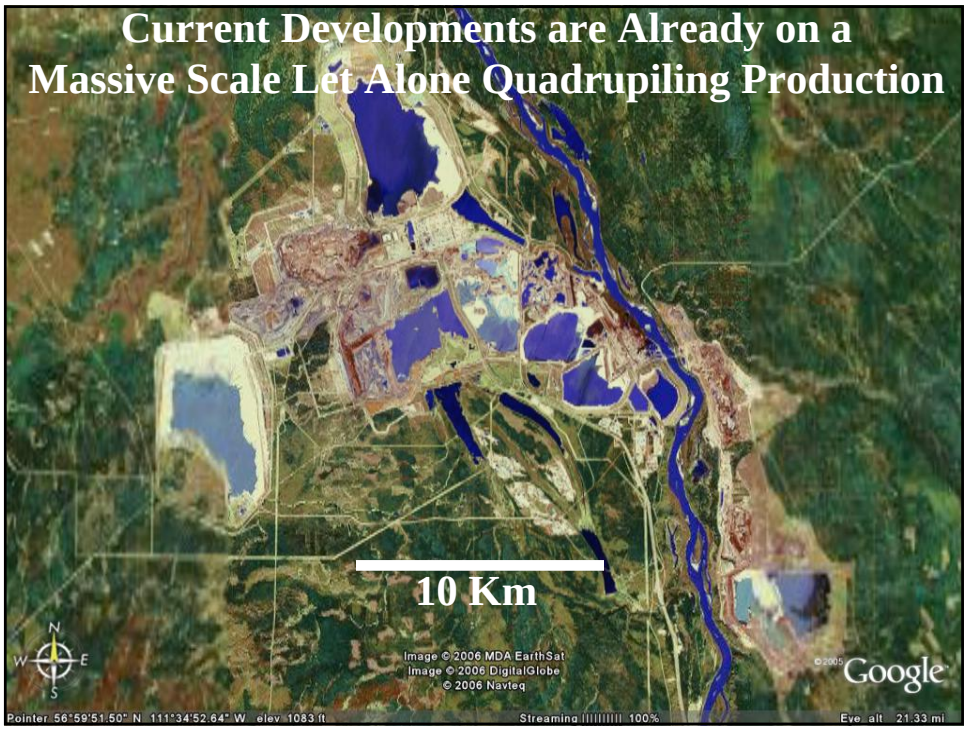
- **Oil from the oil sands is very energy intensive** – Forecast four- to five-fold growth to 2025 will require between 1.6 and 2.3 bcf/day of natural gas, which is approximately equivalent to the planned maximum capacity of the MacKenzie Valley pipeline of 1.9 bcf/day, or about one-fifth of forecast Canadian domestic consumption.

- **Expansion of capacity is limited by natural gas supply and natural gas price,** which could destroy economics if there are shortfalls in supply, **barring widespread application of non-thermal processes, or switching to alternative fuels.**

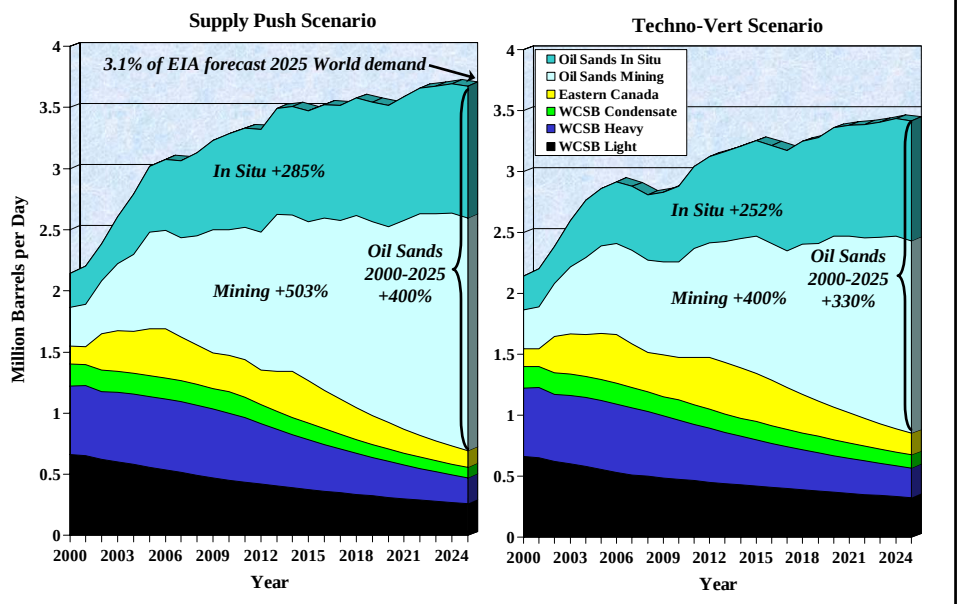
- **Expansion of capacity is limited by water supply** ([1]need average of 1-2 barrels of make-up water for every barrel of oil, depending on recovery method and technology), let alone future expansion **unless technologies to reduce water consumption and/or further recycle water can be employed.**

- **Expansion of bitumen export capacity may also be limited by projected shortfalls of condensate/light crude diluent for blending** which are forecast to occur in the 2004-2006 timeframe (National Energy Board, 2003), requiring other alternatives such as synthetic crude or conventional light oil.

([1]CERI report 2003)

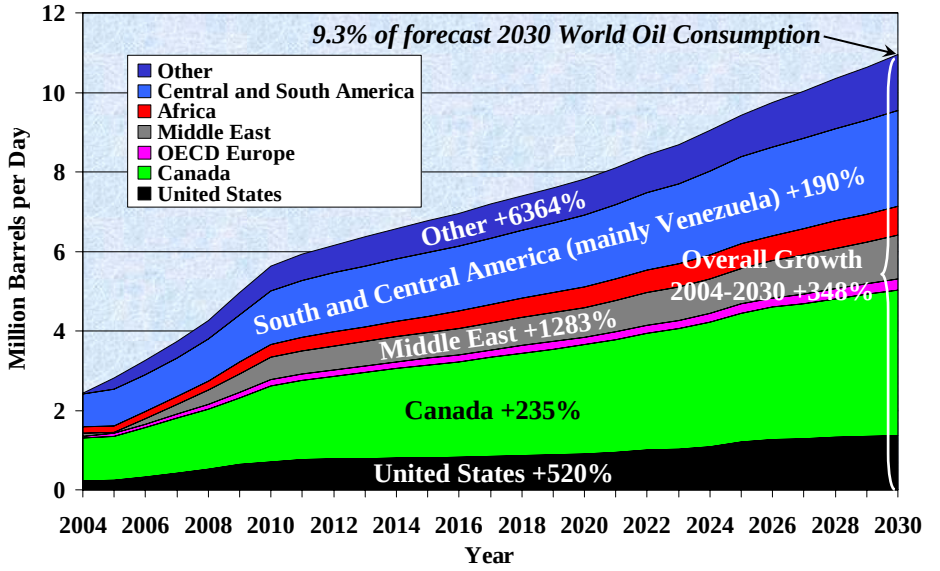


Canada Scenarios of Oil Production Including Oil Sands (NEB, 2003)

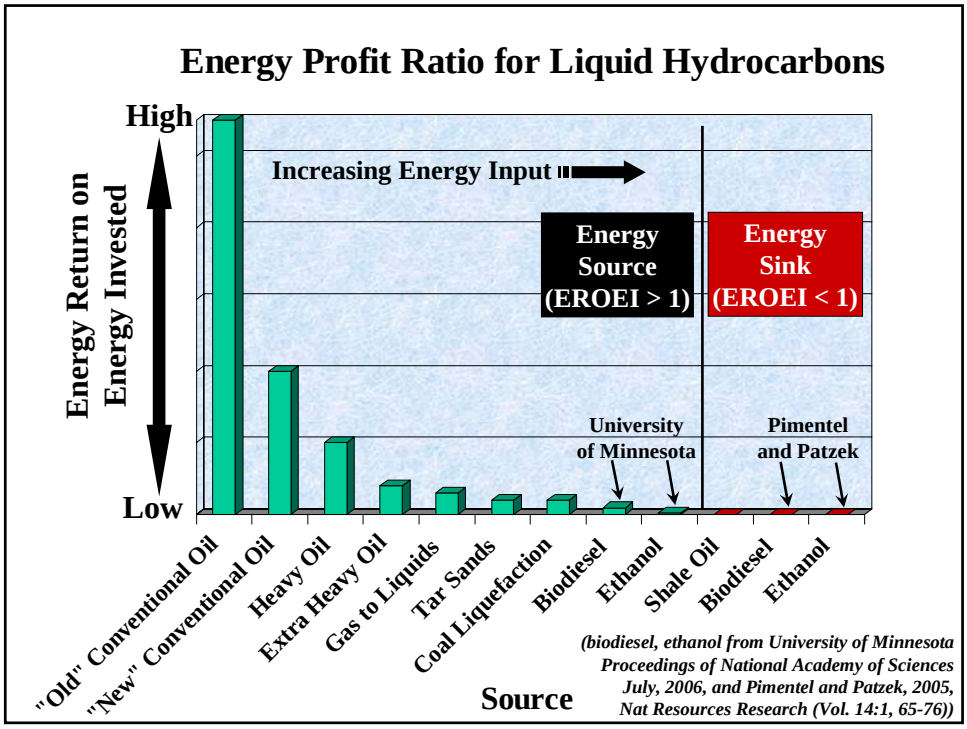


(data from National Energy Board, July, 2003)

EIA World Unconventional Oil Production Forecast 2004-2030 (Reference Economic Case, 2007) – includes Biodiesel, Ethanol, Coal-to-liquids, Gas-to-liquids, Oil sands, Extra Heavy Oil and Oil shale



(data from Energy Information Administration, Annual Energy Outlook 2007, December, 2006)



GAS

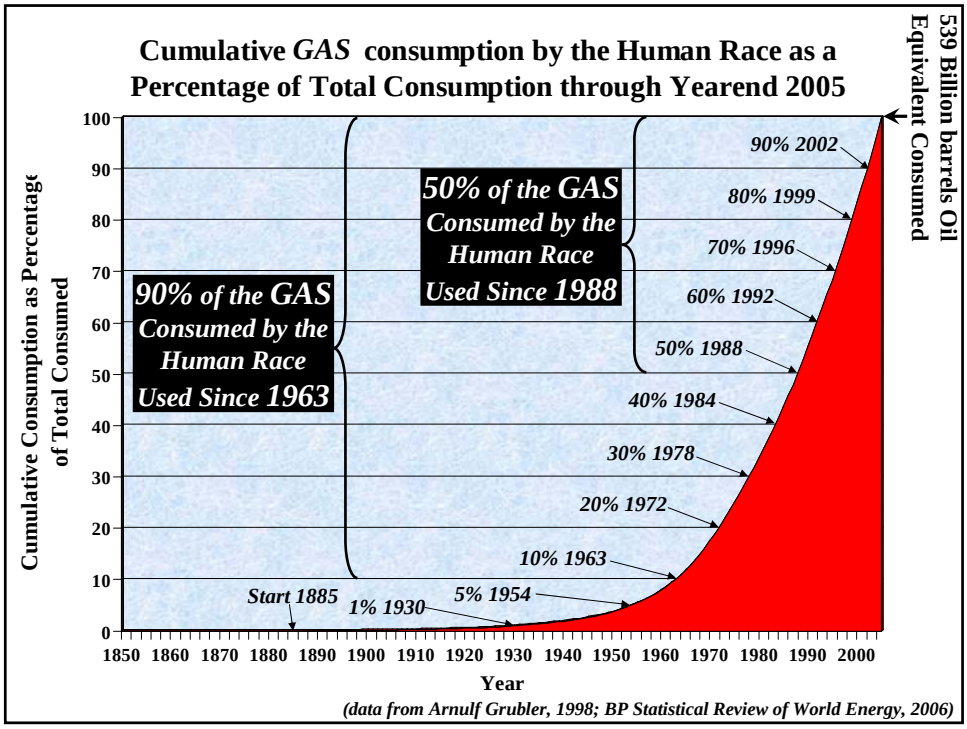
- **The third largest source of energy in the world** *after oil and coal (23.5% of primary energy consumption in 2005)*

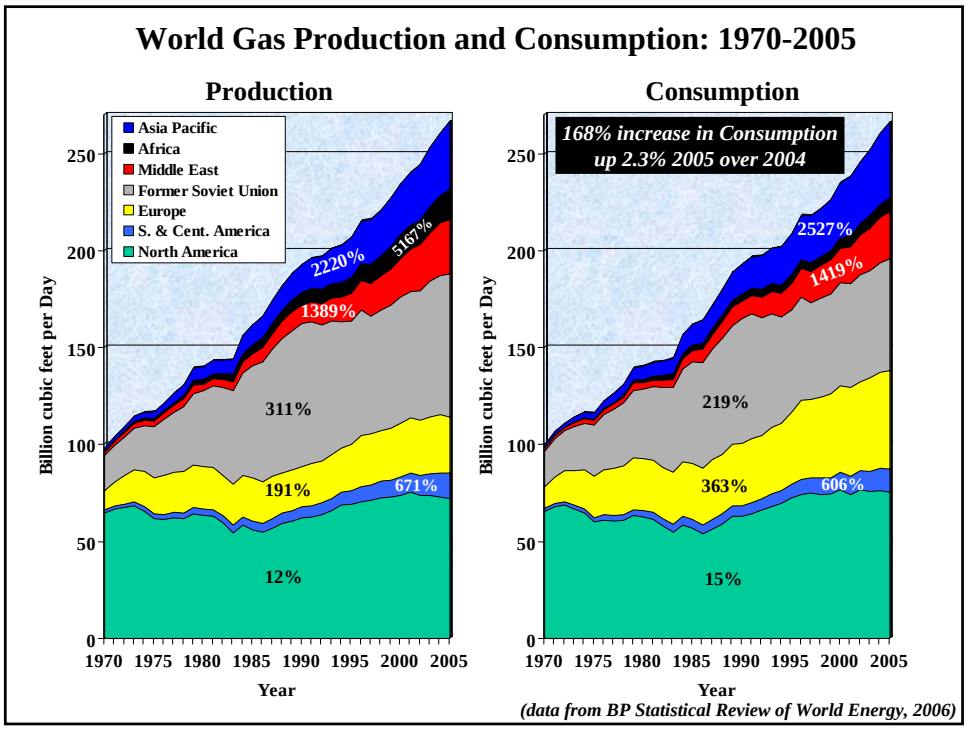
- **Largely landlocked when it comes to international trade,** *unlike oil and coal – 6.9% of World consumption (6.7 Tcf) was moved by Liquefied Natural Gas (LNG) in 2005*

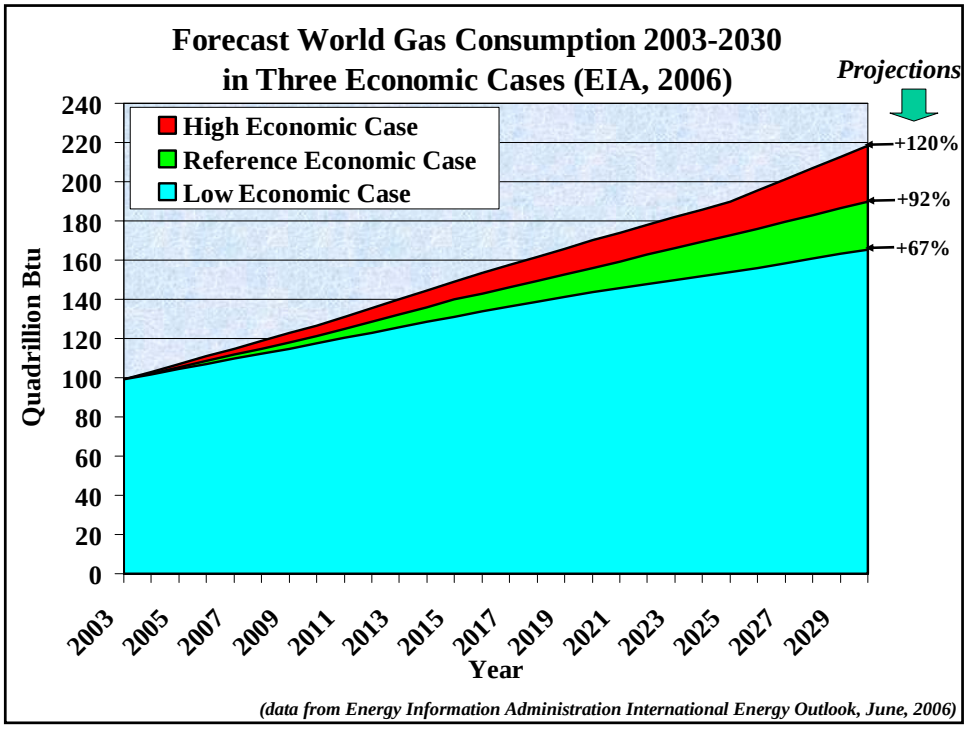
- **Natural Gas is difficult to store by comparison to Oil and Coal** *(approximately 3.2 Tcf of "working" storage in the U.S. or 50 days of U.S. Supply) - North America is a Continental gas market- about 2.9% of North American (ie. U.S.A.) consumption was moved as LNG in 2005*

- **LNG entails an energy loss of between 15 and 30% for liquefaction, transportation and regasification,** *as LNG must be cooled to –165 degrees Celsius for movement by ship,* ***with attendant greenhouse gas emissions***

- **LNG is subject to Geopolitics** *as three-quarters of remaining natural gas reserves are located in the Former Soviet Union and the Middle East,* ***as well as the NIMBY syndrome in locating new receiving terminals in North America*** *because of perceived dangers by the general public*


Cumulative GAS consumption by the Human Race as a Percentage of Total Consumption through Yearend 2005
Cumulative Consumption as Percentage of Total Consumed
539 Billion barrels Oil Equivalent Consumed
90% of the GAS Consumed by the Human Race Used Since 1963
50% of the GAS Consumed by the Human Race Used Since 1988
Start 1885
1% 1930
5% 1954
10% 1963
20% 1972
30% 1978
40% 1984
50% 1988
60% 1992
70% 1996
80% 1999
90% 2002
0 10 20 30 40 50 60 70 80 90 100
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
Year
(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2006)


World Gas Production and Consumption: 1970-2005
Production
Consumption
Asia Pacific
Africa
Middle East
Former Soviet Union
Europe
S. & Cent. America
North America
Billion cubic feet per Day
0 50 100 150 200 250
1970 1975 1980 1985 1990 1995 2000 2005
Year
2220%
5167%
1389%
311%
191%
671%
12%
168% increase in Consumption up 2.3% 2005 over 2004
2527%
1419%
219%
363%
606%
15%
(data from BP Statistical Review of World Energy, 2006)


