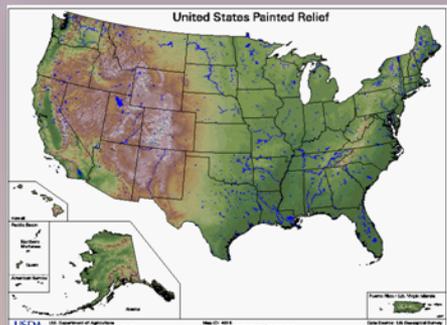


The Global Scramble for Minerals and Energy— Its Impact on Colorado/America



Vince Matthews

Director

Colorado Geological Survey

COLORADO GEOLOGICAL SURVEY





COLORADO GEOLOGICAL SURVEY



COLORADO



DEPARTMENT OF NATURAL RESOURCES

**Mike King,
Executive Director**

COLORADO GEOLOGICAL SURVEY



YOUR Geological Survey !!!

Geology of Water Resources

Geologic Hazards

Colorado Avalanche Information Center

Educate

Assist State and Federal Agencies

Promote Mineral and Energy Resources

COLORADO GEOLOGICAL SURVEY



Everything you need to know about Mineral and Energy in Colorado

I N F O R M A T I O N S E R I E S 7 7

Colorado Mineral and Energy Industry Activities, 2007

by James R. Burnell, Christopher Carroll,
and Genevieve Young

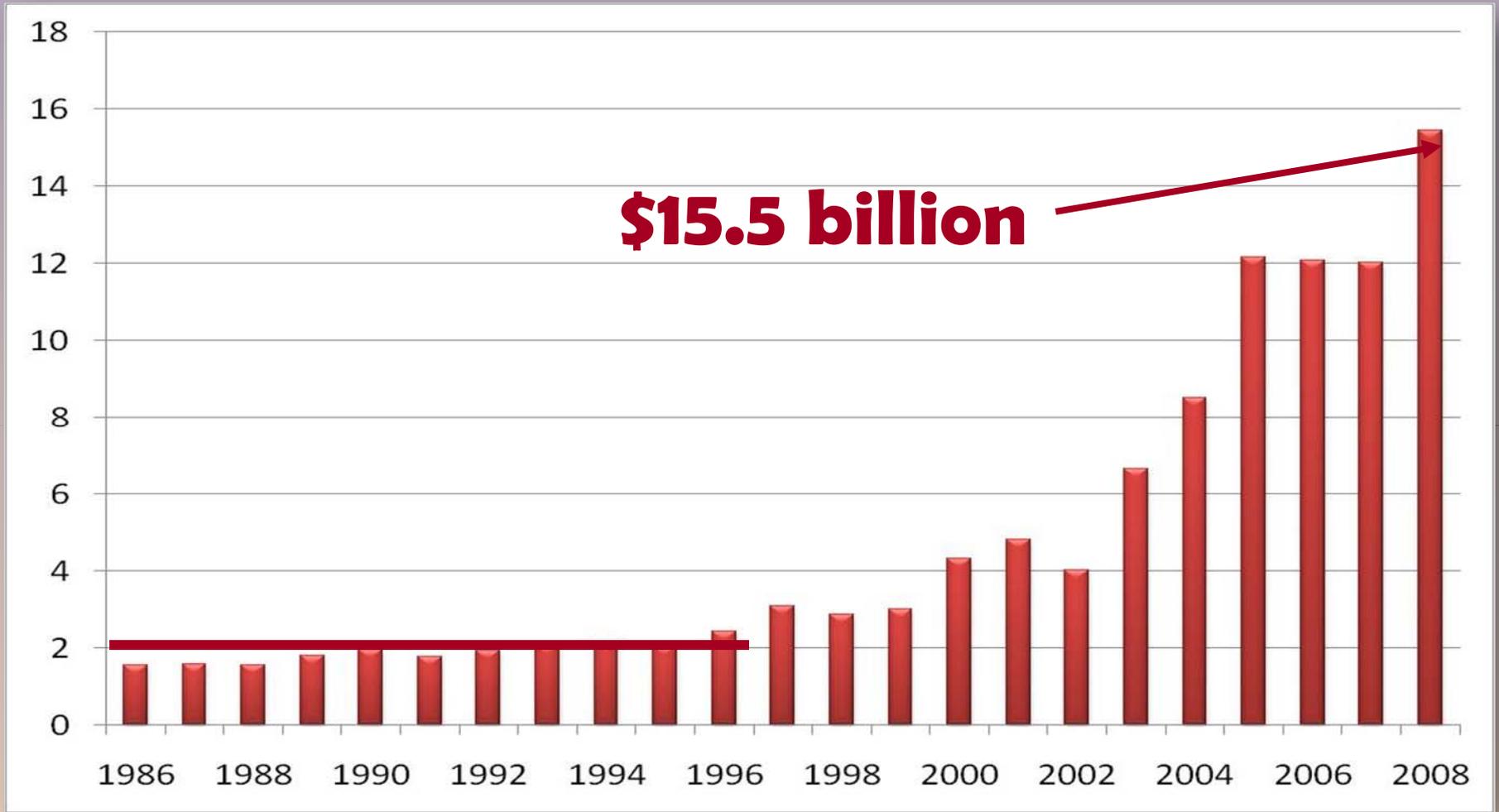


Colorado Geological Survey • Department of Natural Resources • Denver, Colorado • 2008