Forecast World Gas Consumption 2003-2030
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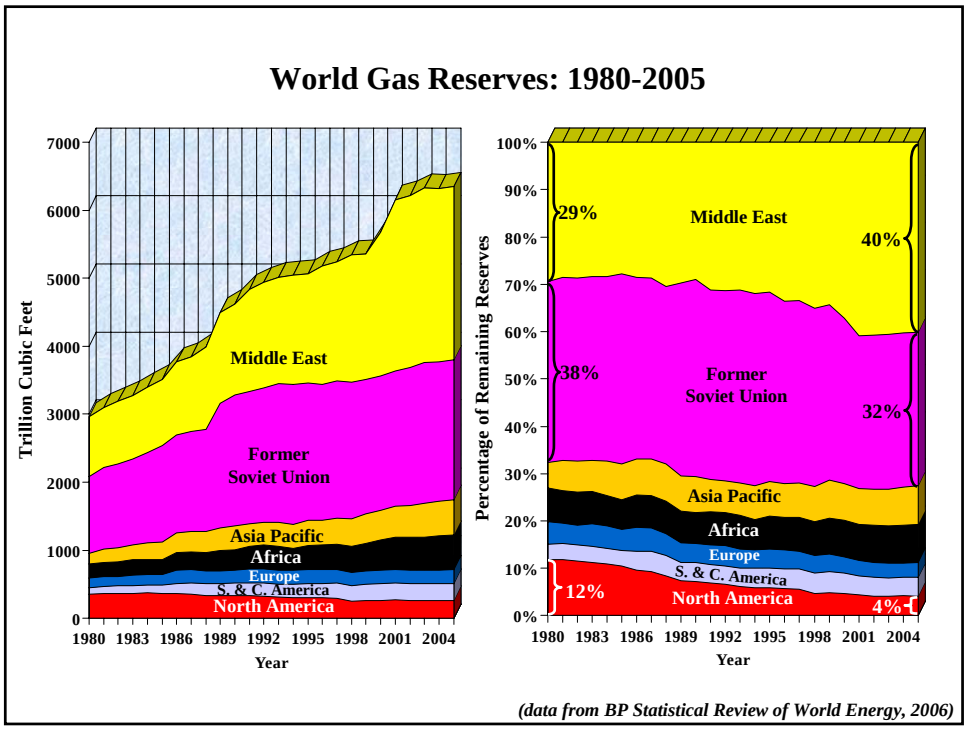
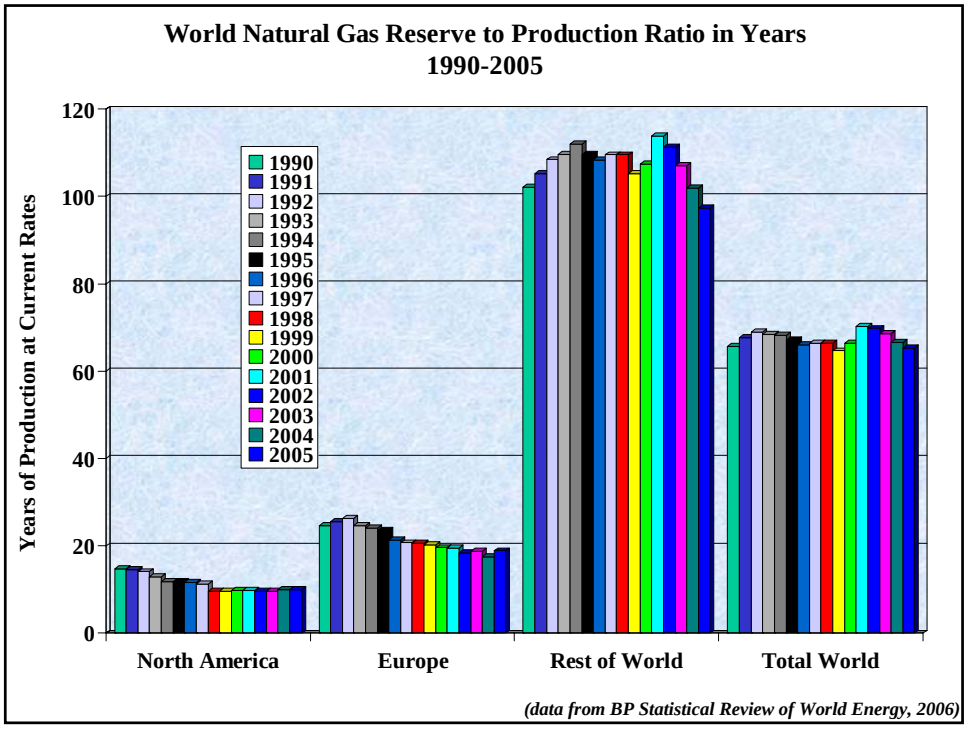
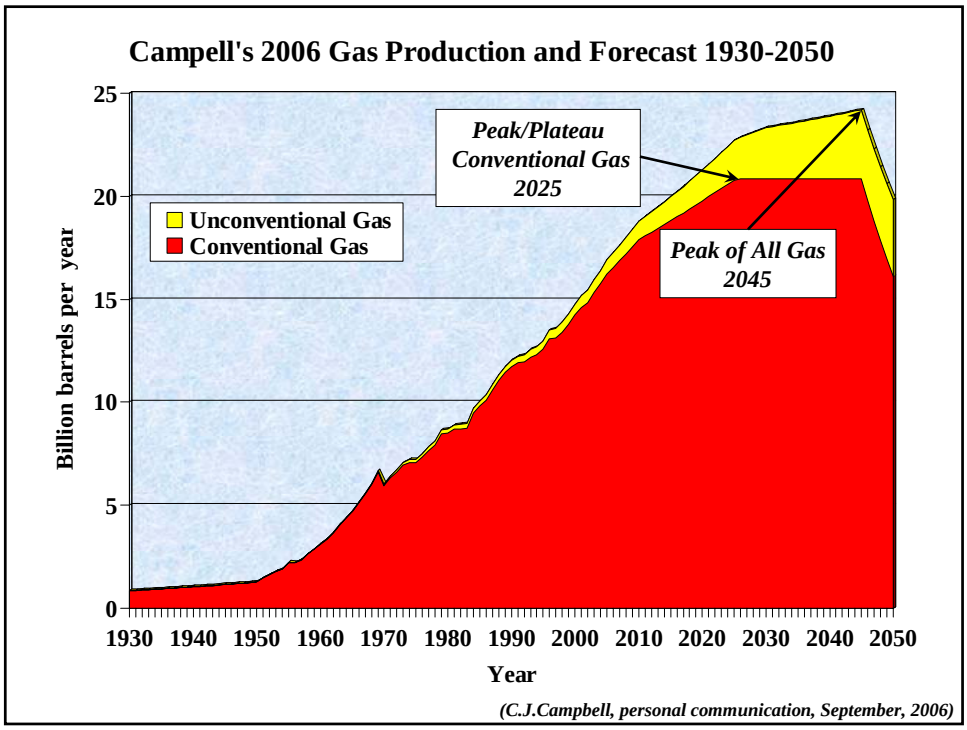
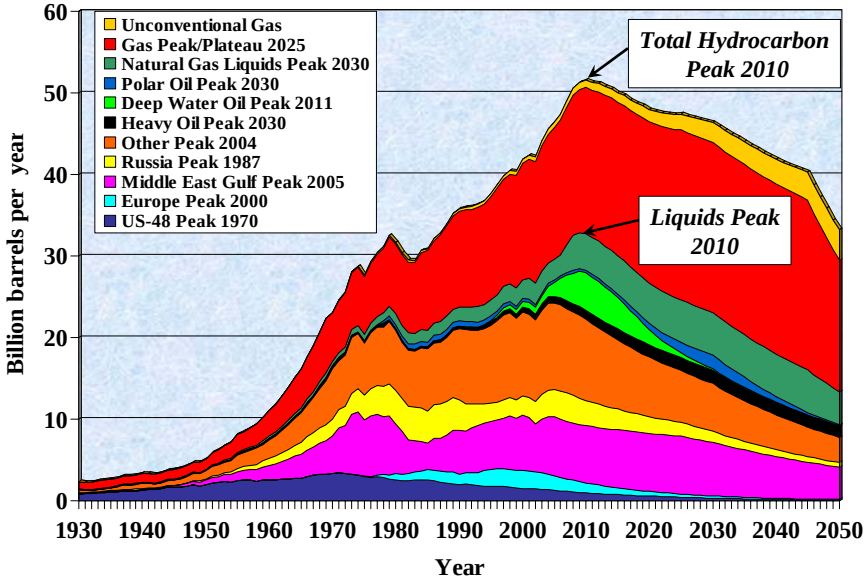
Projections
High Economic Case
Reference Economic Case
Low Economic Case
+120%
+92%
+67%
Quadrillion Btu
240
220
200
180
160
140
120
100
80
60
40
20
0
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
Year
(data from Energy Information Administration International Energy Outlook, June, 2006)


World Gas Reserves: 1980-2005
Trillion Cubic Feet
7000
6000
5000
4000
3000
2000
1000
0
Middle East
Former
Soviet Union
Asia Pacific
Africa
Europe
S. & C. America
North America
1980
1983
1986
1989
1992
1995
1998
2001
2004
Year
Percentage of Remaining Reserves
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
29%
40%
38%
32%
12%
4%
Middle East
Former
Soviet Union
Asia Pacific
Africa
Europe
S. & C. America
North America
1980
1983
1986
1989
1992
1995
1998
2001
2004
Year
(data from BP Statistical Review of World Energy, 2006)


World Natural Gas Reserve to Production Ratio in Years
1990-2005
Years of Production at Current Rates
120
100
80
60
40
20
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
North America
Europe
Rest of World
Total World
(data from BP Statistical Review of World Energy, 2006)

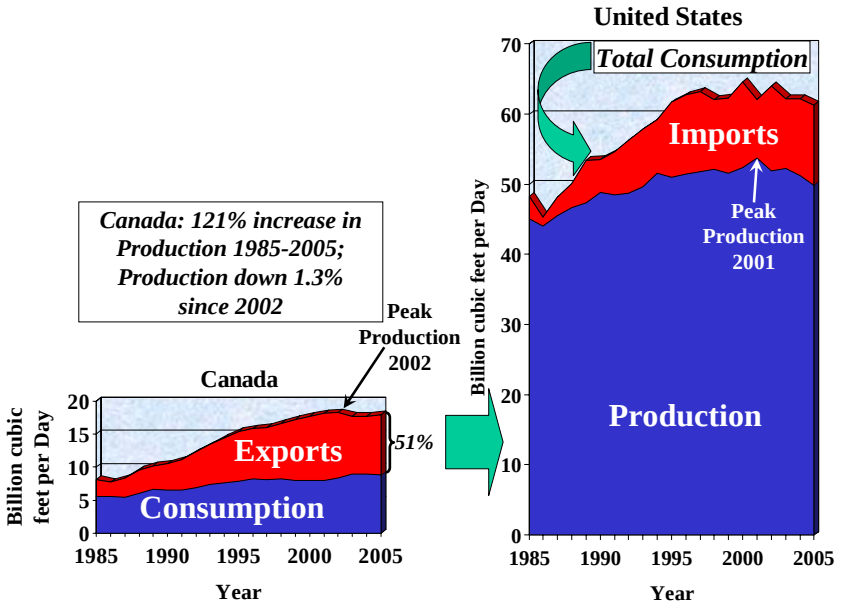

Campell's 2006 Gas Production and Forecast 1930-2050
Billion barrels per year
25
20
15
10
5
0
Unconventional Gas
Conventional Gas
Peak/Plateau
Conventional Gas
2025
Peak of All Gas
2045
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Year
(C.J.Campbell, personal communication, September, 2006)

Campell's 2006 Total Hydrocarbon Production and Forecast 1930-2050



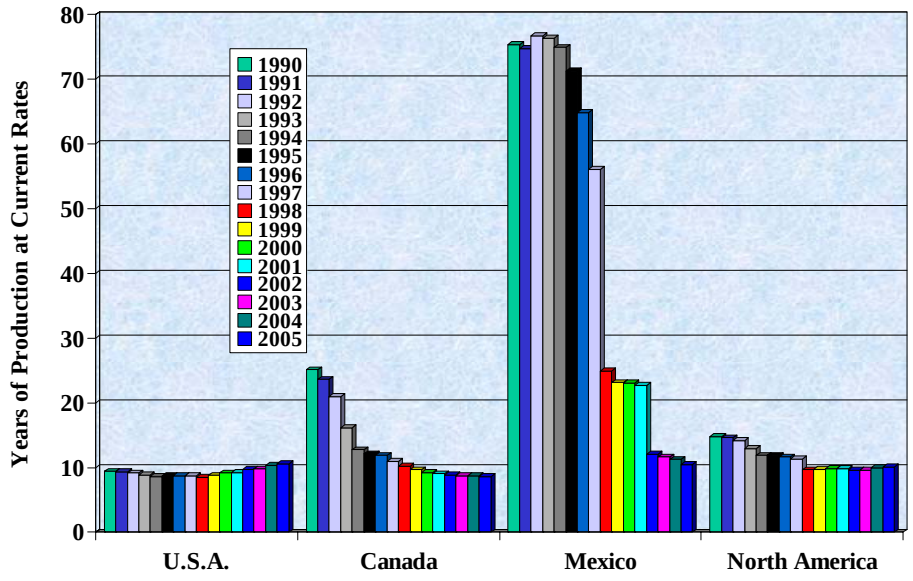
(C.J.Campbell, personal communication, September, 2006)

North American Gas Production and Movements: 1985-2005



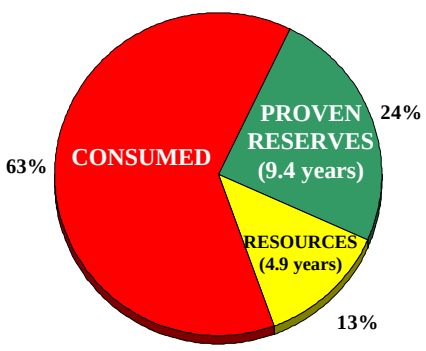
(data from BP Statistical Review of World Energy, 2006)

North America Natural Gas Reserve to Production Ratio in Years 1990-2005

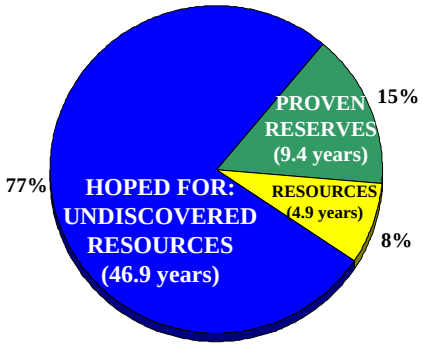


(data from BP Statistical Review of World Energy, 2006)

Canada's Remaining Discovered and Undiscovered Conventional Marketable Natural Gas Resources According to NEB (2006) Estimates including Lifetime assuming 2005 Production Rates

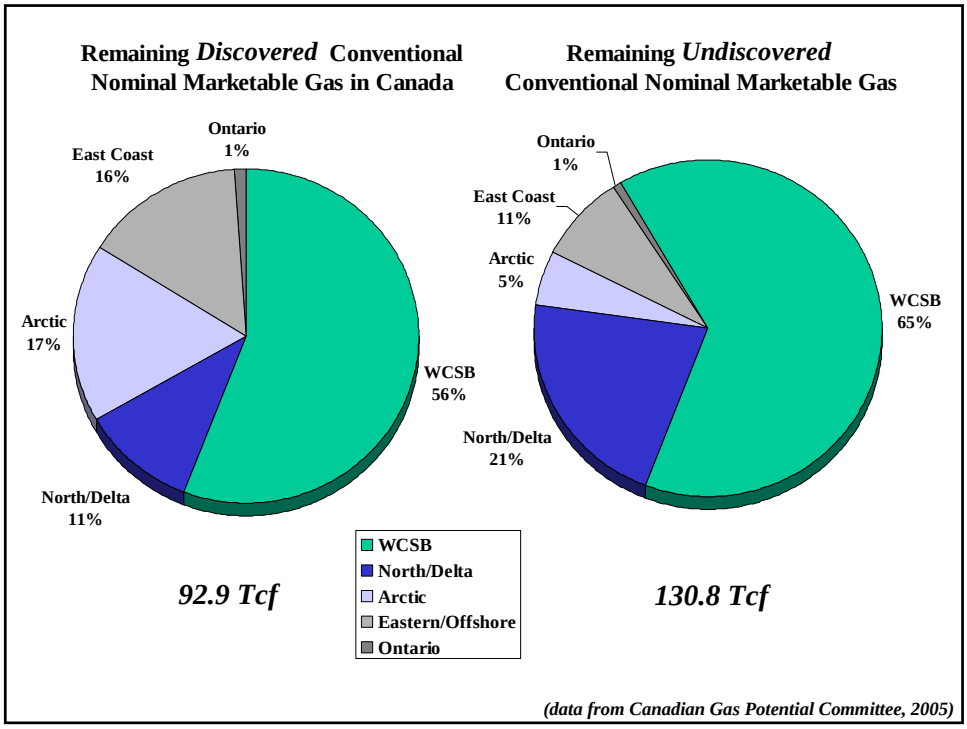


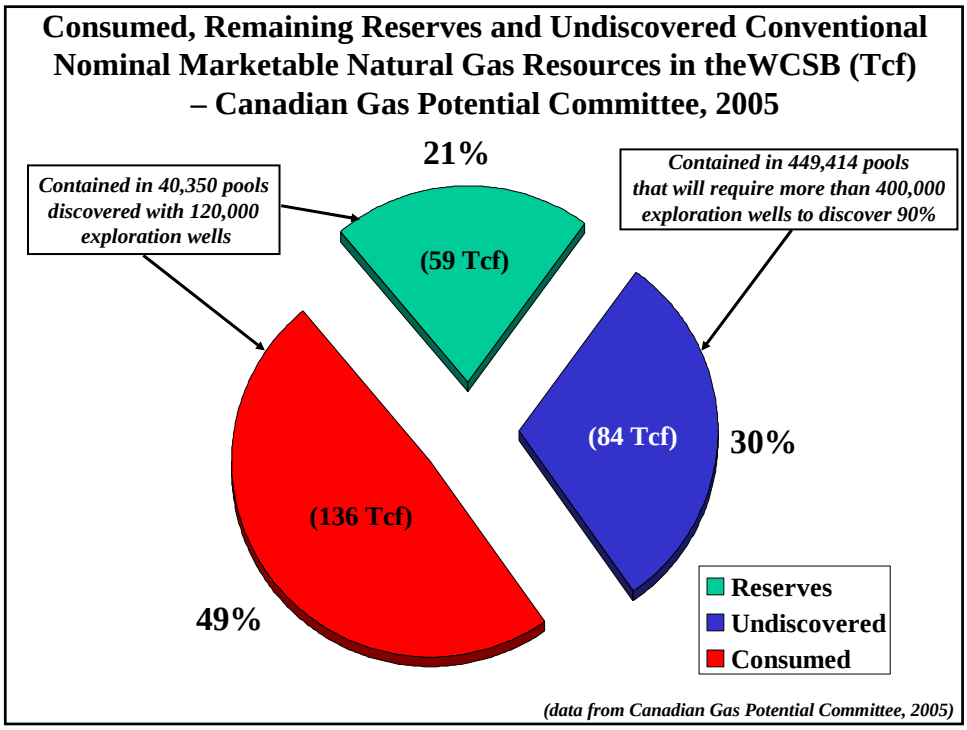
Discovered Resources



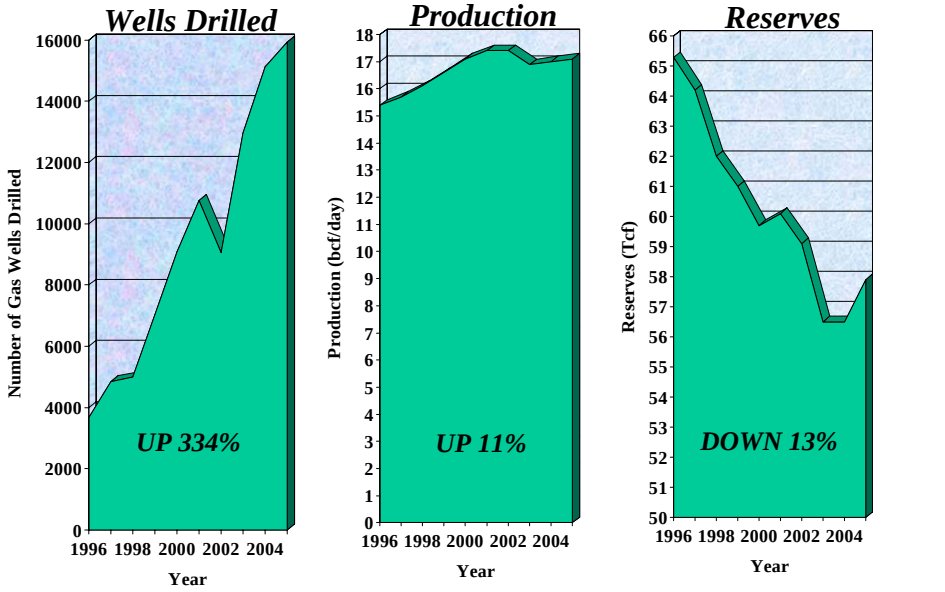
Remaining Discovered and Undiscovered Resources