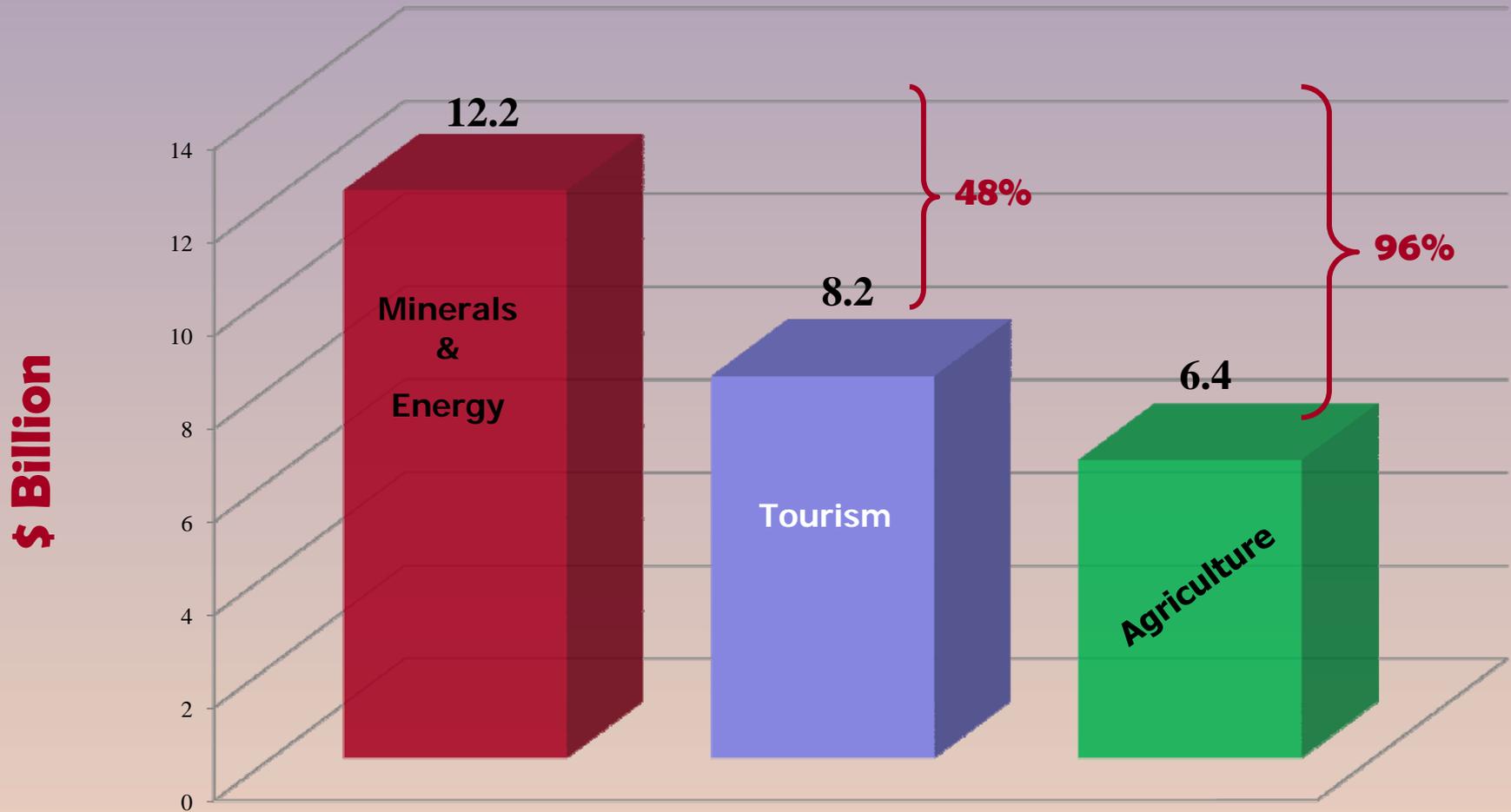
COLORADO GEOLOGICAL SURVEY



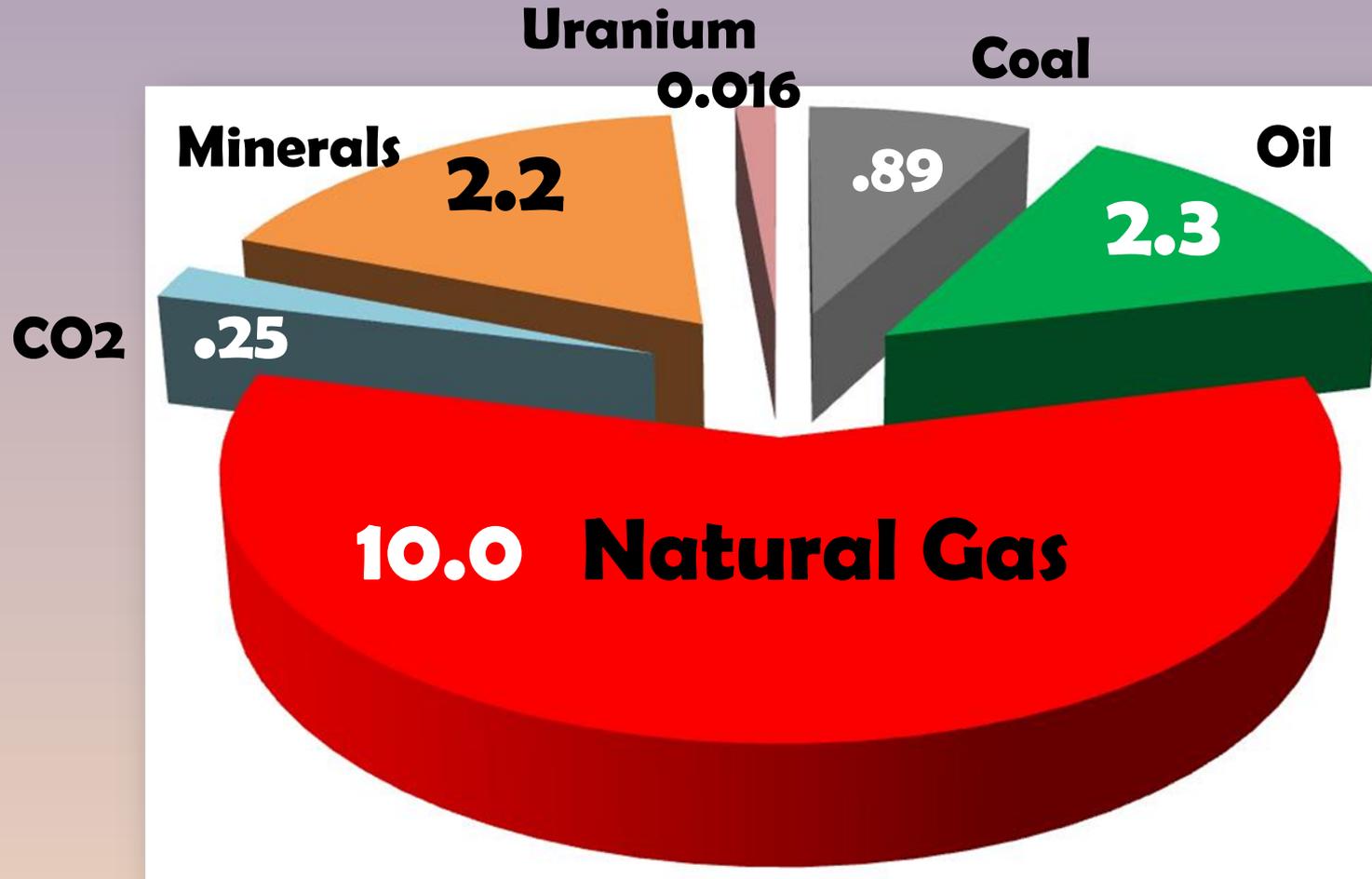
Production of Natural Resources is an Important Part of Colorado's Economy



Revenue comparison of Colorado's Important Economic Sectors (2005)



Distribution of Colorado Mineral & Energy Value 2008 (\$ Billions)



Production of Natural Resources has *Always* been an Important Part of Colorado's Economy



Boulder 1902



NORTH BEND OIL WELL, SHOT BY THE CHAFFEE BROS JUNE 10 1902
TAIN JOE PHOTOGRAPHER.

Just off 51st Street

Overall Impacts

Americans will suffer from natural-resource-driven inflation

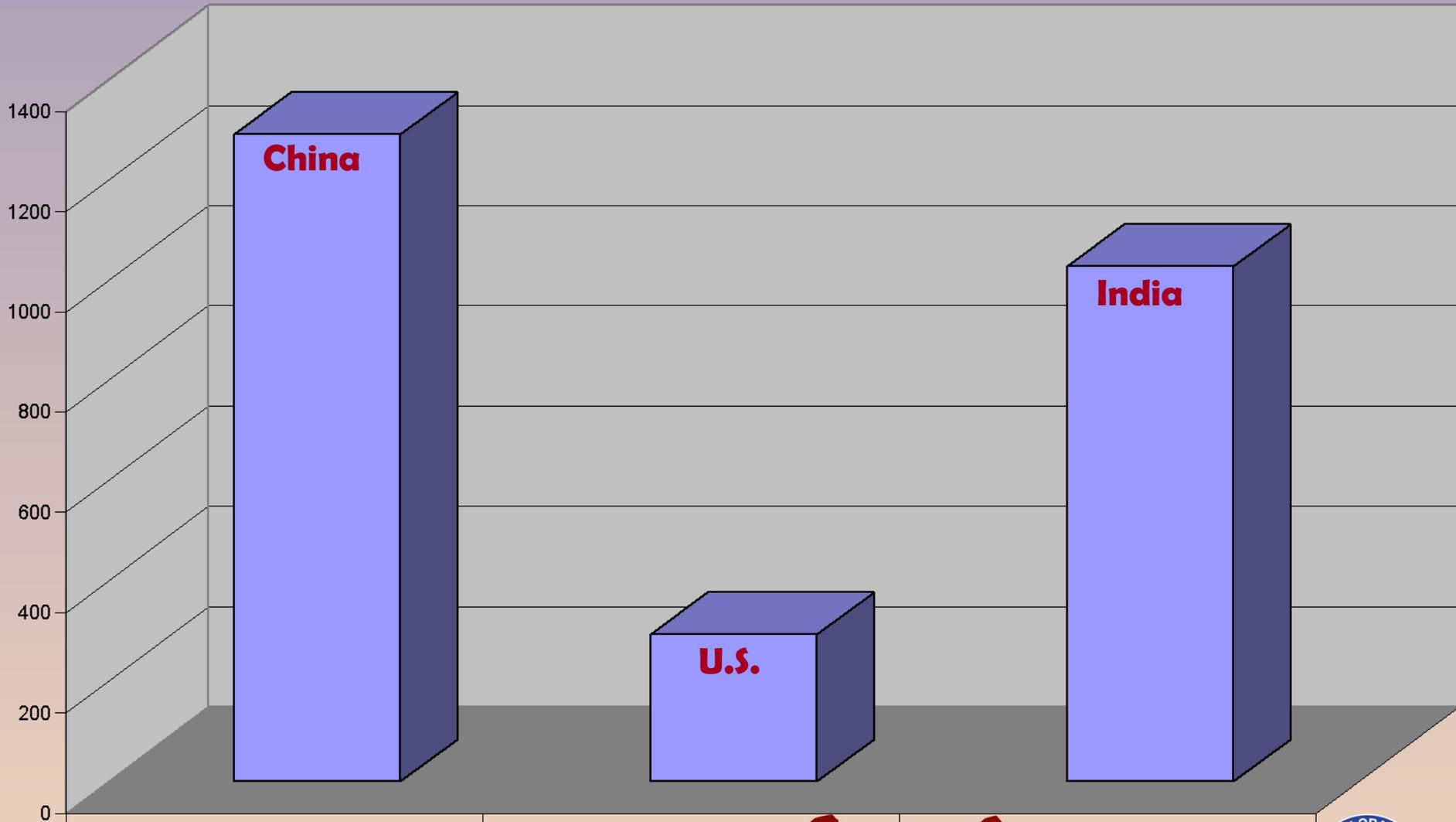
Americans may see increasing shortages of critical raw materials

Pressures will mount to develop more of America's natural resources

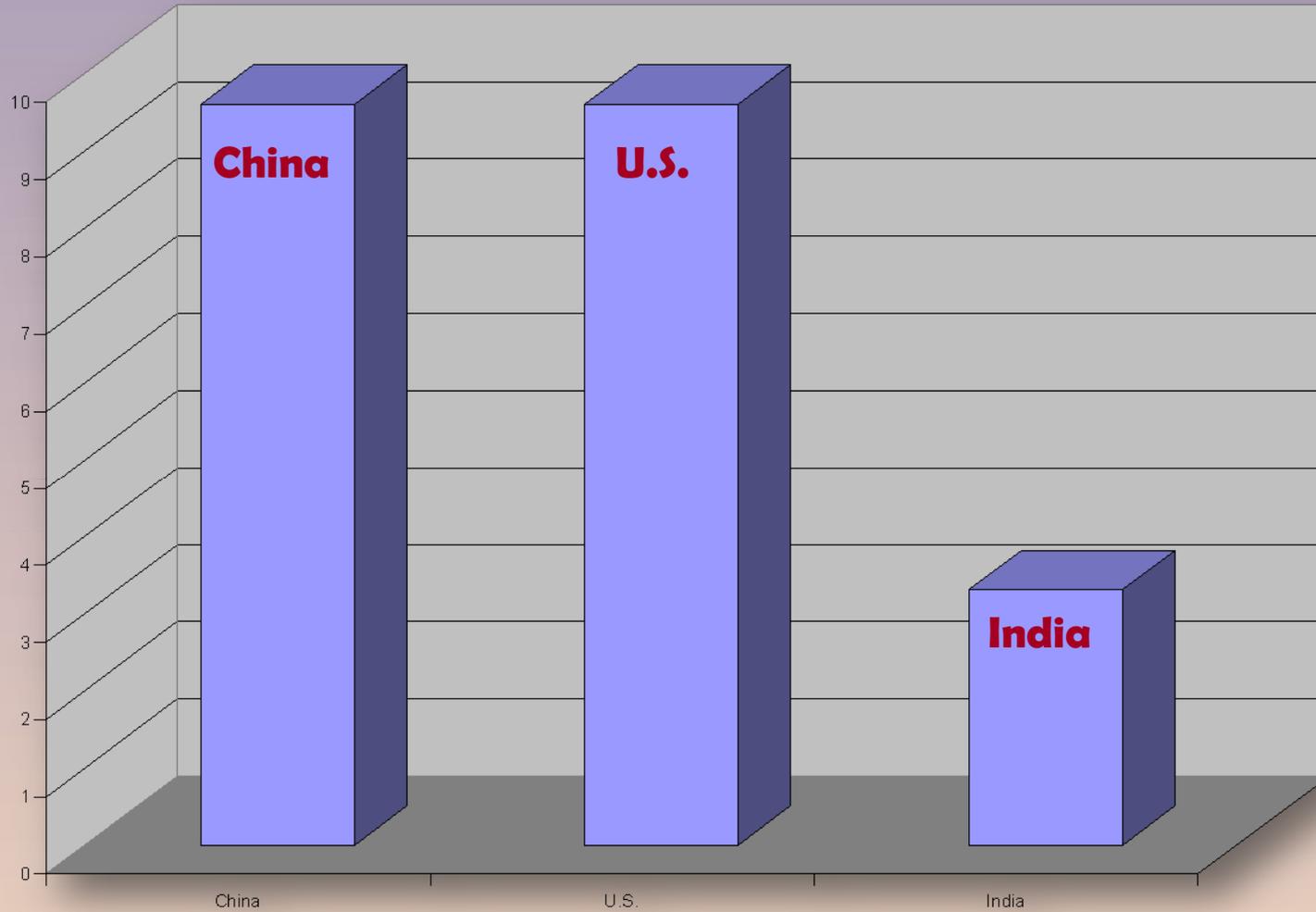
Conflicts may arise with multi-national corporations operating in America

How do we turn lemons into lemonade?