(Resource estimates from National Energy Board, March, 2006, Report 2006-A, as at December 31, 2004; 2004 Proven Reserves from CAPP, 2006; 2005 Production from Statistics Canada, 2006)


Remaining *Discovered* Conventional Nominal Marketable Gas in Canada
Ontario 1%
East Coast 16%
Arctic 17%
WCSB 56%
North/Delta 11%
92.9 Tcf
Remaining *Undiscovered* Conventional Nominal Marketable Gas
Ontario 1%
East Coast 11%
Arctic 5%
WCSB 65%
North/Delta 21%
130.8 Tcf
WCSB
North/Delta
Arctic
Eastern/Offshore
Ontario
(data from Canadian Gas Potential Committee, 2005)

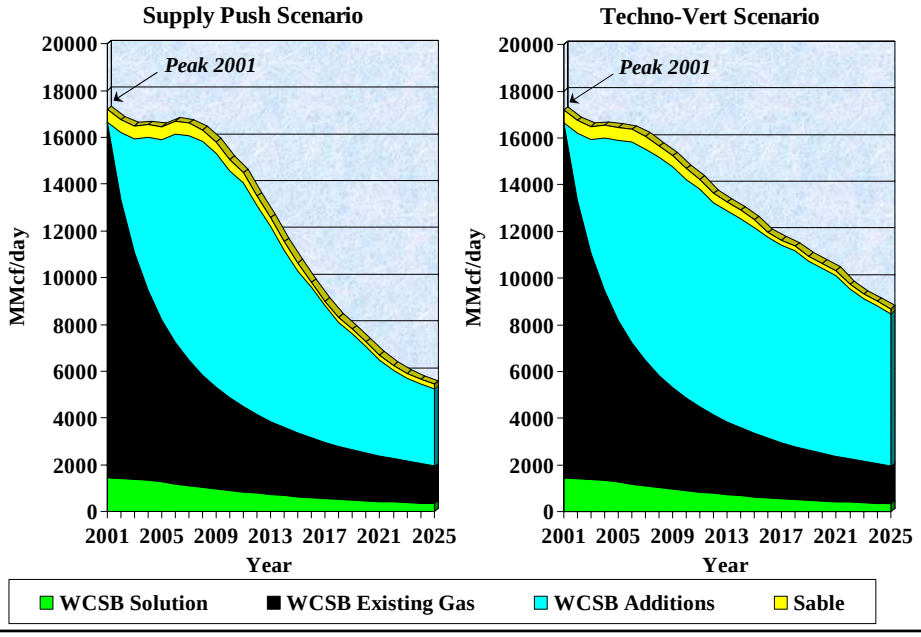

Consumed, Remaining Reserves and Undiscovered Conventional Nominal Marketable Natural Gas Resources in theWCSB (Tcf) – Canadian Gas Potential Committee, 2005
21%
Contained in 40,350 pools discovered with 120,000 exploration wells
Contained in 449,414 pools that will require more than 400,000 exploration wells to discover 90%
(59 Tcf)
(84 Tcf)
30%
(136 Tcf)
49%
Reserves
Undiscovered
Consumed
(data from Canadian Gas Potential Committee, 2005)

Canada's Exploration Treadmill – more and more drilling to find less and less gas

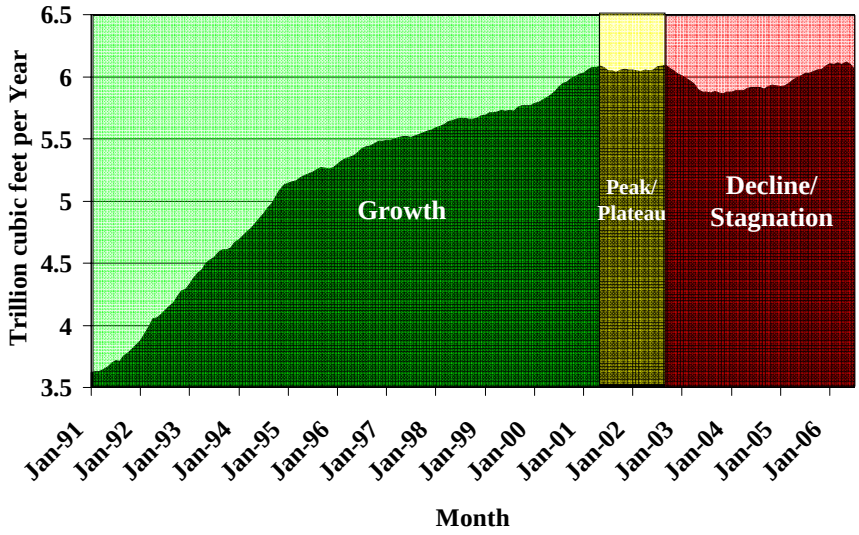


(Data from Canadian Association of Petroleum Producers, 2007)

NEB, July, 2003, Deliverability Scenarios from Existing Gas Sources

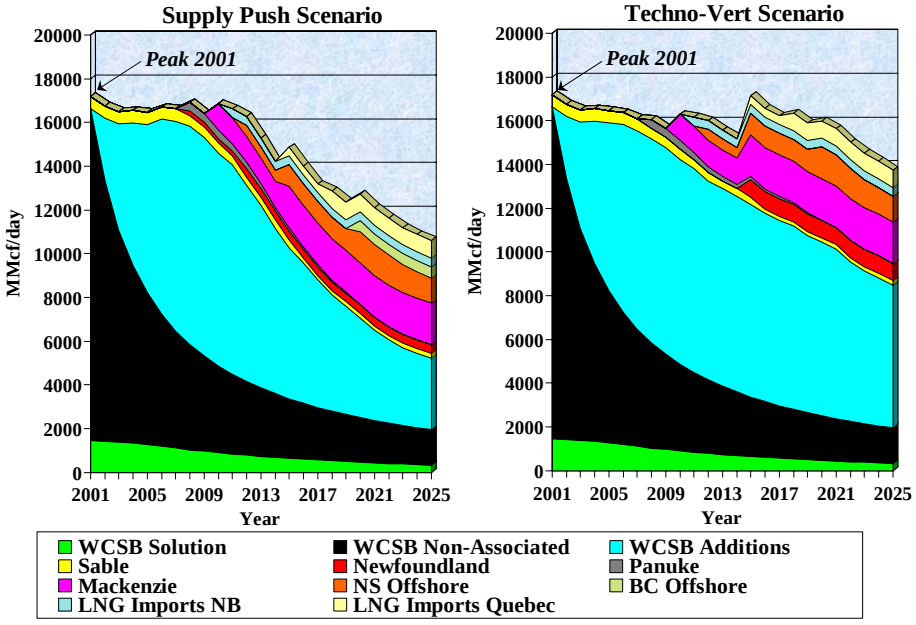


Annual Canadian Marketable Natural Gas Production by Month January 1991 - December 2006 (12 month centered moving average)

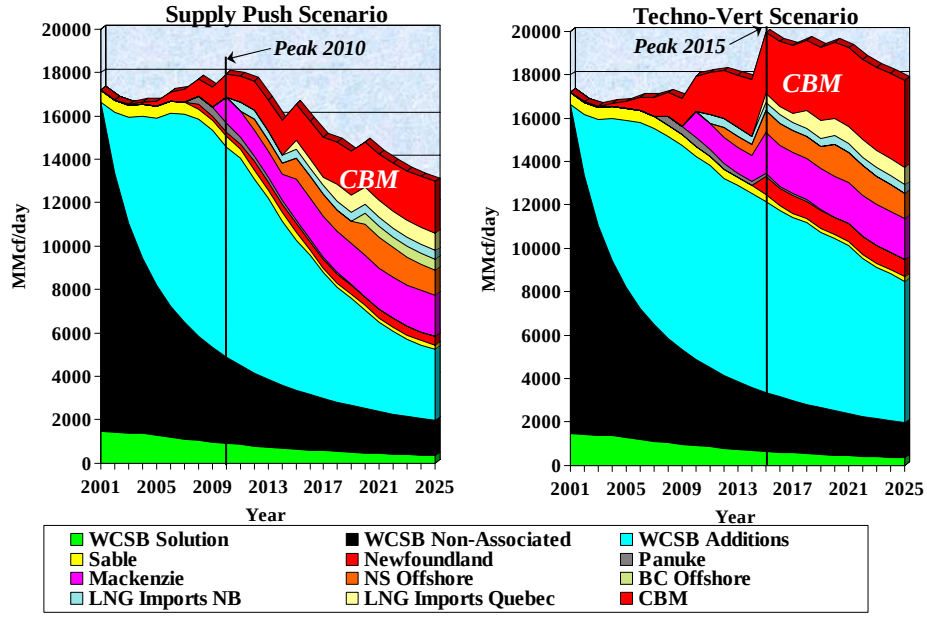


(Source of data Statistics Canada, March, 2007)

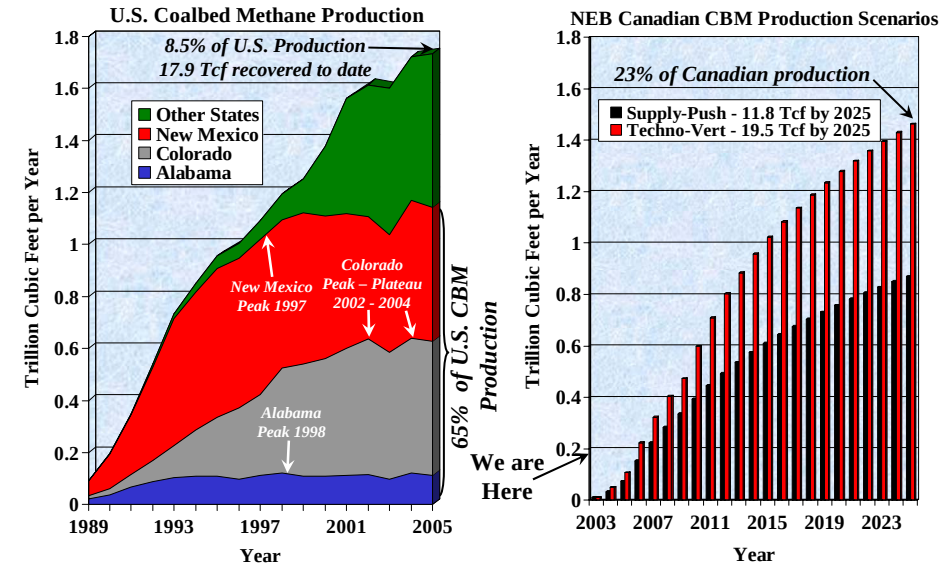
NEB, July, 2003, Deliverability Scenarios from Existing and Proposed Conventional Gas Sources



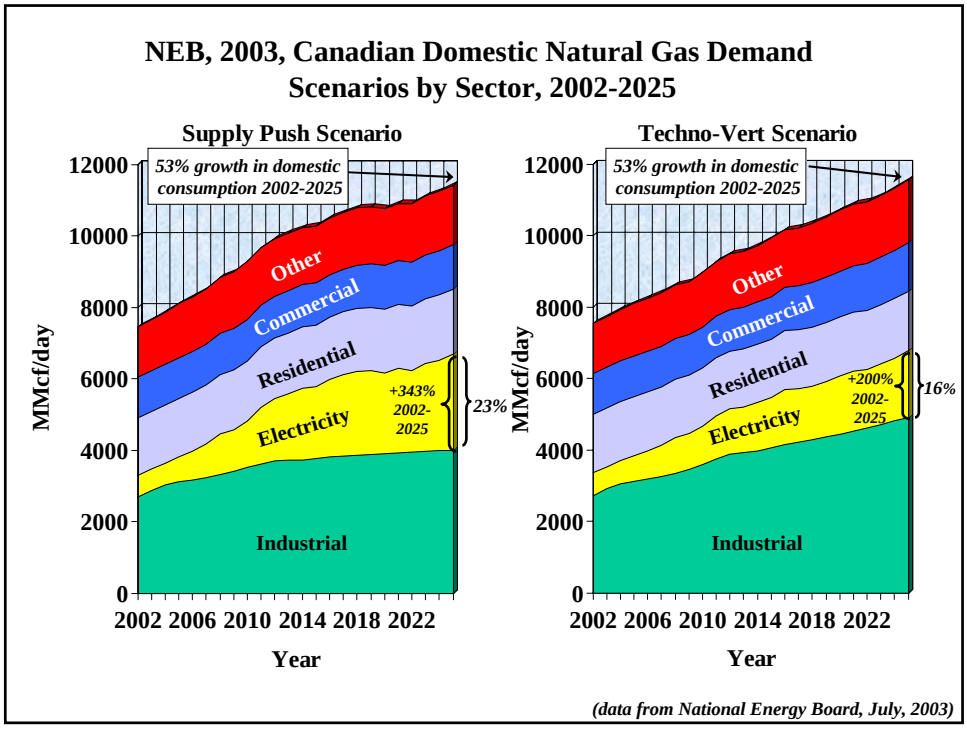
NEB, July, 2003, Deliverability Scenarios from Existing and Proposed Conventional Gas Sources Including Coalbed Methane

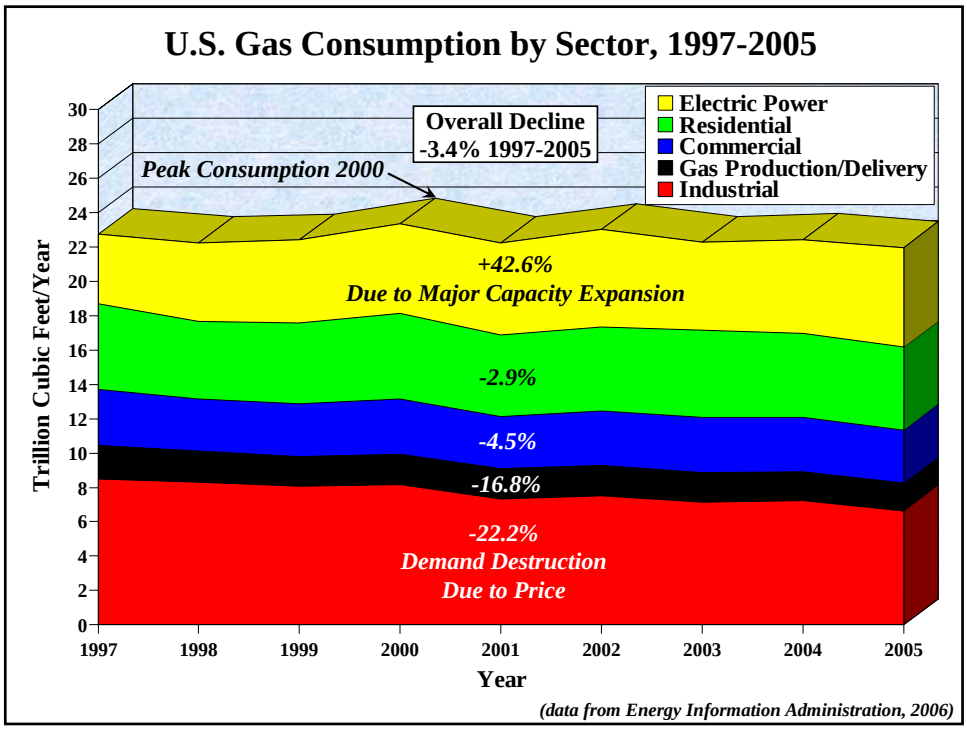


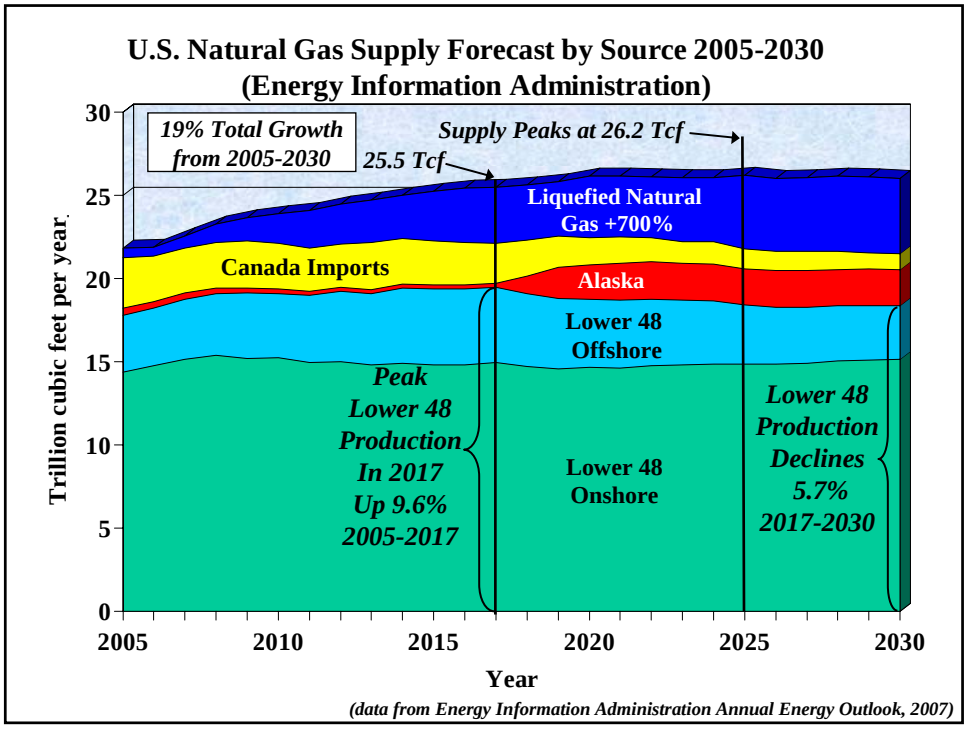
Actual Coalbed Methane Production in the U.S. 1997-2005 Compared to NEB Coalbed Methane Production Canada Scenarios 2003-2025

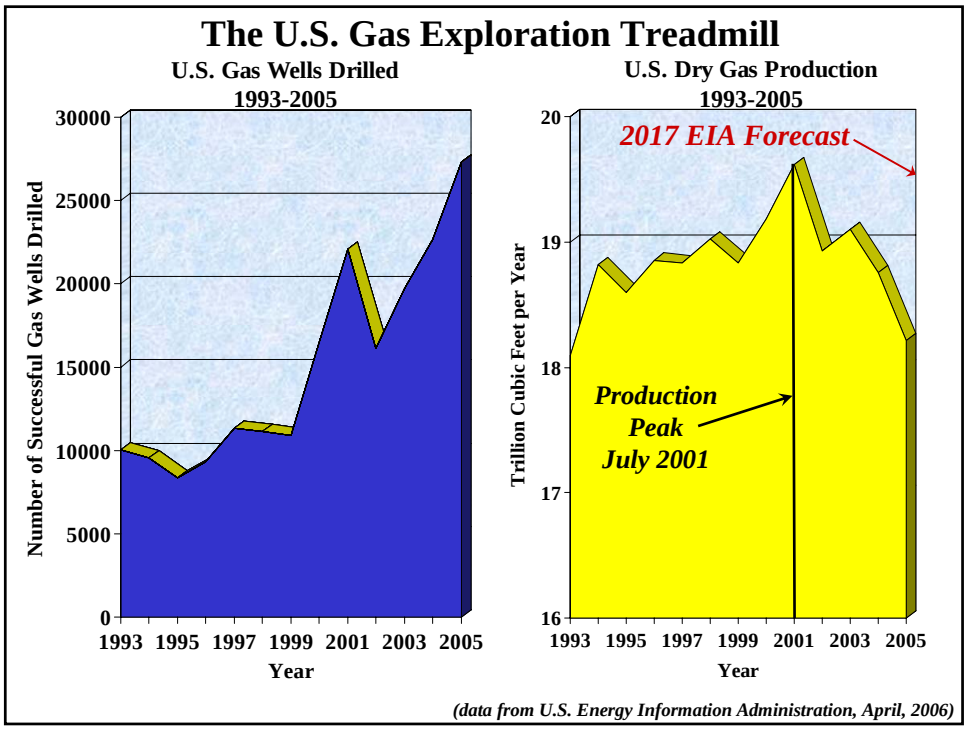


(Source of data Energy Information Administration, 2007; National Energy Board, July, 2003)