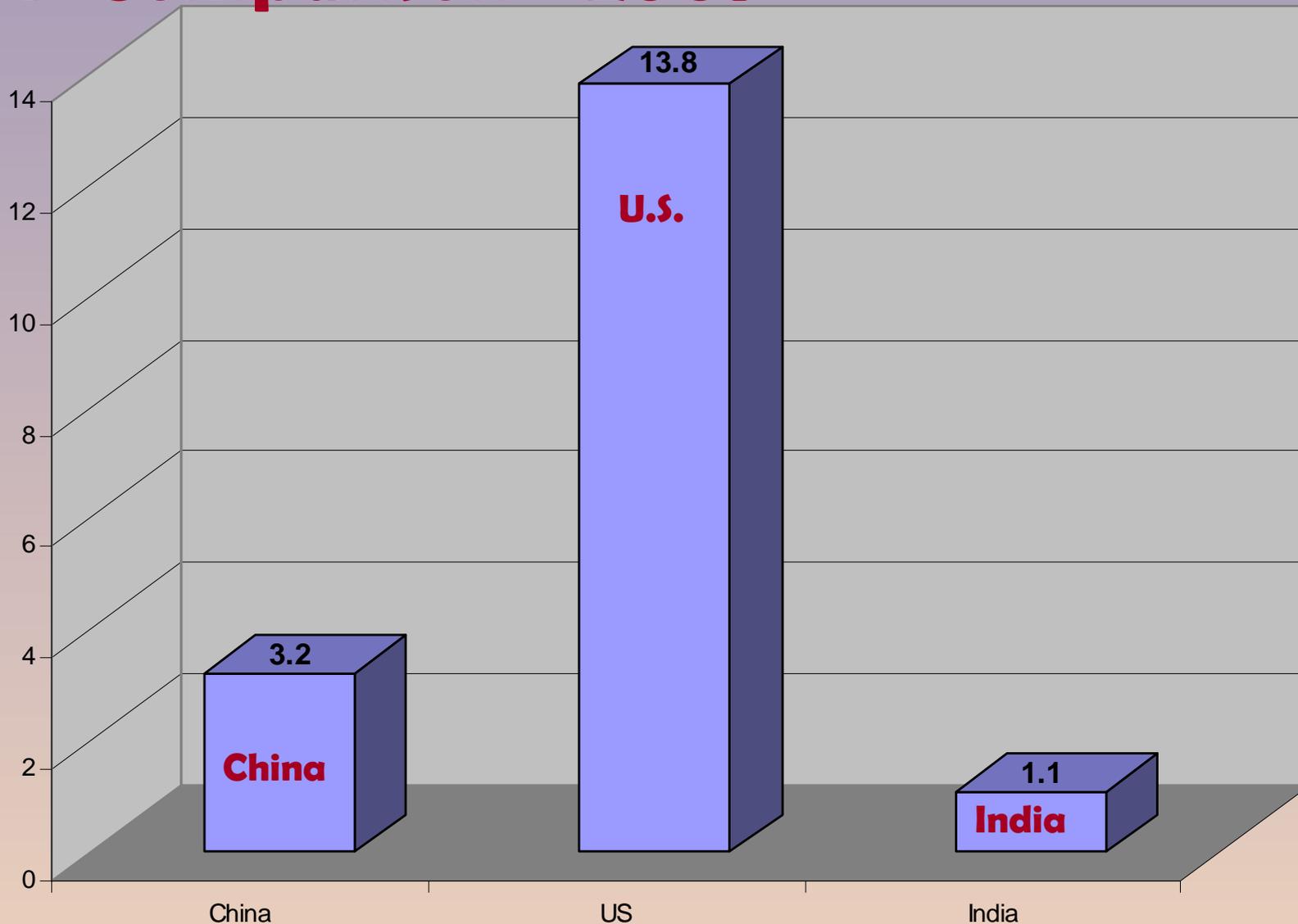
Population Comparison



Land Area Comparison



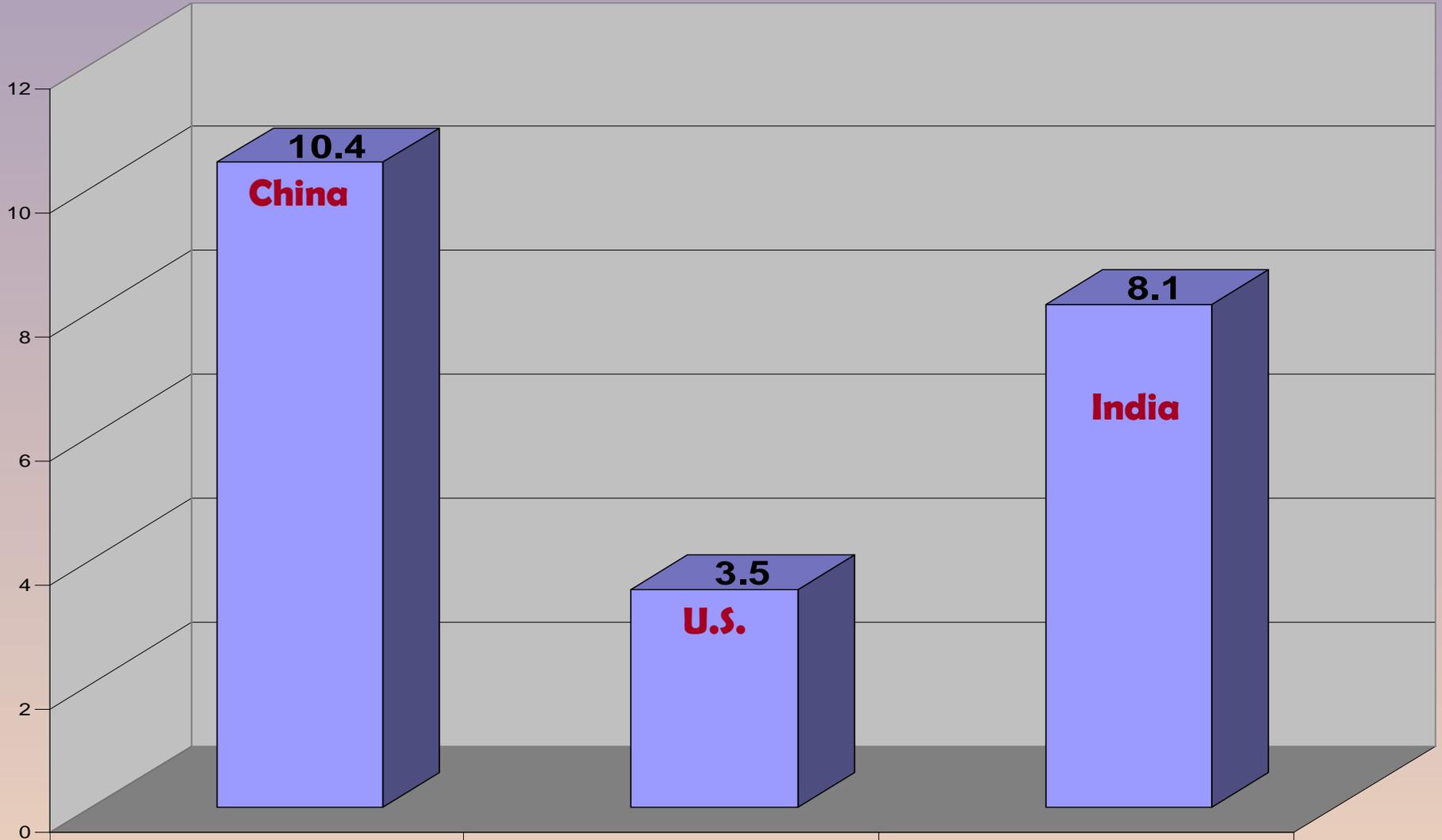
GDP Comparison - 2007



Source: World Bank



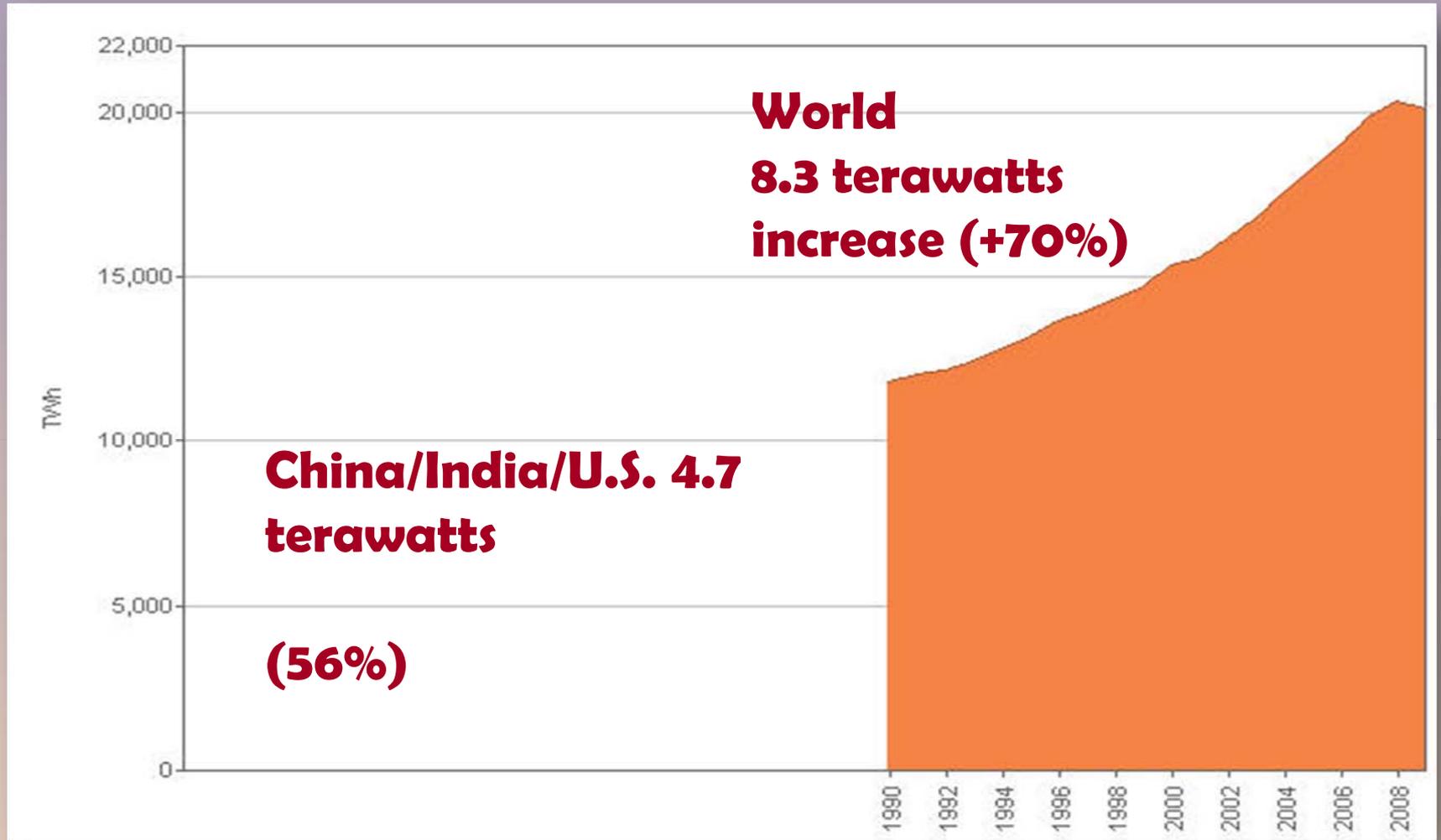
GDP Growth Comparison 2004-06



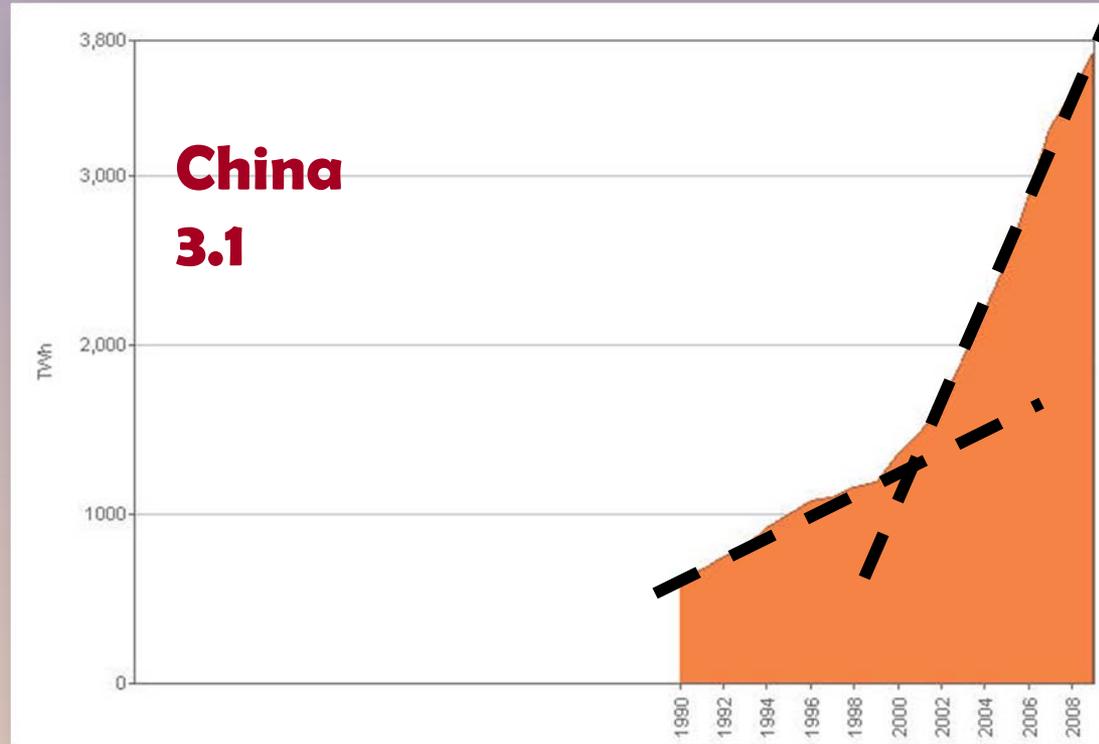
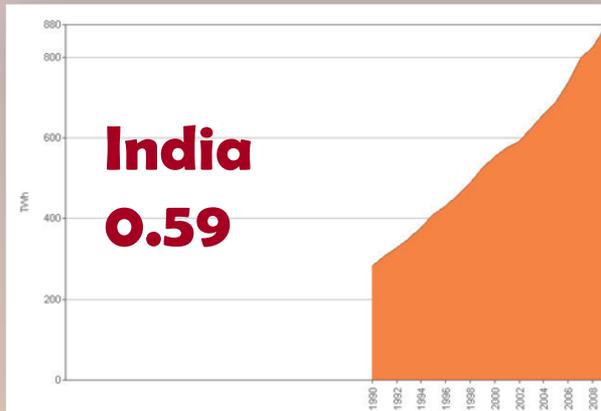