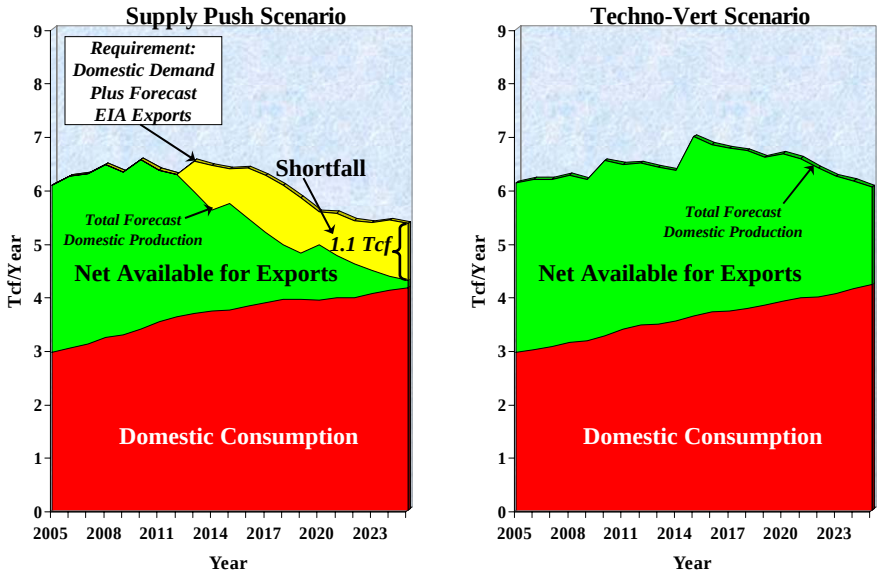

NEB, 2003, Canadian Domestic Natural Gas Demand Scenarios by Sector, 2002-2025
Supply Push Scenario
Techno-Vert Scenario
53% growth in domestic consumption 2002-2025
Other
Commercial
Residential
Electricity
Industrial
+343% 2002-2025
23%
+200% 2002-2025
16%
MMcf/day
12000
10000
8000
6000
4000
2000
0
2002 2006 2010 2014 2018 2022
Year
(data from National Energy Board, July, 2003)


U.S. Gas Consumption by Sector, 1997-2005
Overall Decline
-3.4% 1997-2005
Peak Consumption 2000
Electric Power
Residential
Commercial
Gas Production/Delivery
Industrial
+42.6%
Due to Major Capacity Expansion
-2.9%
-4.5%
-16.8%
-22.2%
Demand Destruction
Due to Price
Trillion Cubic Feet/Year
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
(data from Energy Information Administration, 2006)


U.S. Natural Gas Supply Forecast by Source 2005-2030
(Energy Information Administration)
19% Total Growth from 2005-2030
Supply Peaks at 26.2 Tcf
25.5 Tcf
Liquefied Natural Gas +700%
Canada Imports
Alaska
Lower 48 Offshore
Lower 48 Onshore
Peak Lower 48 Production In 2017 Up 9.6% 2005-2017
Lower 48 Production Declines 5.7% 2017-2030
Trillion cubic feet per year
Year
(data from Energy Information Administration Annual Energy Outlook, 2007)


The U.S. Gas Exploration Treadmill
U.S. Gas Wells Drilled 1993-2005
Number of Successful Gas Wells Drilled
Year
U.S. Dry Gas Production 1993-2005
2017 EIA Forecast
Production Peak July 2001
Trillion Cubic Feet per Year
Year
(data from U.S. Energy Information Administration, April, 2006)

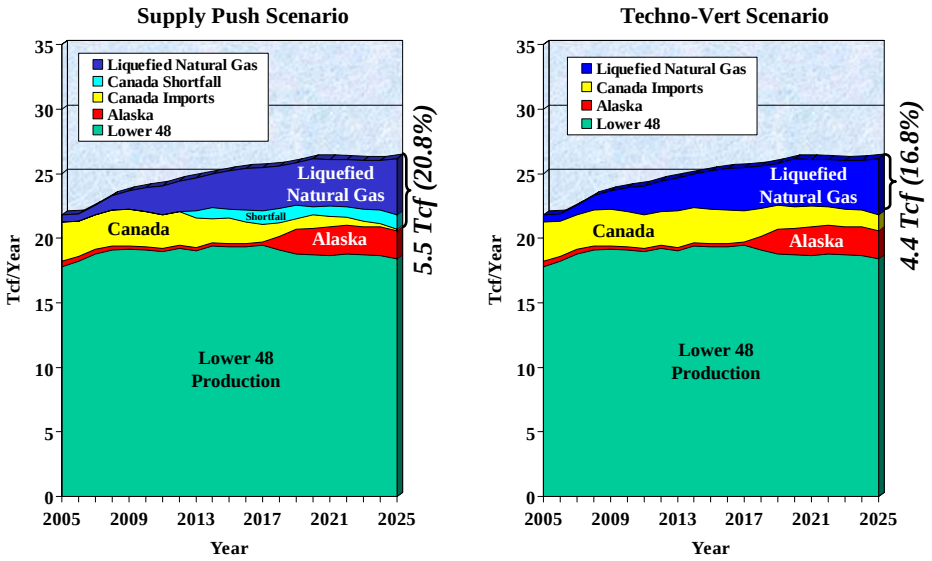
Canadian Shortfalls in Gas Supply Given Domestic Production Scenarios and Forecast EIA (AEO 2007) Reference U.S. Import Requirements



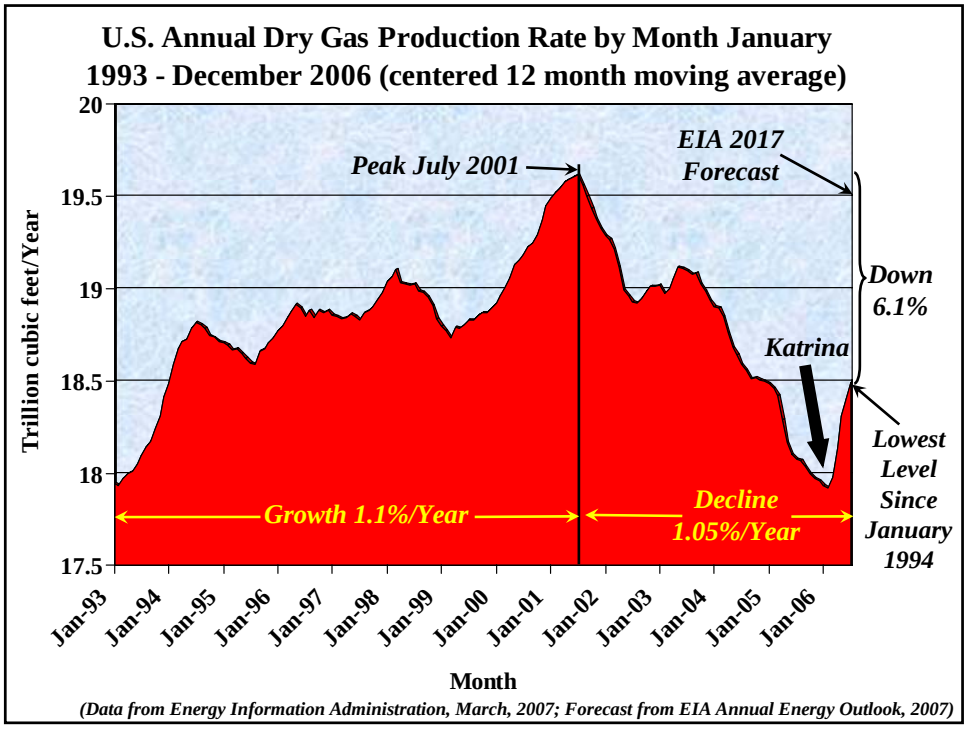
Note: Forecast Canadian LNG Imports are Excluded from Domestic Production

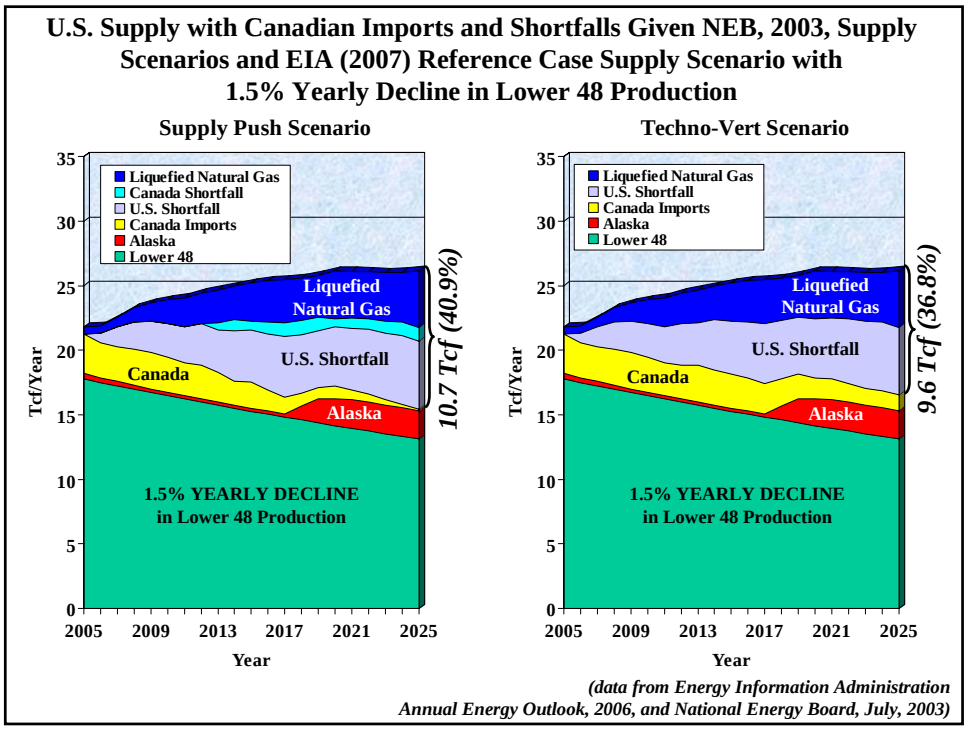
(data from National Energy Board, July, 2003, and EIA Annual Energy Outlook, 2007)

U.S. Supply with Canadian Imports and Shortfalls Given NEB, 2003, Supply Scenarios and EIA (2007) Reference Case Supply Scenario



(data from Energy Information Administration Annual Energy Outlook, 2007, and National Energy Board, July, 2003)


U.S. Annual Dry Gas Production Rate by Month January 1993 - December 2006 (centered 12 month moving average)
Trillion cubic feet/Year
20
19.5
19
18.5
18
17.5
Peak July 2001
EIA 2017 Forecast
Down 6.1%
Katrina
Lowest Level Since January 1994
Growth 1.1%/Year
Decline 1.05%/Year
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Month
(Data from Energy Information Administration, March, 2007; Forecast from EIA Annual Energy Outlook, 2007)


U.S. Supply with Canadian Imports and Shortfalls Given NEB, 2003, Supply Scenarios and EIA (2007) Reference Case Supply Scenario with 1.5% Yearly Decline in Lower 48 Production
Supply Push Scenario
Techno-Vert Scenario
Liquefied Natural Gas
Canada Shortfall
U.S. Shortfall
Canada Imports
Alaska
Lower 48
Tcf/Year
35
30
25
20
15
10
5
0
Liquefied Natural Gas
U.S. Shortfall
Canada
Alaska
10.7 Tcf (40.9%)
9.6 Tcf (36.8%)
1.5% YEARLY DECLINE in Lower 48 Production
2005
2009
2013
2017
2021
2025
Year
(data from Energy Information Administration Annual Energy Outlook, 2006, and National Energy Board, July, 2003)

FUTURE OUTLOOK:

- *IMPLICATIONS* – If supply and demand forecasts are to be believed, there appear to be serious supply shortfalls in Continental natural gas coming – *Canada is unlikely to be able to fill the supply gap*

- *SOLUTIONS* - probably involve a portfolio of options:

- **Conservation and Efficiency**
- **LNG –** ***already factored into existing forecasts; GEOPOLITICAL + NIMBY IMPLICATIONS***
- **Unconventional Gas -** ***already factored into existing forecasts in a big way***
- **Fuel Switching –** ***to oil or coal – capacity quite limited without new capital investment***
- **Destroy Demand –** ***move gas intensive industries offshore (fertilizer and petrochemical plants) - this is already happening; GEOPOLITICAL IMPLICATIONS***

LNG Logistics

OPERATING COSTS (FREEPORT, TEXAS[1]):

- ***Production =*** ***$US .50-$1.00/mcf***
- ***Liquefaction =*** ***$US .80-$1.00/mcf***

- ***Shipping =*** ***$US .50-$1.45/mcf***
- ***Receiving =*** ***$US .24-$.40/mcf***
- **TOTAL = $US 2.04-$3.85/mcf**

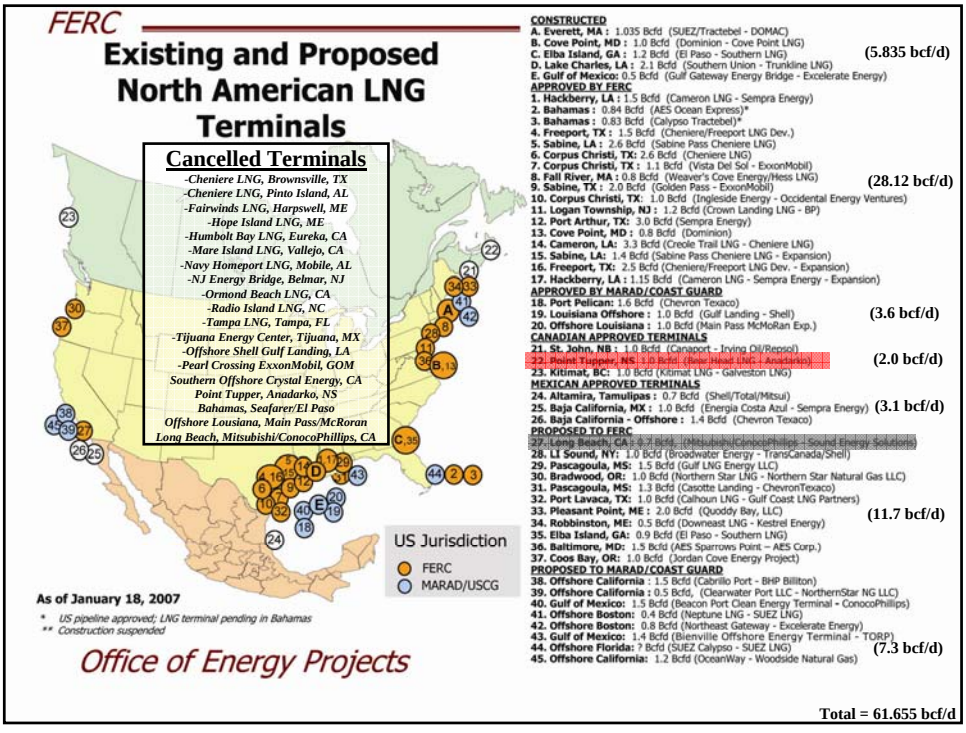
(U.S. 2005 Imports priced at $US 5.72-$7.44/mcf)

([1]Reimer, Freeport LNG, 2003; EIA November, 2005)

LNG Logistics

COVERING PROJECTED U.S. SHORTFALLS OF 4-11 TCF/YEAR WITH LNG WOULD REQUIRE NEARLY DOUBLING TO TRIPLING THE WORLD'S PRESENT LNG CAPACITY (the U.S. will also be in competition with many other countries for LNG supplies). EXPANSION OF NORTH AMERICAN LNG CAPACITY TO 11 TCF/YEAR WOULD REQUIRE ON THE ORDER OF:

- *200 New 3bcf capacity LNG Tankers*
- *30 New 1bcf/day North America-based receiving terminals*
- *56 New Foreign-based 200 bcf/year liquefaction trains*
- *Capital investment in the order of $US100-200 Billion*
- *Time to Build Total Capacity = 10-20+ Years*
- *OVERCOMING THE NIMBY SYNDROME IN LOCATING NEW TERMINALS*
- *ACCEPTING THE GEOPOLITICAL IMPLICATIONS OF DEPENDENCY ON OFFSHORE SUPPLY SOURCES*



CONSTRUCTED
A. Everett, MA : 1.035 Bcfd (SUEZ/Tractebel - DOMAC)
B. Cove Point, MD : 1.0 Bcfd (Dominion - Cove Point LNG)
C. Elba Island, GA : 1.2 Bcfd (El Paso - Southern LNG) **(5.835 bcf/d)**
D. Lake Charles, LA : 2.1 Bcfd (Southern Union - Trunkline LNG)
E. Gulf of Mexico: 0.5 Bcfd (Gulf Gateway Energy Bridge - Excelerate Energy)

APPROVED BY FERC
1. Hackberry, LA : 1.5 Bcfd (Cameron LNG - Sempra Energy)
2. Bahamas : 0.84 Bcfd (AES Ocean Express)*
3. Bahamas : 0.83 Bcfd (Calypso Tractebel)*
4. Freeport, TX : 1.5 Bcfd (Cheniere/Freeport LNG Dev.)
5. Sabine, LA : 2.6 Bcfd (Sabine Pass Cheniere LNG)
6. Corpus Christi, TX: 2.6 Bcfd (Cheniere LNG)
7. Corpus Christi, TX : 1.1 Bcfd (Vista Del Sol - ExxonMobil)
8. Fall River, MA : 0.8 Bcfd (Weaver's Cove Energy/Hess LNG) **(28.12 bcf/d)**
9. Sabine, TX : 2.0 Bcfd (Golden Pass - ExxonMobil)
10. Corpus Christi, TX: 1.0 Bcfd (Ingleside Energy - Occidental Energy Ventures)
11. Logan Township, NJ : 1.2 Bcfd (Crown Landing LNG - BP)
12. Port Arthur, TX: 3.0 Bcfd (Sempra Energy)
13. Cove Point, MD : 0.8 Bcfd (Dominion)
14. Cameron, LA: 3.3 Bcfd (Creole Trail LNG - Cheniere LNG)
15. Sabine, LA: 1.4 Bcfd (Sabine Pass Cheniere LNG - Expansion)
16. Freeport, TX: 2.5 Bcfd (Cheniere/Freeport LNG Dev. - Expansion)
17. Hackberry, LA : 1.15 Bcfd (Cameron LNG - Sempra Energy - Expansion)

APPROVED BY MARAD/COAST GUARD
18. Port Pelican: 1.6 Bcfd (Chevron Texaco)
19. Louisiana Offshore : 1.0 Bcfd (Gulf Landing - Shell) **(3.6 bcf/d)**
20. Offshore Louisiana : 1.0 Bcfd (Main Pass McMoRan Exp.)

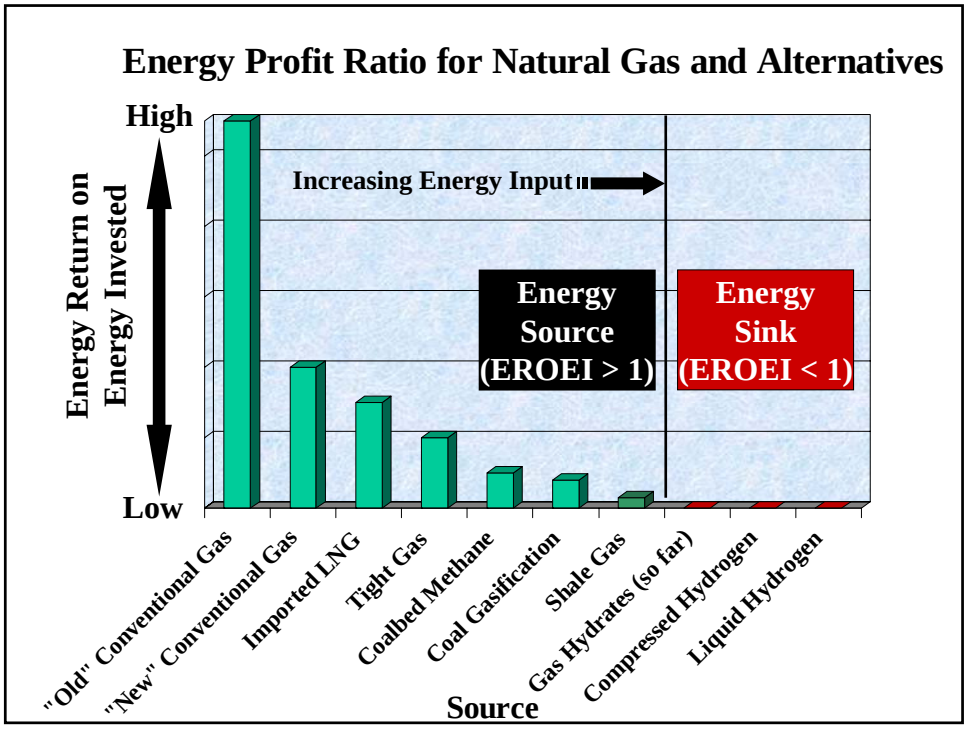
CANADIAN APPROVED TERMINALS
21. St. John, NB : 1.0 Bcfd (Canaport - Irving Oil/Repsol)
22. Point Tupper, NS: 1.0 Bcfd (Bear Head LNG - Anadarko) **(2.0 bcf/d)**
23. Kitimat, BC: 1.0 Bcfd (Kitimat LNG - Galveston LNG)

MEXICAN APPROVED TERMINALS
24. Altamira, Tamulipas : 0.7 Bcfd (Shell/Total/Mitsui)
25. Baja California, MX : 1.0 Bcfd (Energia Costa Azul - Sempra Energy) **(3.1 bcf/d)**
26. Baja California - Offshore : 1.4 Bcfd (Chevron Texaco)

PROPOSED TO FERC
27. Long Beach, CA : 0.7 Bcfd (Mitsubishi/ConocoPhillips - Sound Energy Solutions)
28. LI Sound, NY: 1.0 Bcfd (Broadwater Energy - TransCanada/Shell)
29. Pascagoula, MS: 1.5 Bcfd (Gulf LNG Energy LLC)
30. Bradwood, OR: 1.0 Bcfd (Northern Star LNG - Northern Star Natural Gas LLC)
31. Pascagoula, MS: 1.3 Bcfd (Casotte Landing - ChevronTexaco)
32. Port Lavaca, TX: 1.0 Bcfd (Calhoun LNG - Gulf Coast LNG Partners)
33. Pleasant Point, ME : 2.0 Bcfd (Quoddy Bay, LLC) **(11.7 bcf/d)**
34. Robbinston, ME: 0.5 Bcfd (Downeast LNG - Kestrel Energy)
35. Elba Island, GA: 0.9 Bcfd (El Paso - Southern LNG)
36. Baltimore, MD: 1.5 Bcfd (AES Sparrows Point – AES Corp.)
37. Coos Bay, OR: 1.0 Bcfd (Jordan Cove Energy Project)

PROPOSED TO MARAD/COAST GUARD
38. Offshore California : 1.5 Bcfd (Cabrillo Port - BHP Billiton)
39. Offshore California : 0.5 Bcfd, (Clearwater Port LLC - NorthernStar NG LLC)
40. Gulf of Mexico: 1.5 Bcfd (Beacon Port Clean Energy Terminal - ConocoPhillips)
41. Offshore Boston: 0.4 Bcfd (Neptune LNG - SUEZ LNG)
42. Offshore Boston: 0.8 Bcfd (Northeast Gateway - Excelerate Energy)
43. Gulf of Mexico: 1.4 Bcfd (Bienville Offshore Energy Terminal - TORP)
44. Offshore Florida: ? Bcfd (SUEZ Calypso - SUEZ LNG) **(7.3 bcf/d)**
45. Offshore California: 1.2 Bcfd (OceanWay - Woodside Natural Gas)

Total = 61.655 bcf/d



COAL

- Two-thirds of the world's remaining hydrocarbon energy

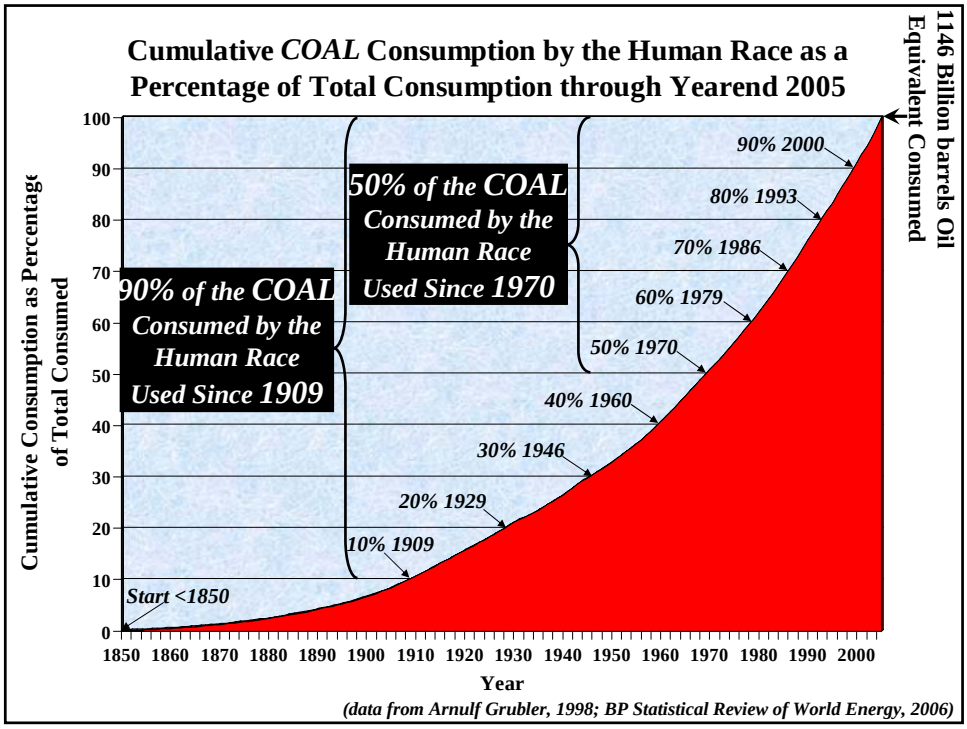
- 27.8% of the world's primary energy consumption in 2005 – second only to *OIL – Projected by EIA to be fastest growing fuel through 2030*

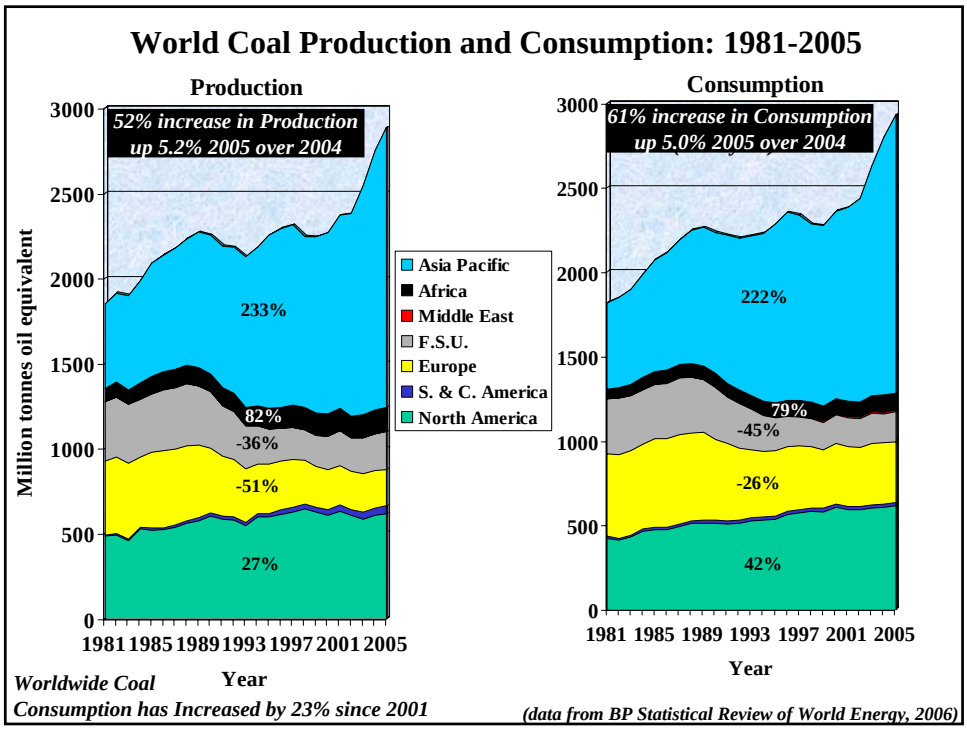
- Used for electricity generation (more so than any other fuel), primary heat and in the steel industry

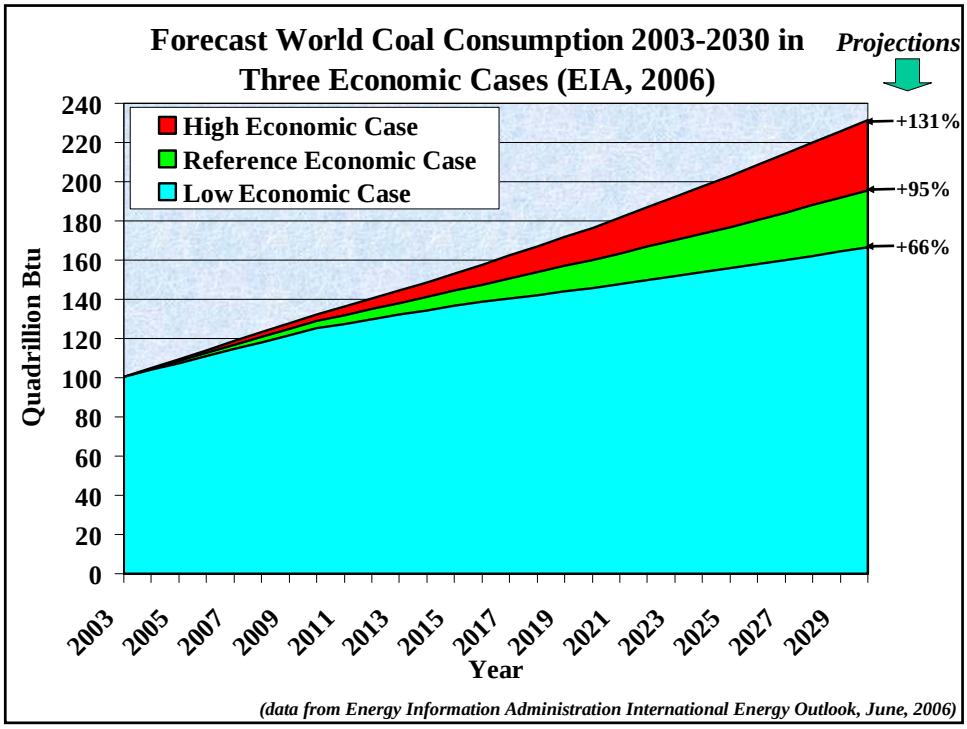
- Lowest cost heat source: $0.84-$3.00US/gigajoule versus $9.52US/gigajoule for gas and $9.69US/gigajoule for oil

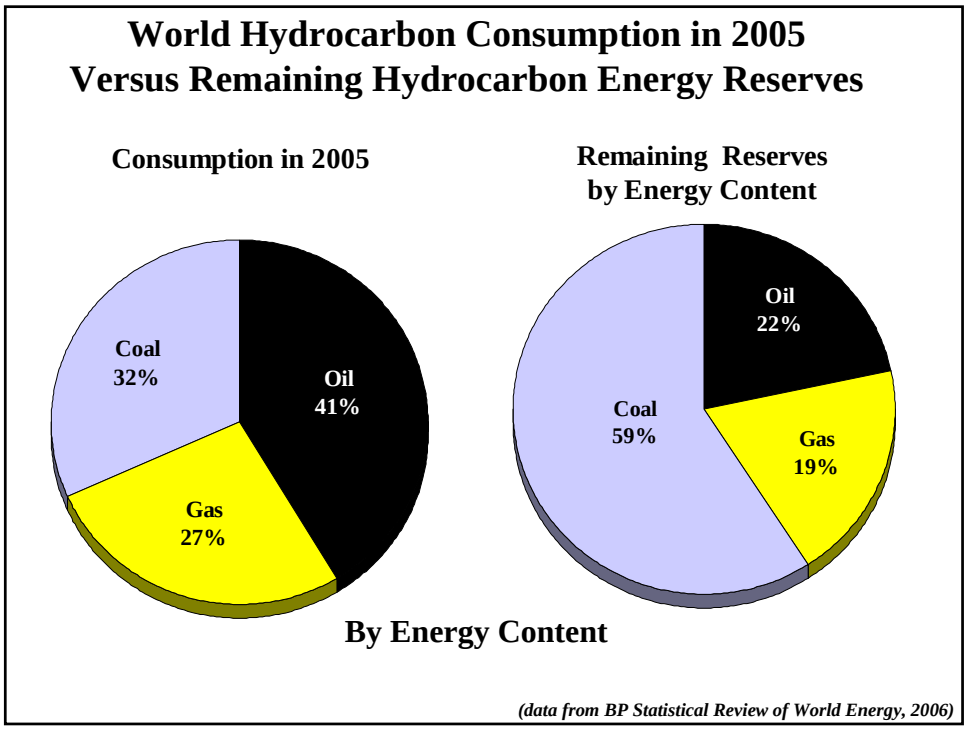
- Double the carbon footprint of gas using conventional technology – with advanced "clean coal" technologies the carbon footprint can be reduced almost to that of gas (but costs $$$)

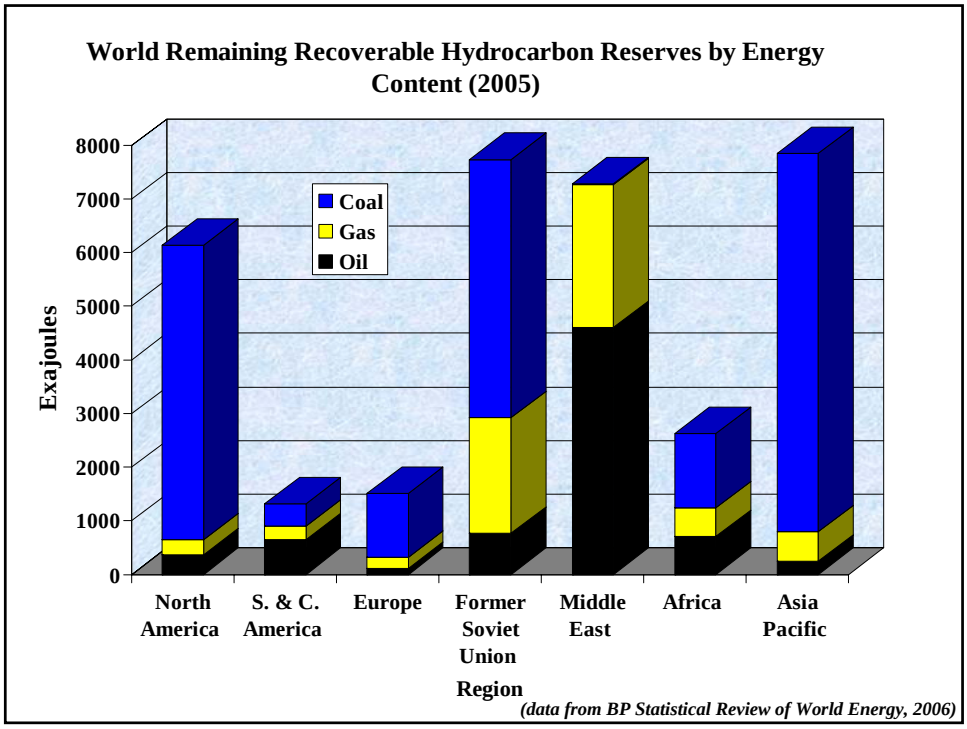
- Fastest growing hydrocarbon fuel source: consumption has grown 23% since yearend 2001 (5.0% in 2005)

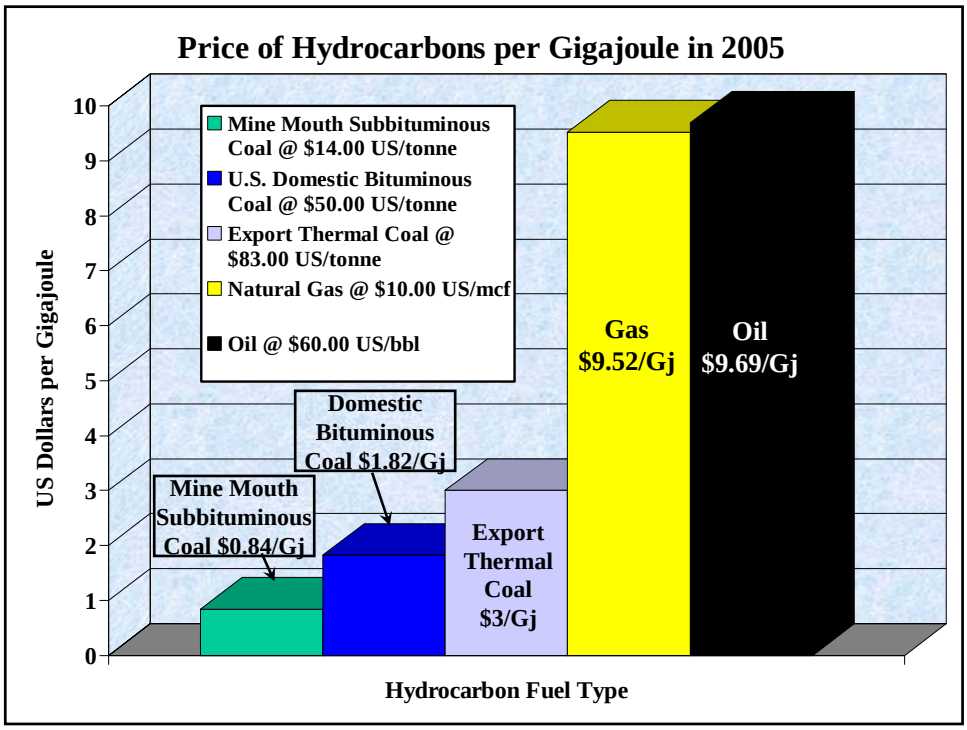

Cumulative *COAL* Consumption by the Human Race as a Percentage of Total Consumption through Yearend 2005
Cumulative Consumption as Percentage of Total Consumed
1146 Billion barrels Oil Equivalent Consumed
90% of the COAL Consumed by the Human Race Used Since 1909
50% of the COAL Consumed by the Human Race Used Since 1970
Start <1850
10% 1909
20% 1929
30% 1946
40% 1960
50% 1970
60% 1979
70% 1986
80% 1993
90% 2000
0 10 20 30 40 50 60 70 80 90 100
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
Year
(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2006)