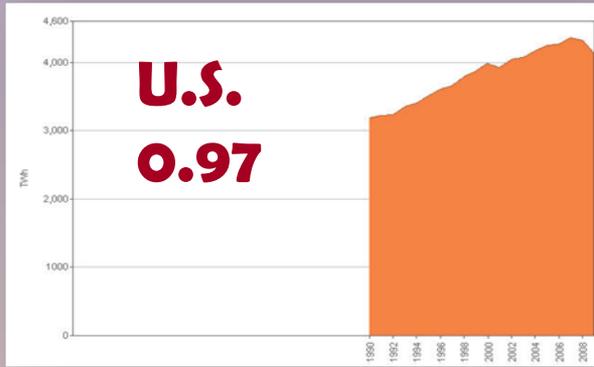
Source: World Bank



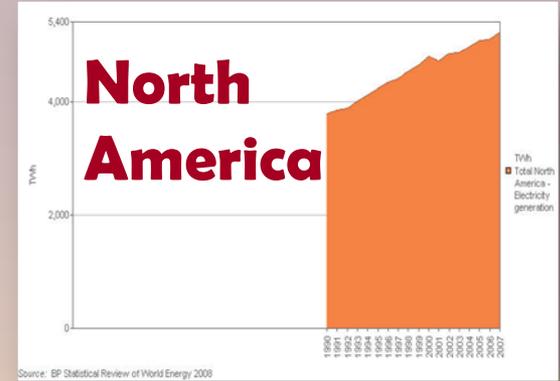
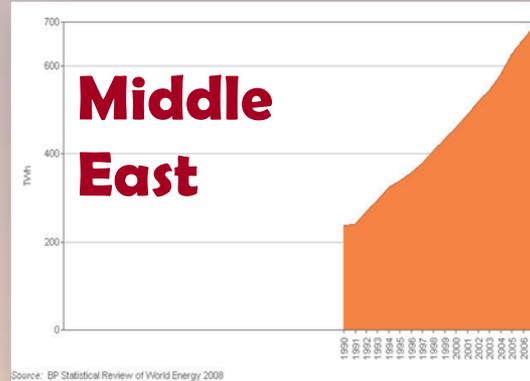
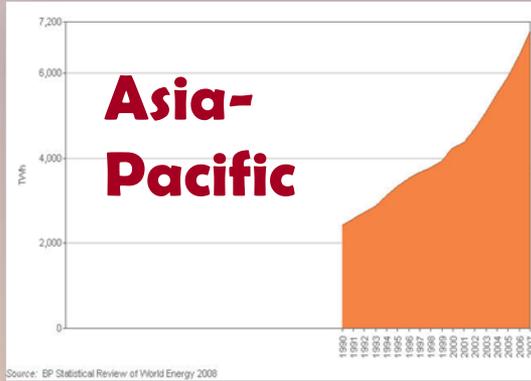
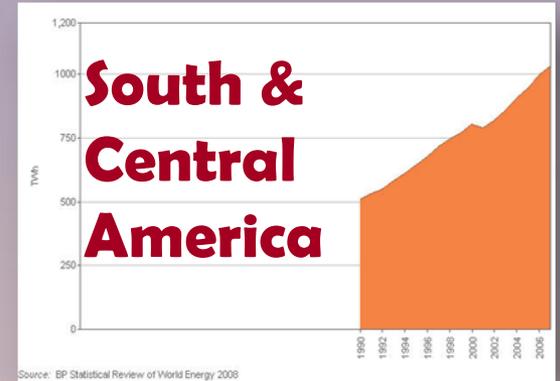
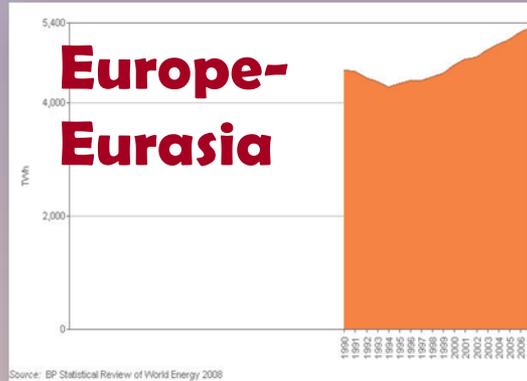
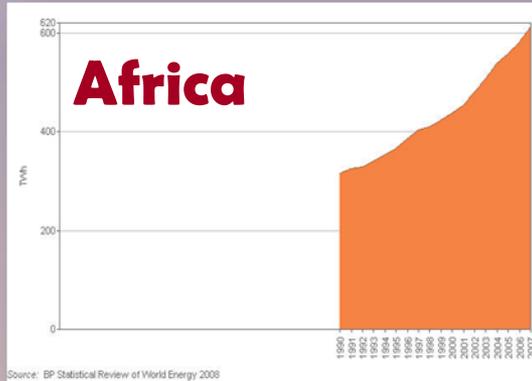
World Electrical Growth