World Coal Production and Consumption: 1981-2005
Production
52% increase in Production up 5.2% 2005 over 2004
Million tonnes oil equivalent
233%
82%
-36%
-51%
27%
0 500 1000 1500 2000 2500 3000
1981 1985 1989 1993 1997 2001 2005
Year
Asia Pacific
Africa
Middle East
F.S.U.
Europe
S. & C. America
North America
Consumption
61% increase in Consumption up 5.0% 2005 over 2004
222%
79%
-45%
-26%
42%
0 500 1000 1500 2000 2500 3000
1981 1985 1989 1993 1997 2001 2005
Year
Worldwide Coal Consumption has Increased by 23% since 2001
(data from BP Statistical Review of World Energy, 2006)

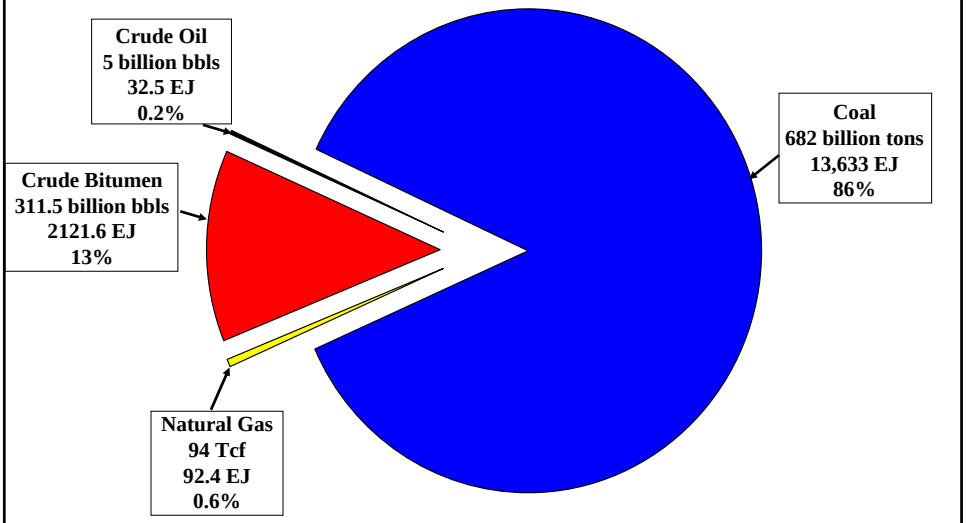

Forecast World Coal Consumption 2003-2030 in Three Economic Cases (EIA, 2006)
Projections
High Economic Case
Reference Economic Case
Low Economic Case
+131%
+95%
+66%
Quadrillion Btu
240
220
200
180
160
140
120
100
80
60
40
20
0
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
Year
(data from Energy Information Administration International Energy Outlook, June, 2006)


World Hydrocarbon Consumption in 2005
Versus Remaining Hydrocarbon Energy Reserves
Consumption in 2005
Coal 32%
Oil 41%
Gas 27%
Remaining Reserves by Energy Content
Oil 22%
Coal 59%
Gas 19%
By Energy Content
(data from BP Statistical Review of World Energy, 2006)


World Remaining Recoverable Hydrocarbon Reserves by Energy Content (2005)
Exajoules
8000
7000
6000
5000
4000
3000
2000
1000
0
Coal
Gas
Oil
North America
S. & C. America
Europe
Former Soviet Union
Middle East
Africa
Asia Pacific
Region
(data from BP Statistical Review of World Energy, 2006)

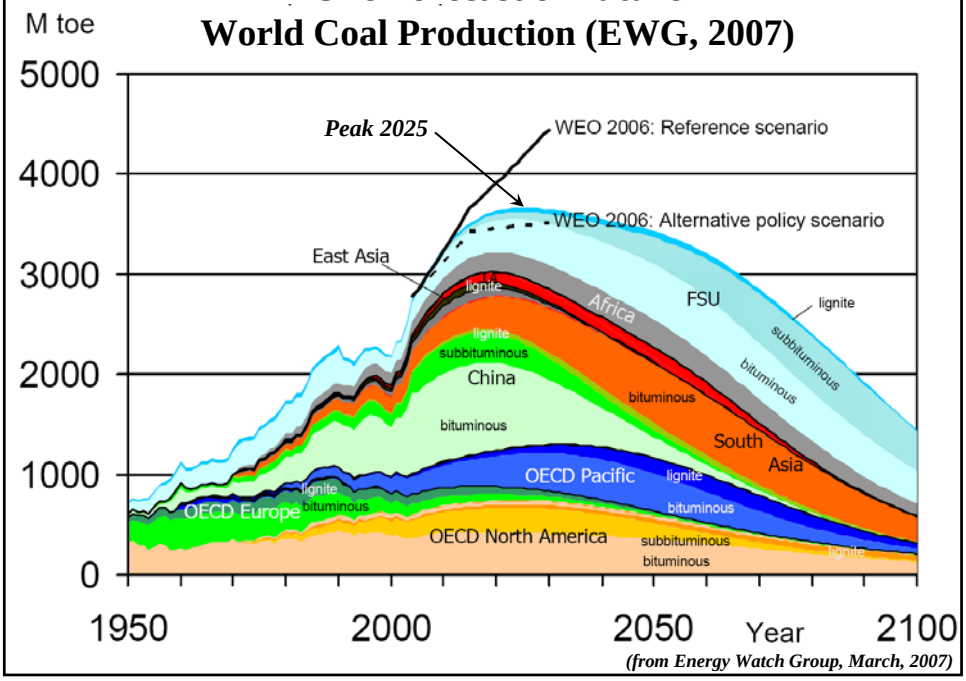

Price of Hydrocarbons per Gigajoule in 2005
US Dollars per Gigajoule
10
9
8
7
6
5
4
3
2
1
0
Mine Mouth Subbituminous Coal @ $14.00 US/tonne
U.S. Domestic Bituminous Coal @ $50.00 US/tonne
Export Thermal Coal @ $83.00 US/tonne
Natural Gas @ $10.00 US/mcf
Oil @ $60.00 US/bbl
Domestic Bituminous Coal $1.82/Gj
Mine Mouth Subbituminous Coal $0.84/Gj
Export Thermal Coal $3/Gj
Gas $9.52/Gj
Oil $9.69/Gj
Hydrocarbon Fuel Type

Energy Content in Recoverable Remaining Ultimate Potential of Hydrocarbons in Alberta (in exajoules)



(data from Alberta Energy and Utilities Board, 2003)

One Forecast of Future World Coal Production (EWG, 2007)



(from Energy Watch Group, March, 2007)

WHAT ABOUT "CLEAN COAL"?

- Higher efficiency generation with new technologies can reduce CO_2 emissions by 25% given existing technologies – more in future, coupled with 99+% reduction in particulates, 99% in SO_x, 90% in NO_x and 90% in mercury

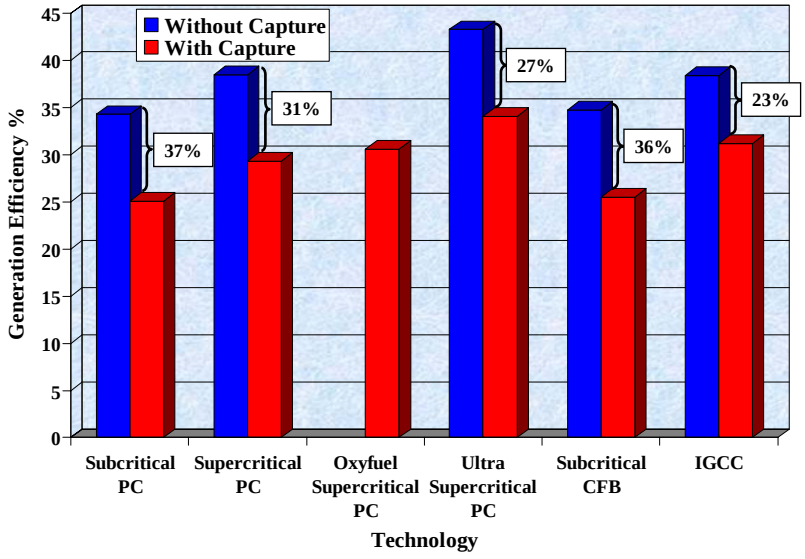
- Clean Coal technologies to reduce emissions coupled with a very aggressive conservation and efficiency program may make more sense than carbon capture and storage at the scale that would allow business-as-usual to exist for a few more years

- Carbon capture and storage implies parasitic power losses of 23 - 37% to plants requiring more plant construction and more fuel consumption to cover losses

- Carbon capture and storage requires much higher capital costs for plant construction (32-74%)

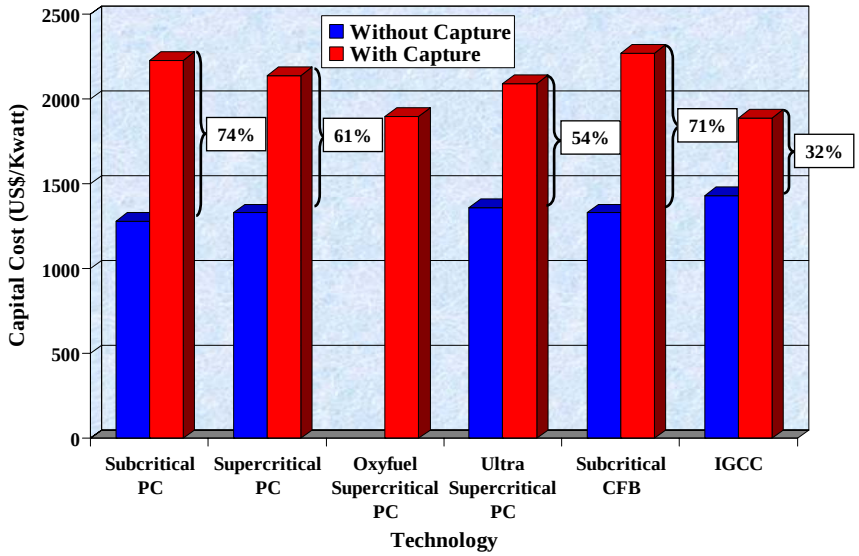
- Carbon capture and storage is unproven at the scale required to make a difference and the CO_2 transportation and sequestration issue likely means even more capital and parasitic energy losses

Generation Efficiency and Parasitic Power Losses for CO_2 Capture from Coal Plants versus Technology



(data from "The Future of Coal", Massachusetts Institute of Technology, 2007)

Capital Cost of Plants with Various Technologies with and without Carbon Capture



(data from "The Future of Coal", Massachusetts Institute of Technology, 2007)

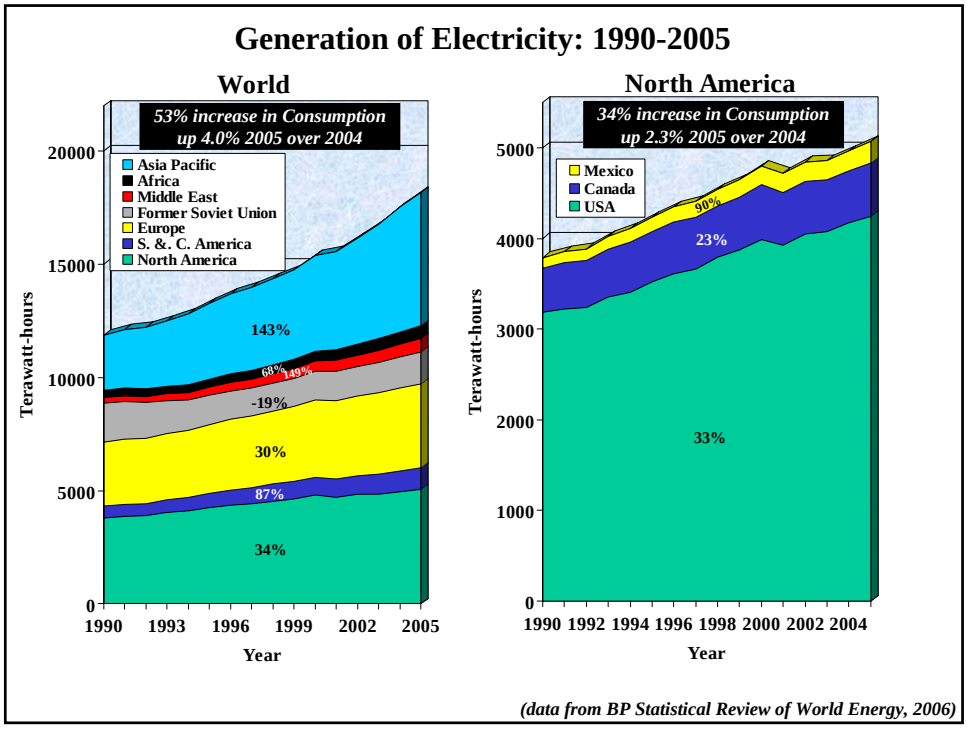
ELECTRICITY

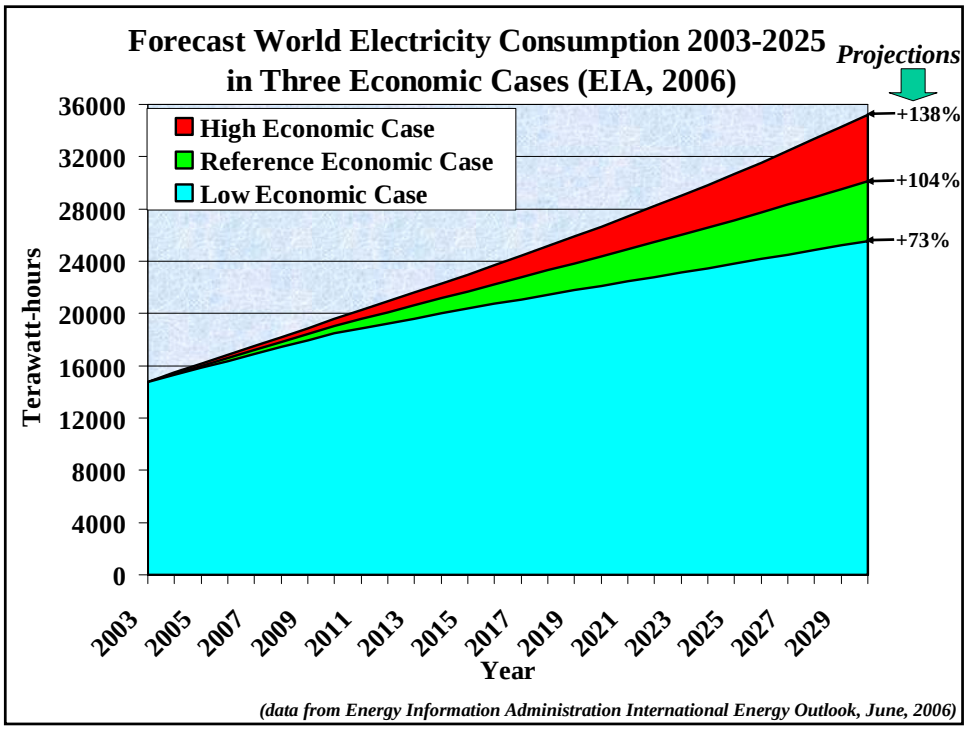
- Availability of reliable electricity defines our modern civilization

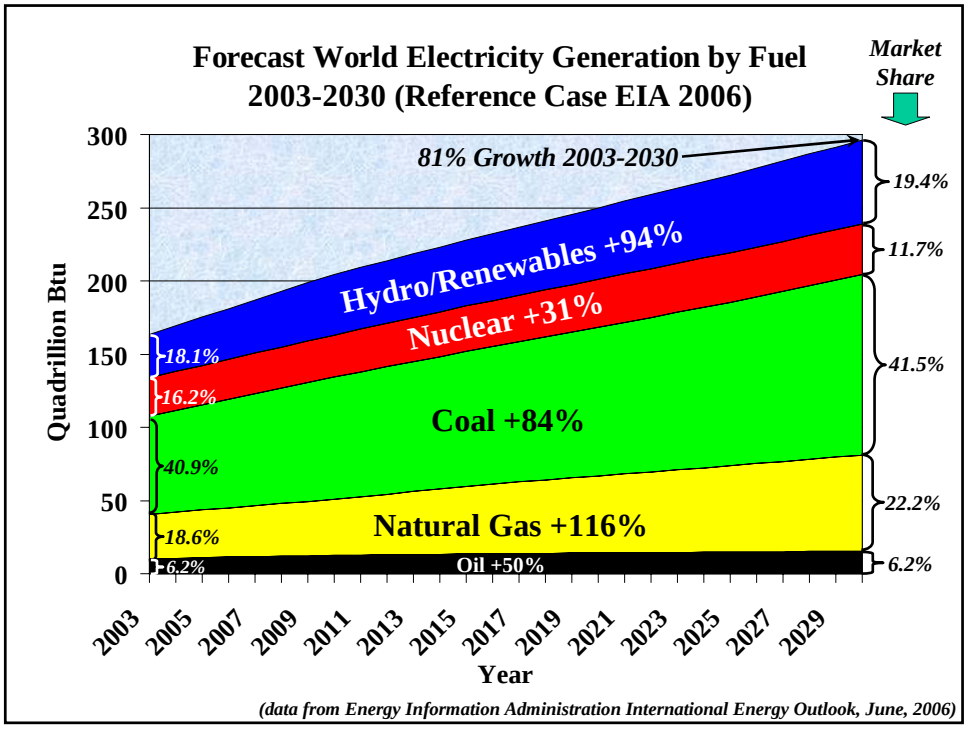
- Electricity in essence cannot be stored in bulk – it must be generated on demand

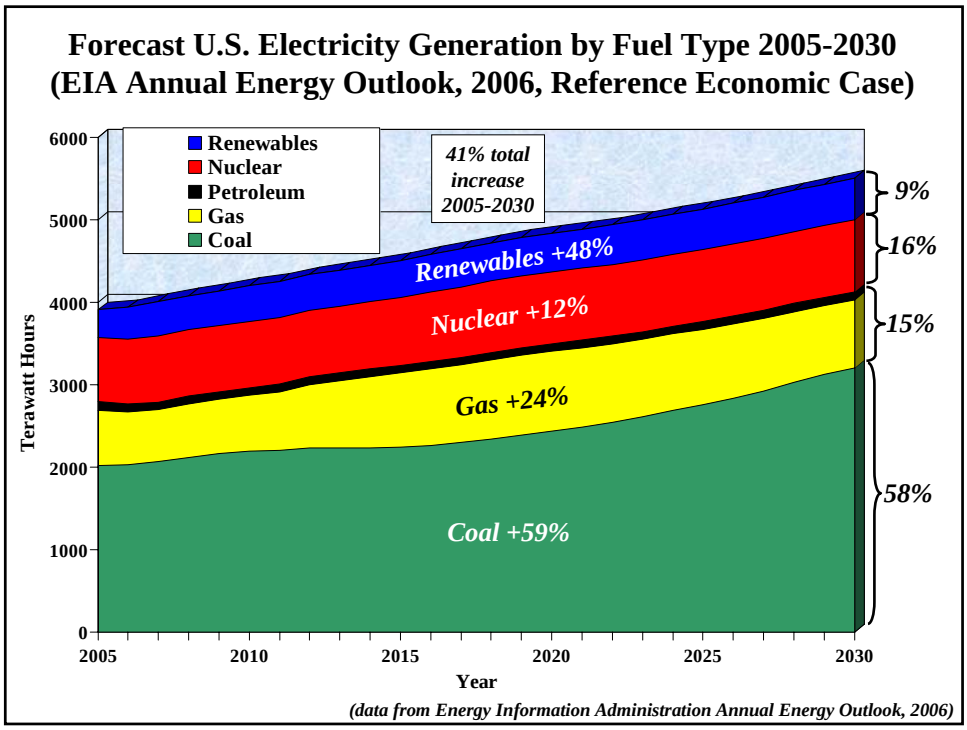
- We convert hydrocarbons to electricity at an energy penalty of from 30 to 70%

- Electricity is transmitted to points of use with losses depending on transmission distance – *IT IS NOT A WORLD TRADABLE COMMODITY*

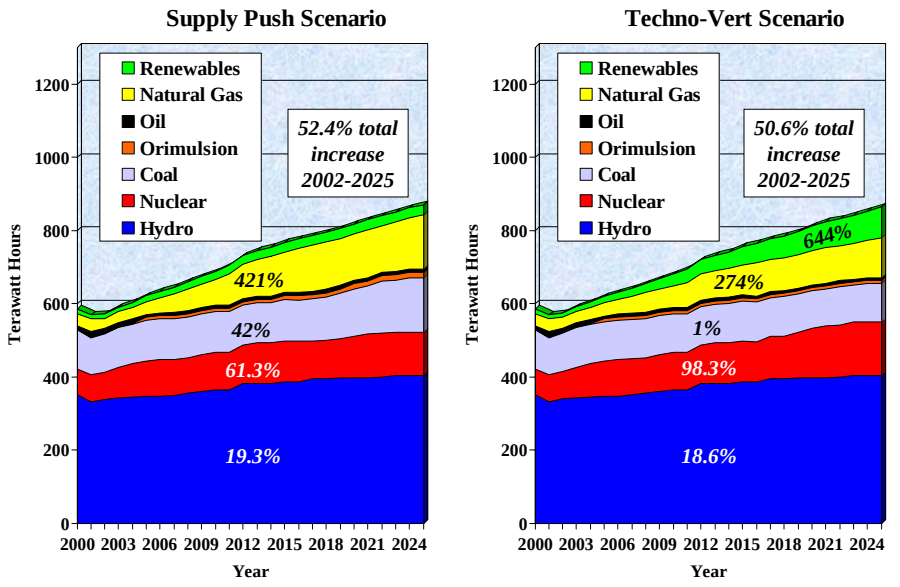

Generation of Electricity: 1990-2005
World
53% increase in Consumption
up 4.0% 2005 over 2004
Asia Pacific
Africa
Middle East
Former Soviet Union
Europe
S. &. C. America
North America
143%
68%
149%
-19%
30%
87%
34%
Terawatt-hours
Year
North America
34% increase in Consumption
up 2.3% 2005 over 2004
Mexico
Canada
USA
90%
23%
33%
Terawatt-hours
Year
(data from BP Statistical Review of World Energy, 2006)


Forecast World Electricity Consumption 2003-2025
in Three Economic Cases (EIA, 2006)
Projections
High Economic Case
Reference Economic Case
Low Economic Case
+138%
+104%
+73%
Terawatt-hours
Year
(data from Energy Information Administration International Energy Outlook, June, 2006)


Forecast World Electricity Generation by Fuel
2003-2030 (Reference Case EIA 2006)
Market Share
81% Growth 2003-2030
Hydro/Renewables +94%
Nuclear +31%
Coal +84%
Natural Gas +116%
Oil +50%
18.1%
16.2%
40.9%
18.6%
6.2%
19.4%
11.7%
41.5%
22.2%
6.2%
Quadrillion Btu
300
250
200
150
100
50
0
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
Year
(data from Energy Information Administration International Energy Outlook, June, 2006)


Forecast U.S. Electricity Generation by Fuel Type 2005-2030
(EIA Annual Energy Outlook, 2006, Reference Economic Case)
Renewables
Nuclear
Petroleum
Gas
Coal
41% total increase 2005-2030
Renewables +48%
Nuclear +12%
Gas +24%
Coal +59%
9%
16%
15%
58%
Terawatt Hours
6000
5000
4000
3000
2000
1000
0
2005
2010
2015
2020
2025
2030
Year
(data from Energy Information Administration Annual Energy Outlook, 2006)

Canadian Electricity Generation Scenarios by Fuel, 2000-2025



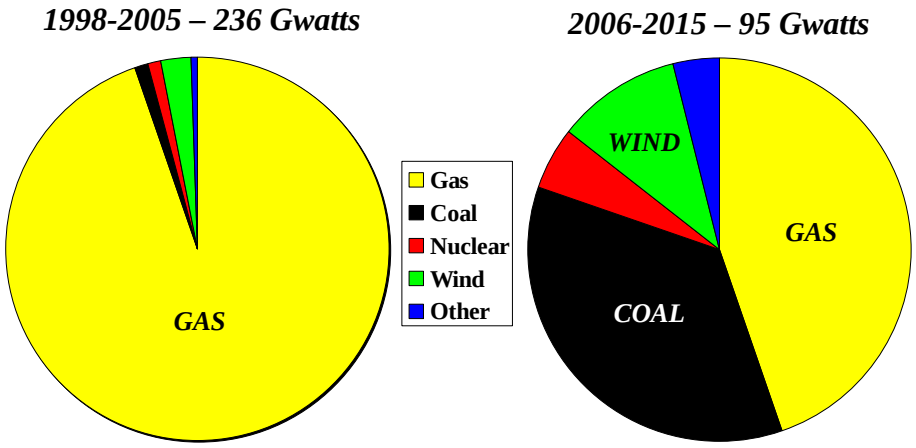
(data from National Energy Board, July, 2003)

Implementation Times and Other Considerations For New Electricity Infrastructure

FACTOR	*GAS*	*COAL*	*NUCLEAR*	*HYDRO*
Capital Cost	LOW-MOD	MOD-HIGH	HIGH - VERY HIGH	VERY HIGH
Fuel Cost	VERY HIGH	LOW	VERY LOW	VERY LOW
Environmental Footprint	LOW	MOD(now) LOW(future)	VERY LOW[1]	VERY LOW[2]
Time to startup (years)	**1-2+**	**5-7+**	**5-12+**	**6-10+**

[1] If the as yet unsolved problem of waste disposal is not considered
[2] If the environmental costs of flooding river valleys, siltation and ecosystem impacts are not considered

North American Generating Capacity Expansion By Fuel (1998-2015)

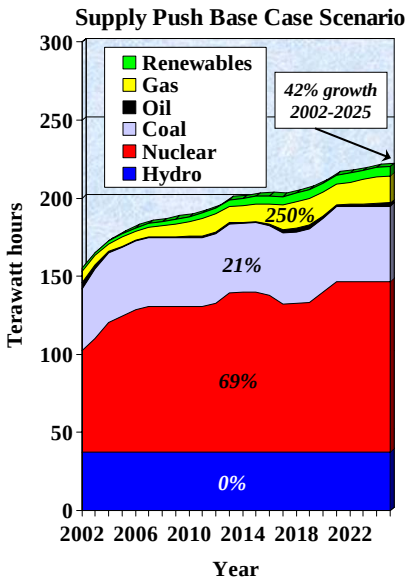


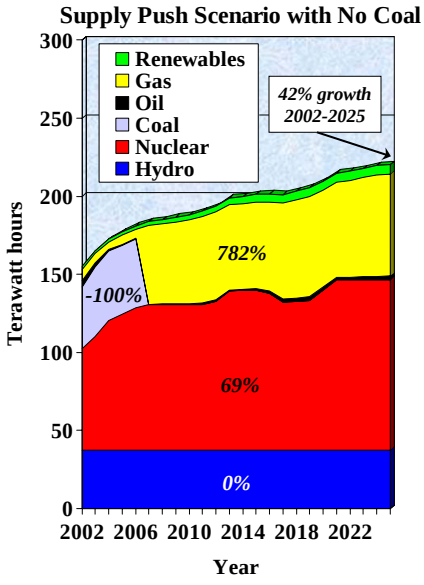
Total Expansion 331 Gwatts or ~30%

(data from National Electricity Reliability Council, October, 2006)

WHAT ABOUT ONTARIO?

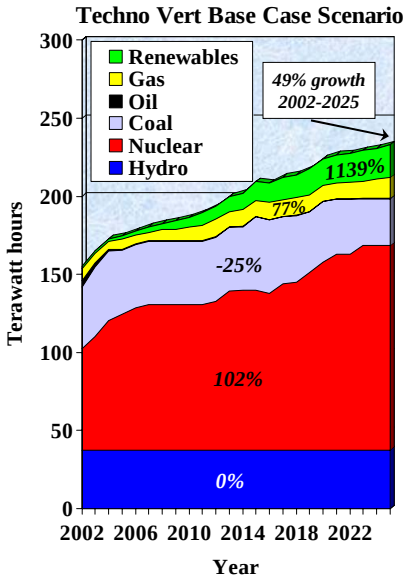
Ontario Electricity Generation with Base Case NEB Supply Push Scenario and shutting down Coal

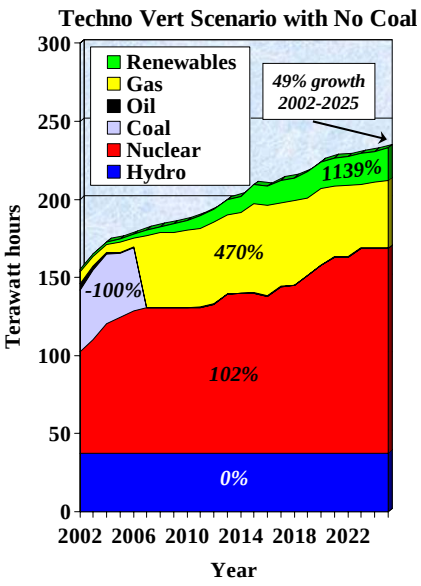




(data from National Energy Board, July, 2003)

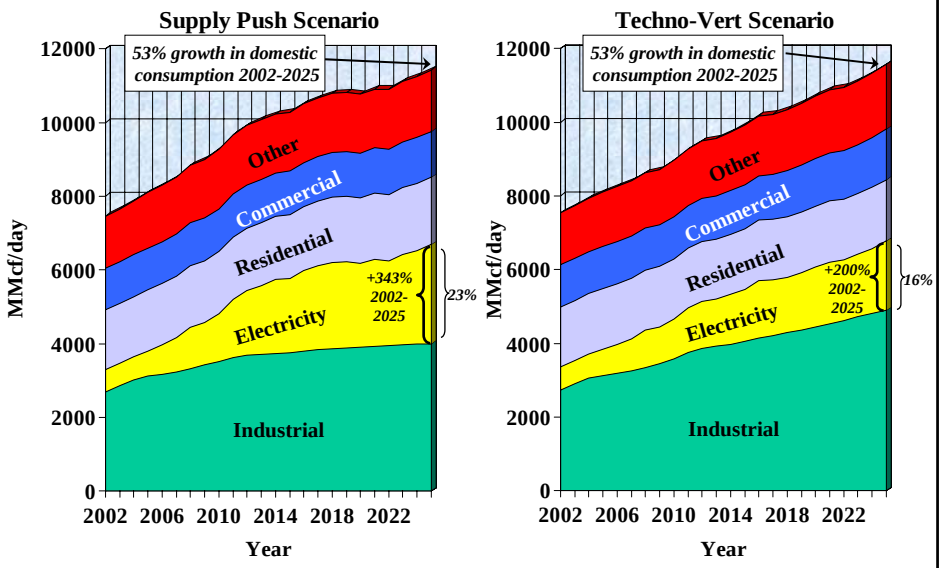
Ontario Electricity Generation with Base Case NEB Techno Vert Scenario and shutting down Coal





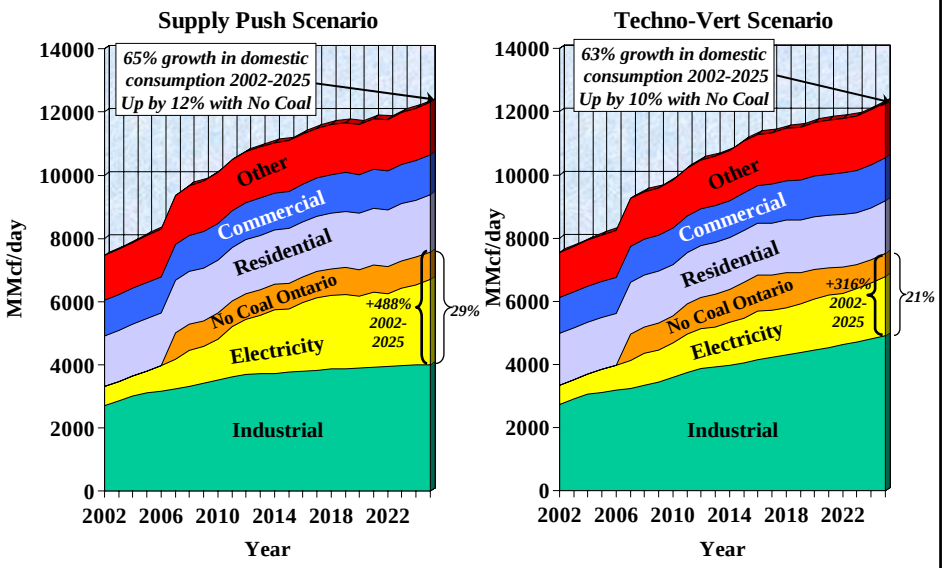
(data from National Energy Board, July, 2003)

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

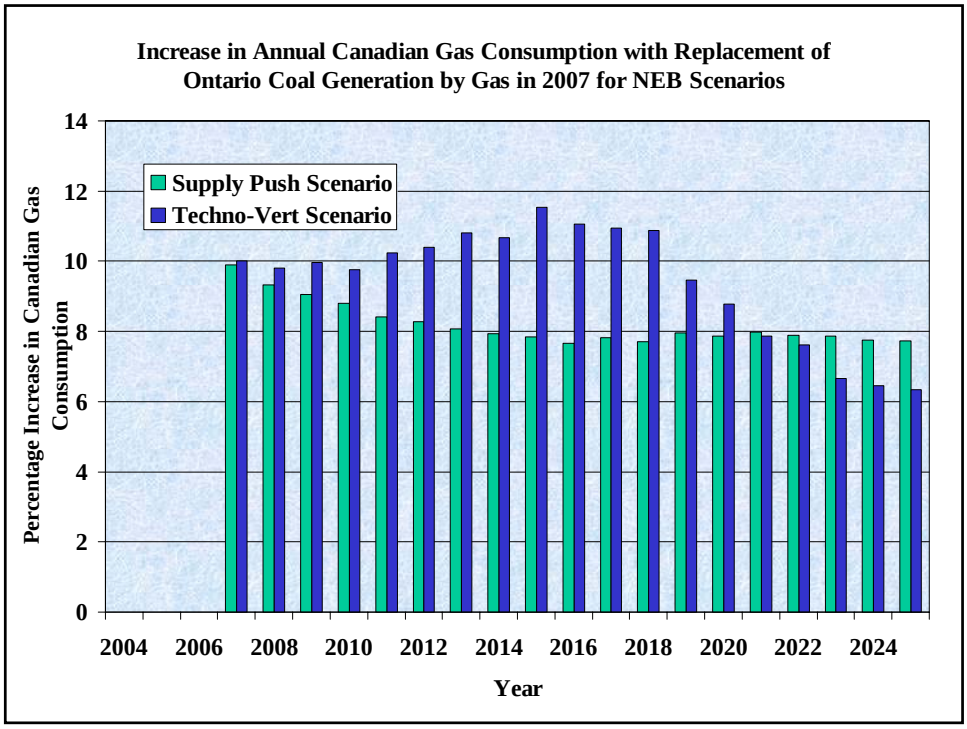


(data from National Energy Board, July, 2003)

Canadian Domestic Natural Gas Demand Scenarios by Sector Assuming Replacement of Ontario Coal Generation by Gas, 2002-2025



(data from National Energy Board, July, 2003)



HYDROGEN
The Silver Bullet?

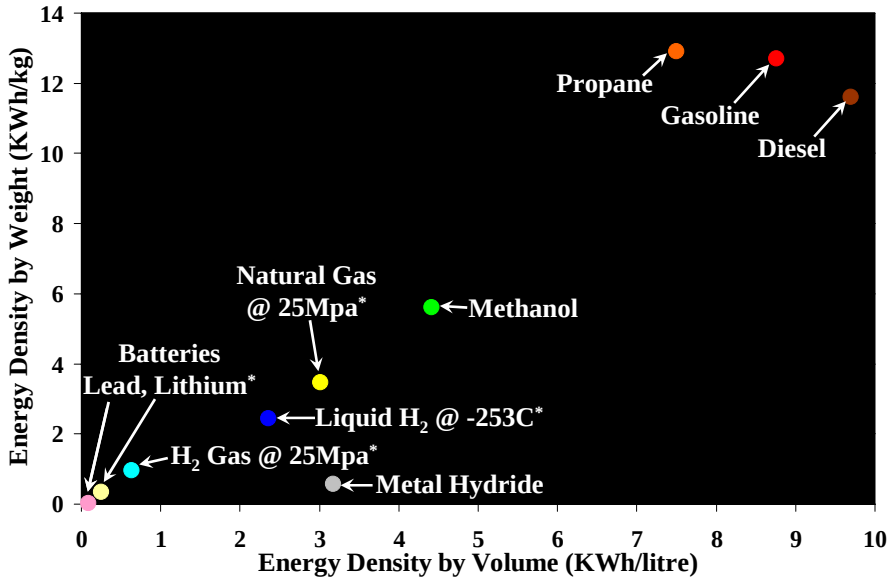
- Hydrogen is an *ENERGY CARRIER* not an *ENERGY SOURCE*

- Hydrogen is largely created from hydrocarbons or electrolysis, each of which can be used directly without the energy conversion losses to hydrogen

- Because of energy losses in production of hydrogen from hydrocarbons or electrolysis, a "Hydrogen Economy" could actually exacerbate the greenhouse gas emission and Global Warming Problem, if hydrogen cannot be generated exclusively from renewable sources (conversion from gas loses 30% and from electolysis 28% (not including the losses from hydrocarbons to electricity – a further 30-70%))

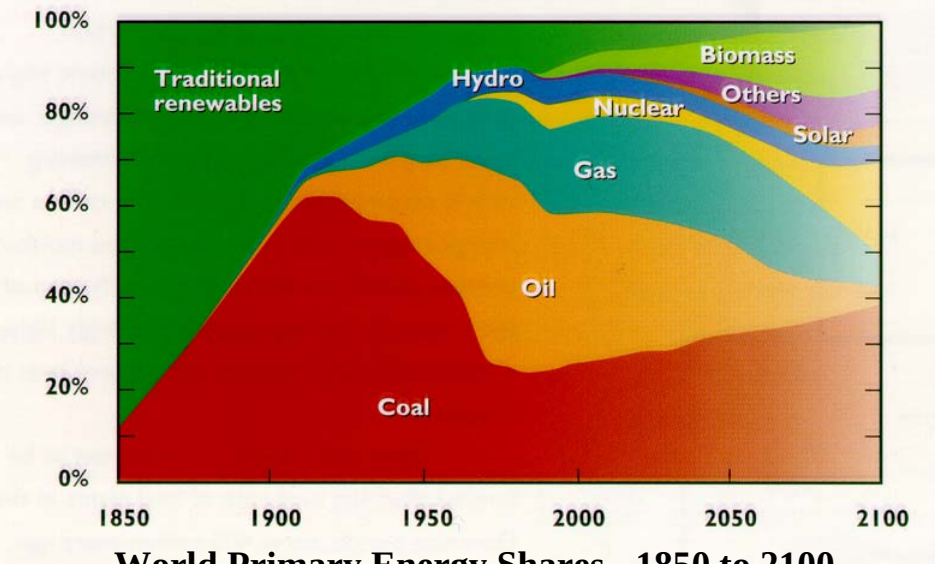
- The stock brokers have already figured it out - witness "Hydrogen's non-future" published in the Financial Post of April 3, 2004, based on BMO Nesbitt Burns analysis of the Hydrogen Economy

Energy Density of Hydrogen in Comparison With Other Energy Carriers



*Includes Weight of Containment Vessel

(data from Dr. Werner Zittel et al, 1996)