World Electrical Growth



World Electrical Growth



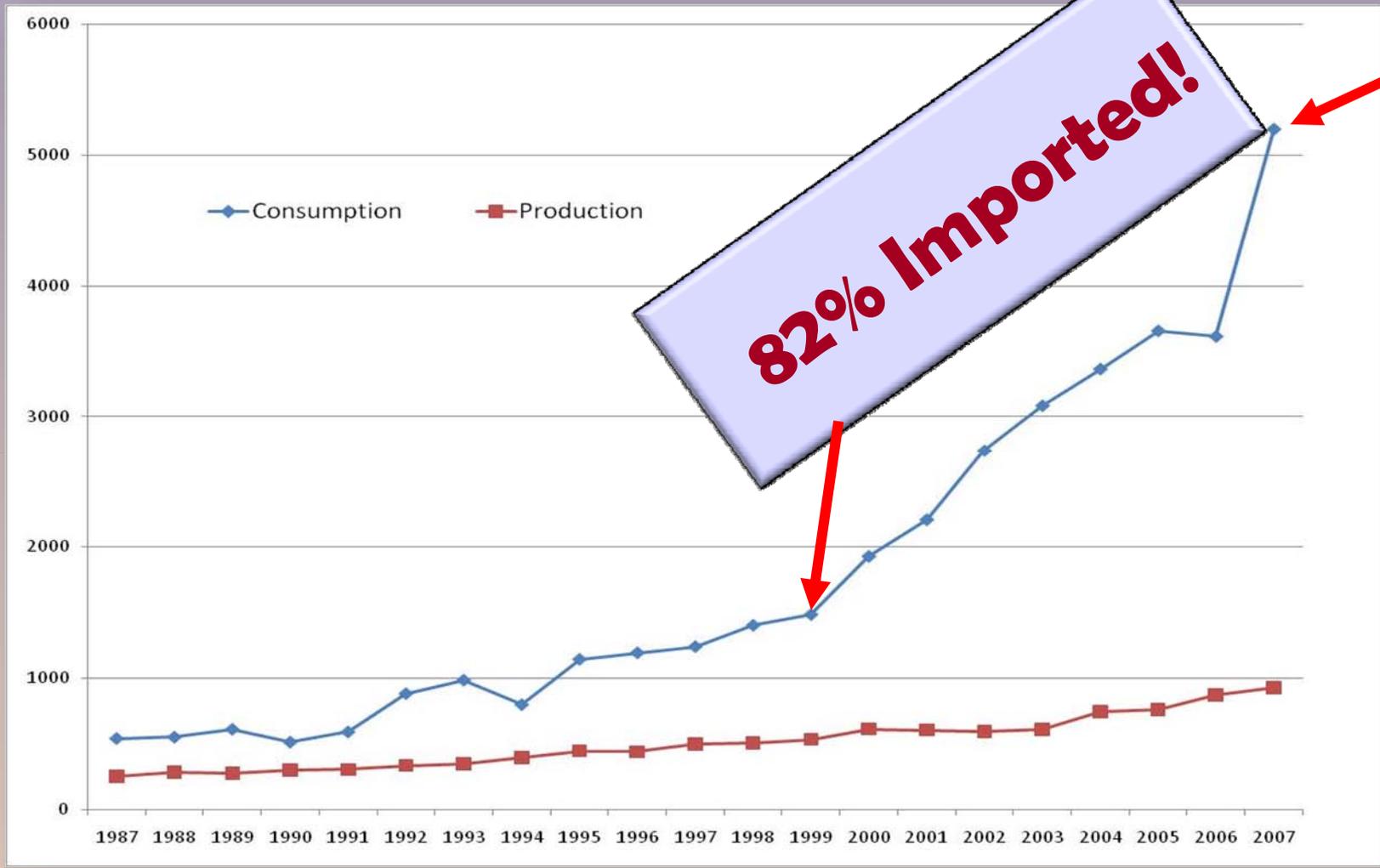
China's Share of World Mineral Production in 2005

Industrial minerals:	%	Rank
Cement	45	1
Fluorspar	51	1
Rare earths	96	1
Metals:		
Aluminum	24	1
Antimony	86	1
Copper	16	2
Gold	9	4
Lead	32	1
Magnesium	75	1
Molybdenum	22	3
Silver	12	3
Steel, crude	31	1
Tin	35	1
Tungsten	87	1
Zinc	26	1

Source: USGS, Menzie and Tse



China's Production and Consumption of Copper



Source: USGS, Menzie, et al



Global Impact



Global Impact



Metal prices fall further than during Great Depression

The price of key industrial metals has fallen further over the last four months than occurred during the worst years of Great Depression between 1929 and 1933, according to research by Barclays Capital.

By Ambrose Evans-Pritchard

Last Updated: 7:29AM GMT 03 Dec 2008

Global Impact



Colorado Impact

Difficulty in manufacturing of copper products

Increased copper thefts

**Pueblo man electrocuted
while trying to steal wiring**
Copper mine reopening
10/27/09

**50% of all copper
mined in the world
was in just the last 25
years**

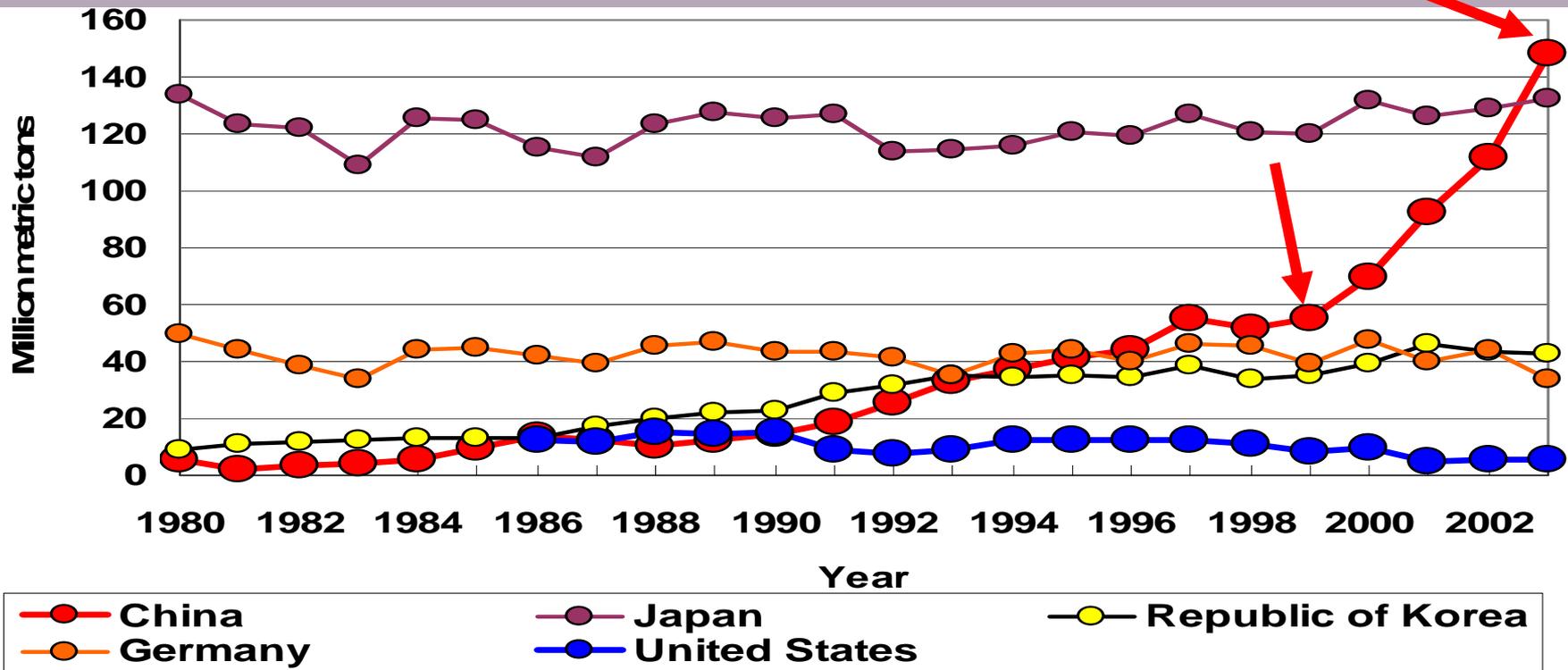


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Source: USGS, Menzie and Tse

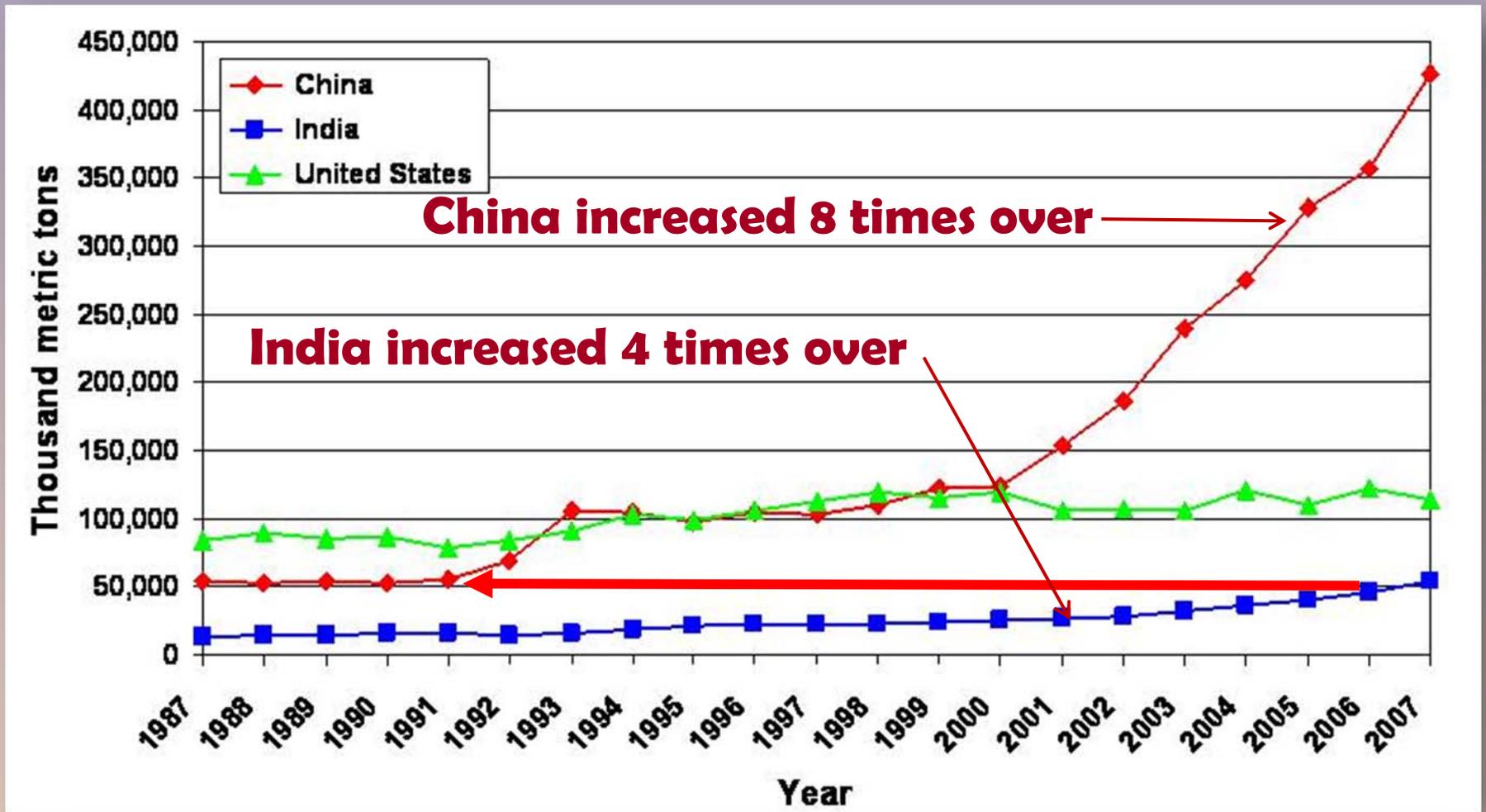
Leading Importers of Iron Ore— 1980–2003



Sources: U.S. Geological Survey Minerals Yearbook; United Nations Conference on Trade and Development.