World Primary Energy Shares - 1850 to 2100 Given Oil and Gas Supply Limitations

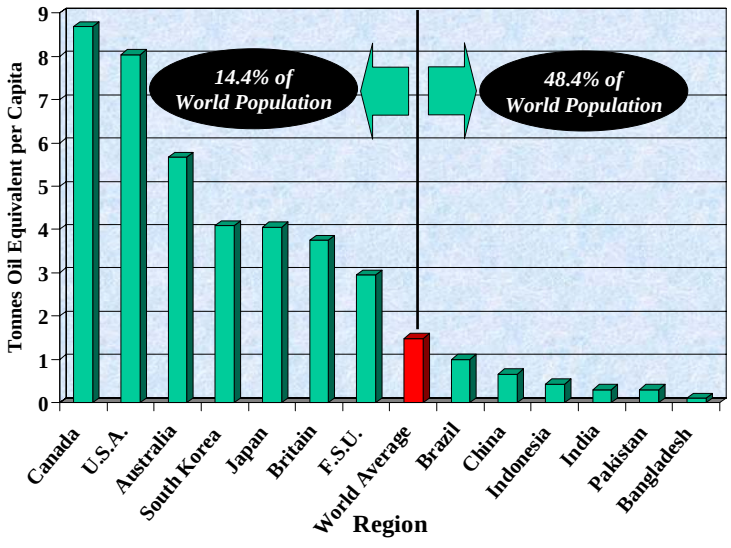
Source - World Coal Institute

The Last Piece of the Energy Sustainability Puzzle:

POPULATION GROWTH and ASPIRATIONS OF GROWTH IN ENERGY CONSUMPTION IN THE DEVELOPING WORLD

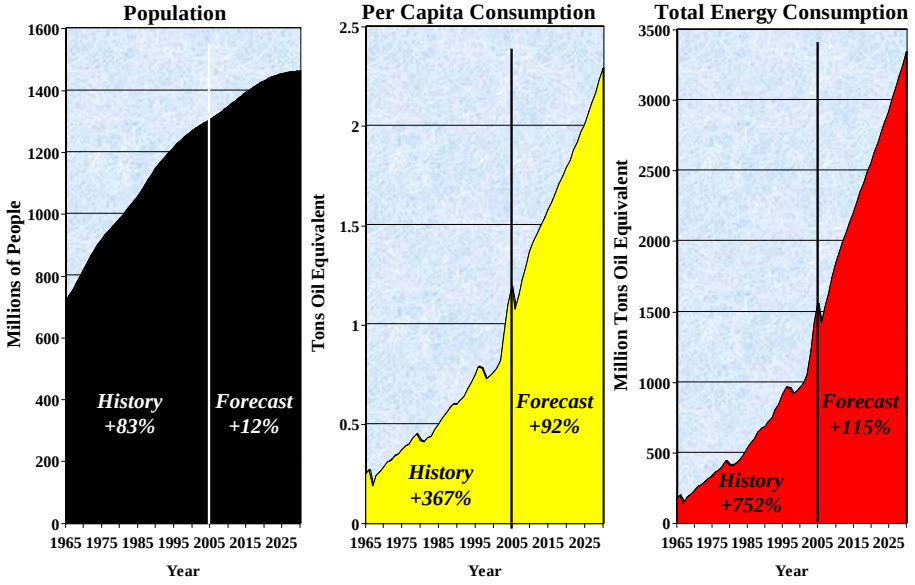
There is a Great Inequity in Energy Consumption Worldwide

Primary Per Capita Energy Consumption of Selected Countries in 2001



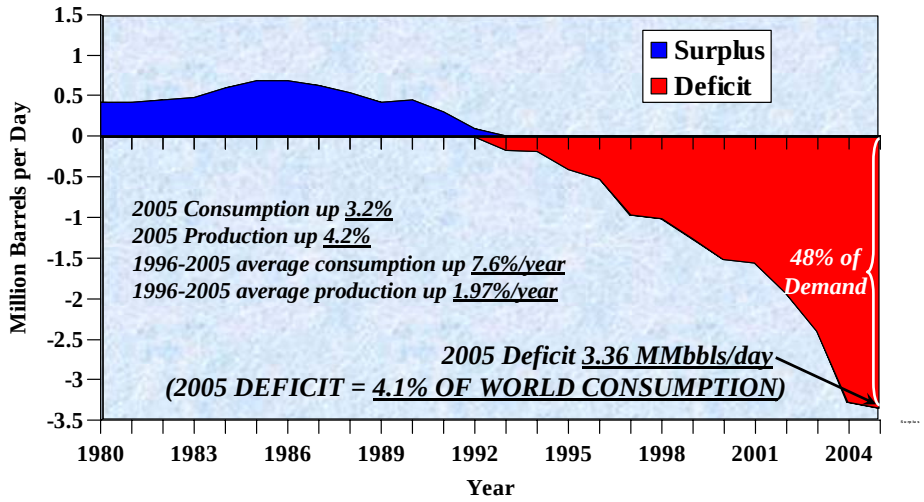
(data from BP Statistical Review of World Energy, 2002, and United Nations World Database, 2002)

China Population and Energy Consumption History and Forecasts (1965-2030)



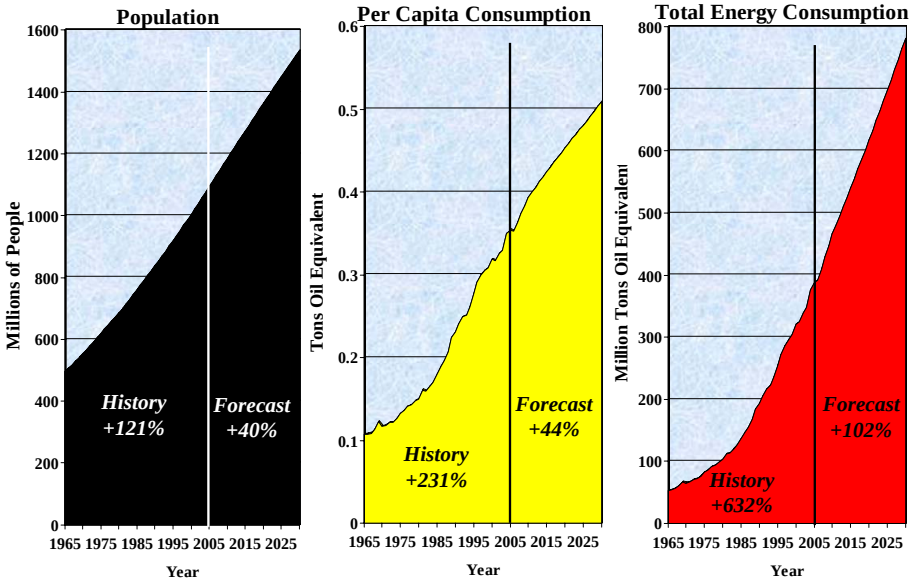
(Consumption History: BP Statistical Review of World Energy, 2006; Population History and Forecast: United States Census Bureau, 2006; Consumption Forecast: Energy Information Administration World Energy Outlook, June, 2006)

CHINA's Oil Production Surplus and Deficit 1980-2005



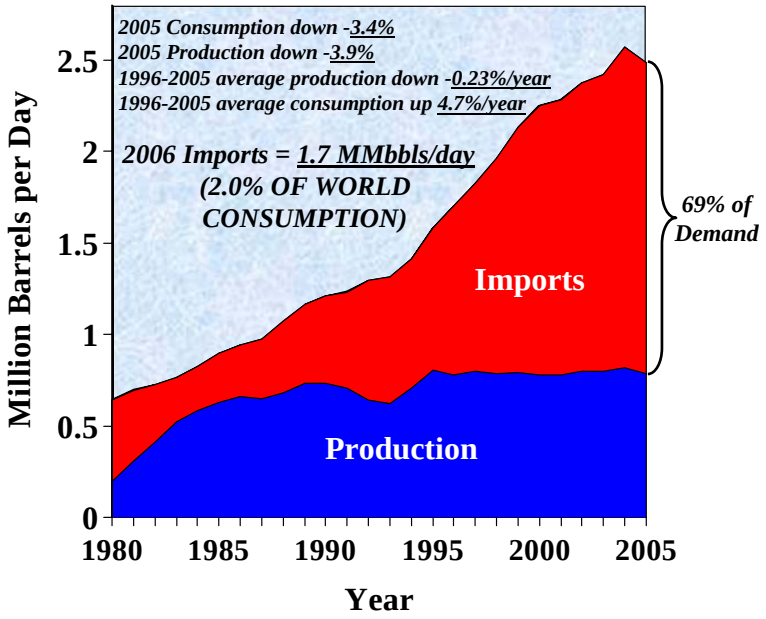
(data from BP Statistical Review of World Energy, 2006)

India Population and Energy Consumption History and Forecasts (1965-2030)



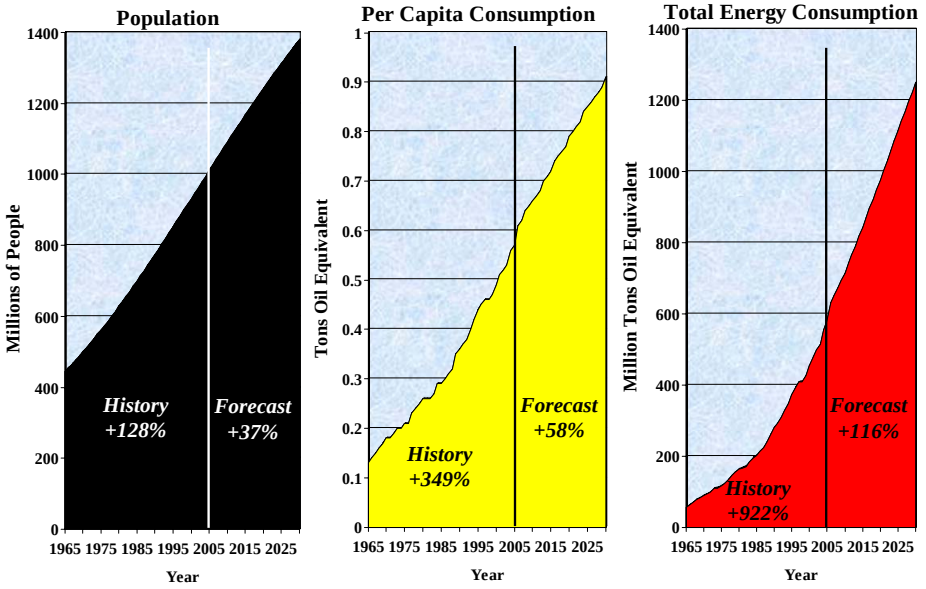
(Consumption History: BP Statistical Review of World Energy, 2006; Population History and Forecast: United States Census Bureau, 2006; Consumption Forecast: Energy Information Administration World Energy Outlook, June, 2006)

INDIA's Oil Production and Imports 1980-2005



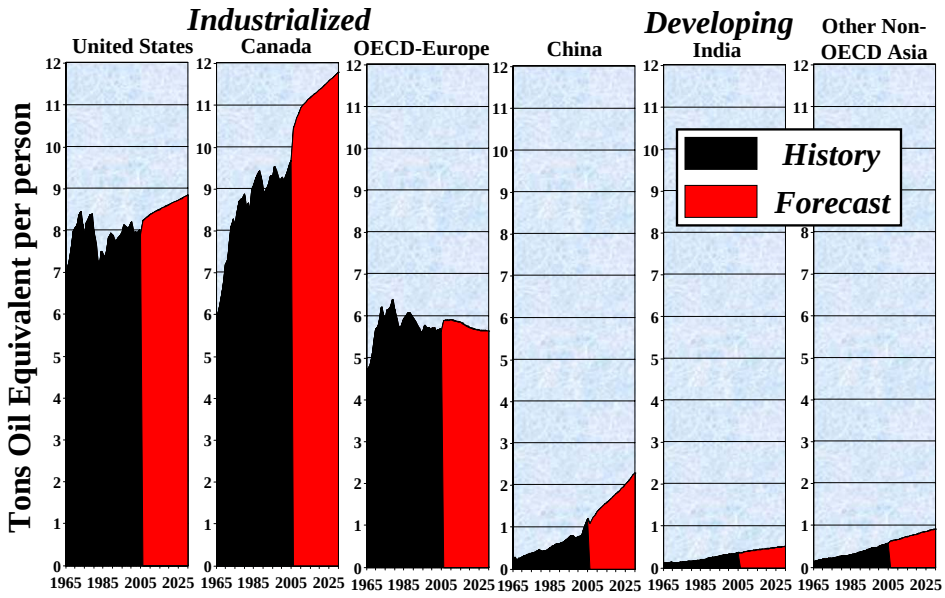
(data from BP Statistical Review of World Energy, 2006)

Non-OECD-Asia Outside of China and India Population and Energy Consumption History and Forecasts (1965-2030)



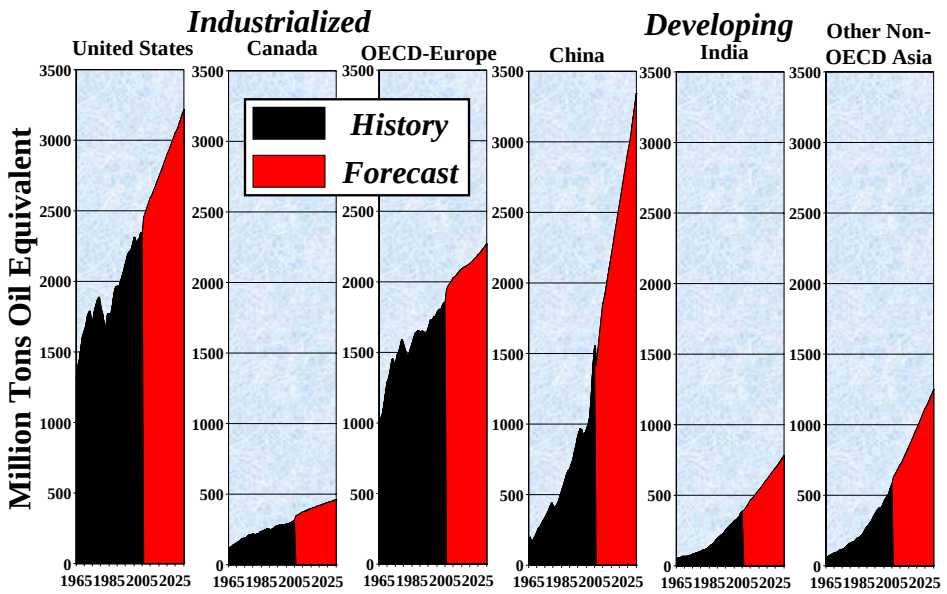
(Consumption History: BP Statistical Review of World Energy, 2006; Population History and Forecast: United States Census Bureau, 2006; Consumption Forecast: Energy Information Administration World Energy Outlook, June, 2006)

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



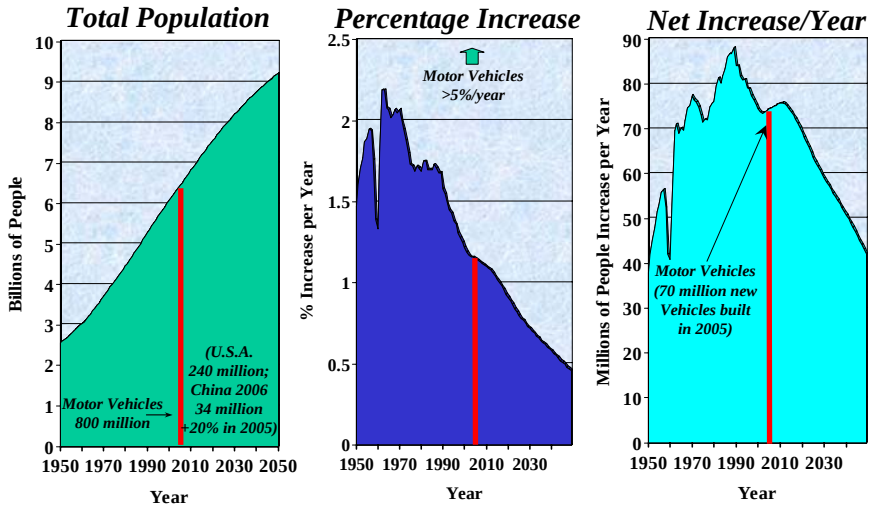
(United States Bureau of Census, November, 2006; BP Statistical Review of World Energy, 2006; EIA International Energy Outlook, June, 2006)

Total Consumption – History and Forecast (1965-2030)



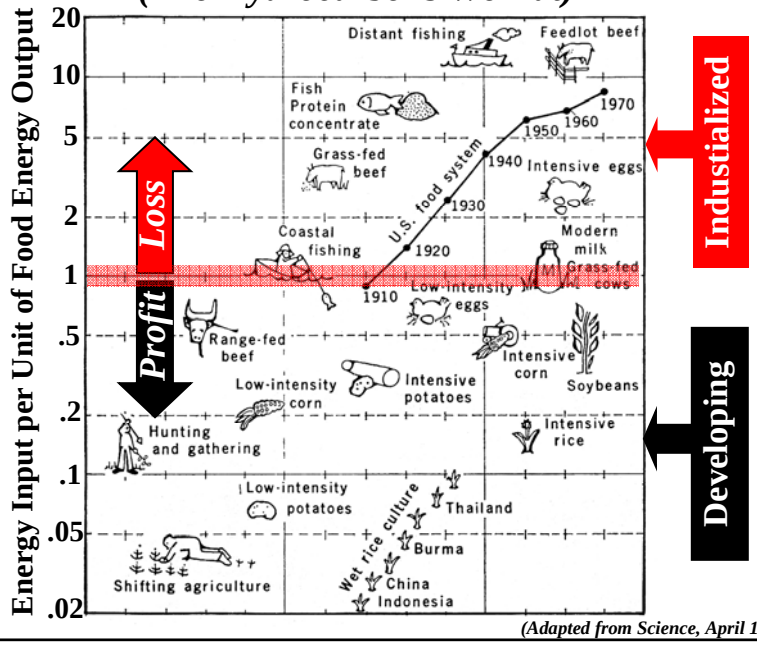
(BP Statistical Review of World Energy, 2006; EIA International Energy Outlook, June, 2006)

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**
- **North America consumes a disproportionate amount of energy (5 times the global per capita average). The Developing World understandably aspires to North American energy consumption levels, however, finite non-renewable resources are unlikely to be sufficient to allow this to happen, setting the stage for global conflict over energy**
- **The realities of the finite nature of non-renewable energy resources are now becoming evident – peak oil in many producing countries, peak North American natural gas, ten-fold increase in uranium prices since 2000, imports of coal into the US after centuries of self-sufficiency**
- **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**

Summary

- 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.
- LNG will help offset these declines but North America will be in competition with other countries who also see LNG as a solution – competition for supplies and NIMBY will likely limit LNG's impact (and we must be mindful of LNG's full cycle carbon emissions)
- Research on new sources such as gas hydrates, shale gas 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
- Natural gas is a very high value fuel and should be conserved for its highest value uses through substitution where possible in an environment of overall radically reduced demand

Summary

- There are some crucial decisions to be made with respect to the future energy security of North America - the future represents a huge challenge and these decisions must be made objectively without ruling out any incremental contribution to supply - we will likely need them all
- Coal represents the most abundant remaining hydrocarbon resource in North America and is forecast to be the largest source of generation by far in the US through 2030
- Even maintaining nuclear's contribution to North America's electricity generation implies a major program of repowering, decommissioning and replacing the aging nuclear fleet
- The natural gas option for replacement of Ontario's coal plants could be extremely problematic given forecast gas deliverability declines and likely price volatility (30-40 year investments need fuel security)
- Future use of coal in Ontario cannot be ruled out if energy security is important, but must utilize the best available technologies, which can greatly reduce emissions of SO_x, NO_x, Mercury, Particulates and CO_2 - even more improvements in efficiency can be made if coal can be implemented in power with district heat application configurations

"…a Lower-Impact Society is the Most Impossible Scenario for Our Future…

…Except for all other Conceivable Scenarios"

Jared Diamond (2005) from his best-seller "Collapse"