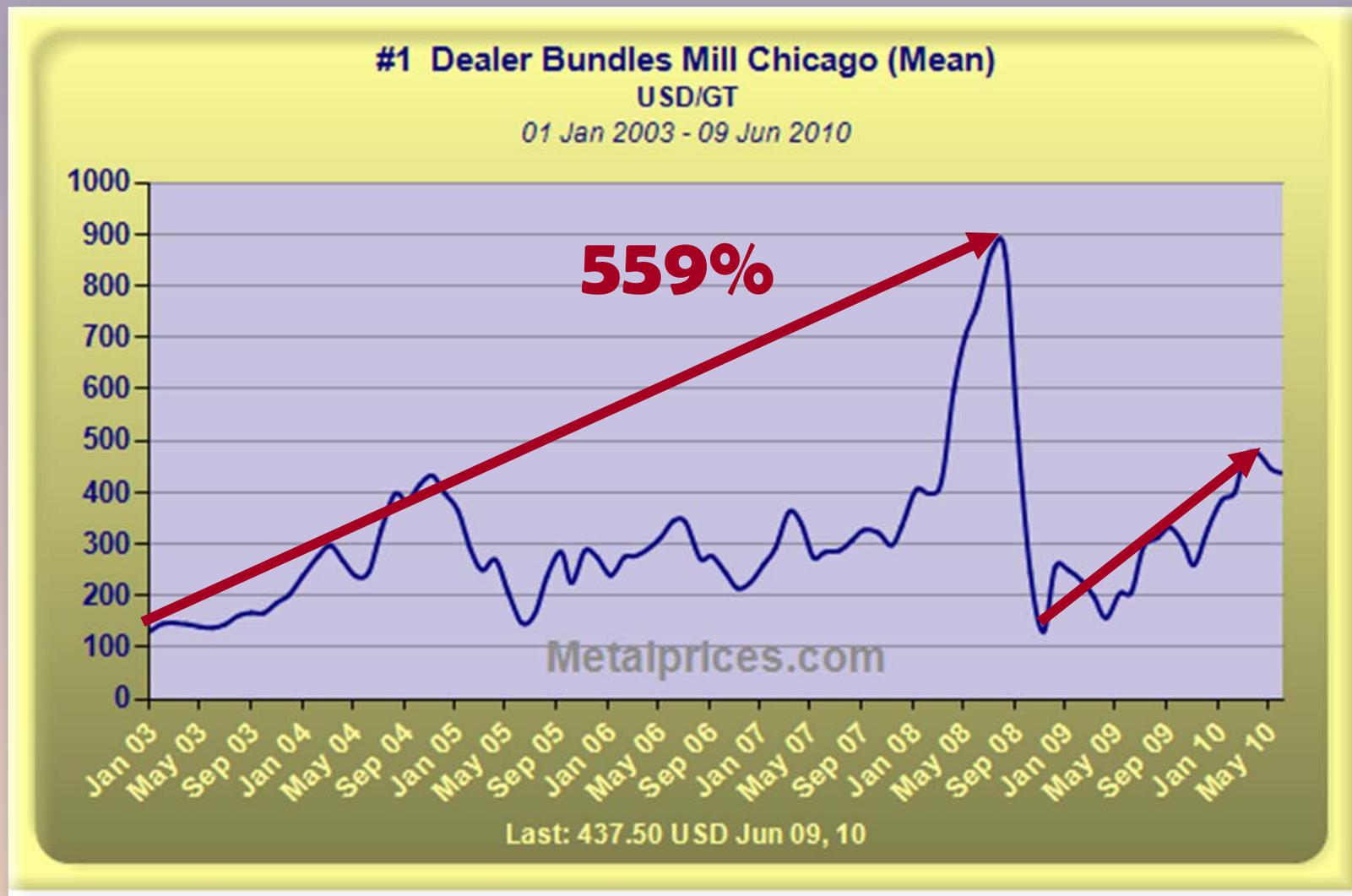


Consumption of Finished Steel



Source: USGS

Price of Scrap Iron



China

2005 – Opened 70,000 new supermarkets

2006 – Became #3 car manufacturer

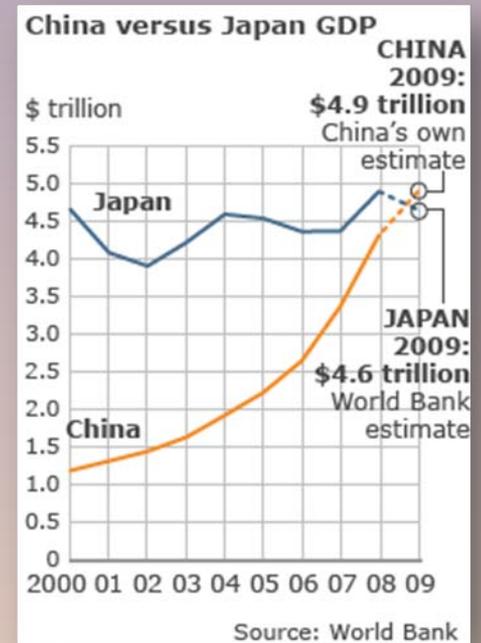
2008 – Became #2 car market

2009 – Became #1 car market

2009 – Became #1 car manufacturer

2009 – Became #1 exporter

2009 – Became #2 economy



Ball mill gets real Leadville welcome

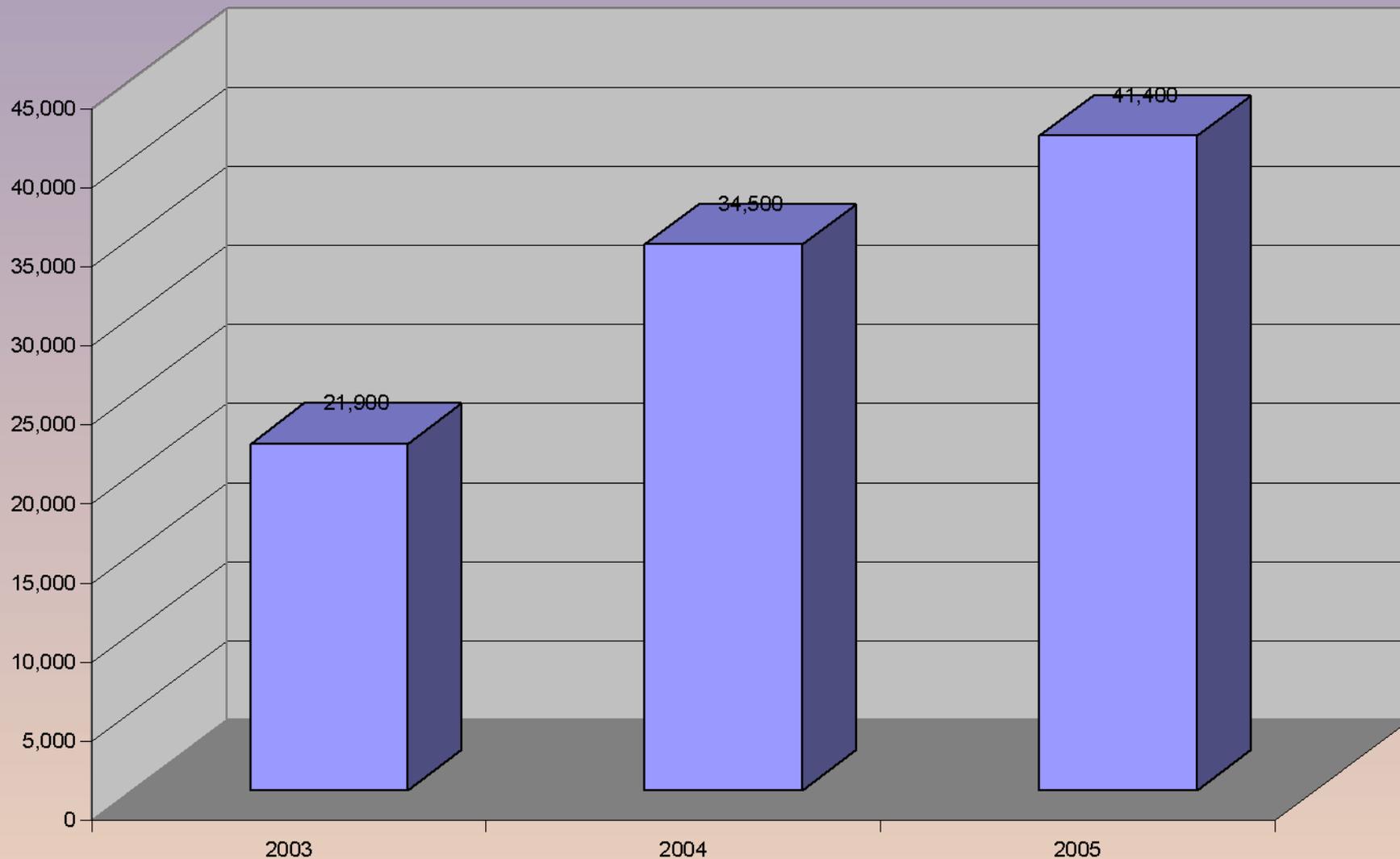


Image courtesy of Leadville Herald Democrat

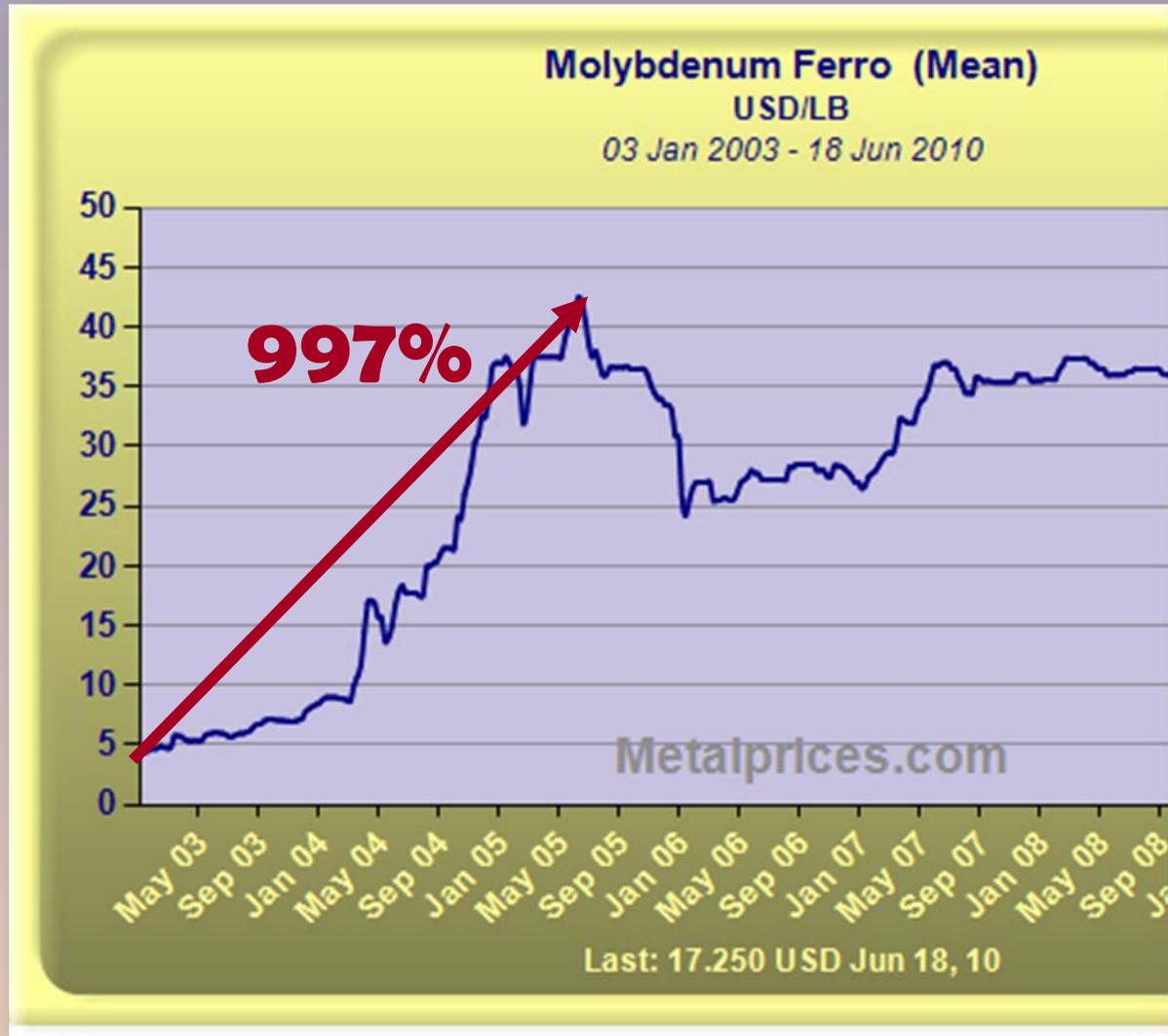
COLORADO GEOLOGICAL SURVEY



U.S. molybdenum exports



MOLYBDENUM Price



Ball mill gets real Leadville welcome

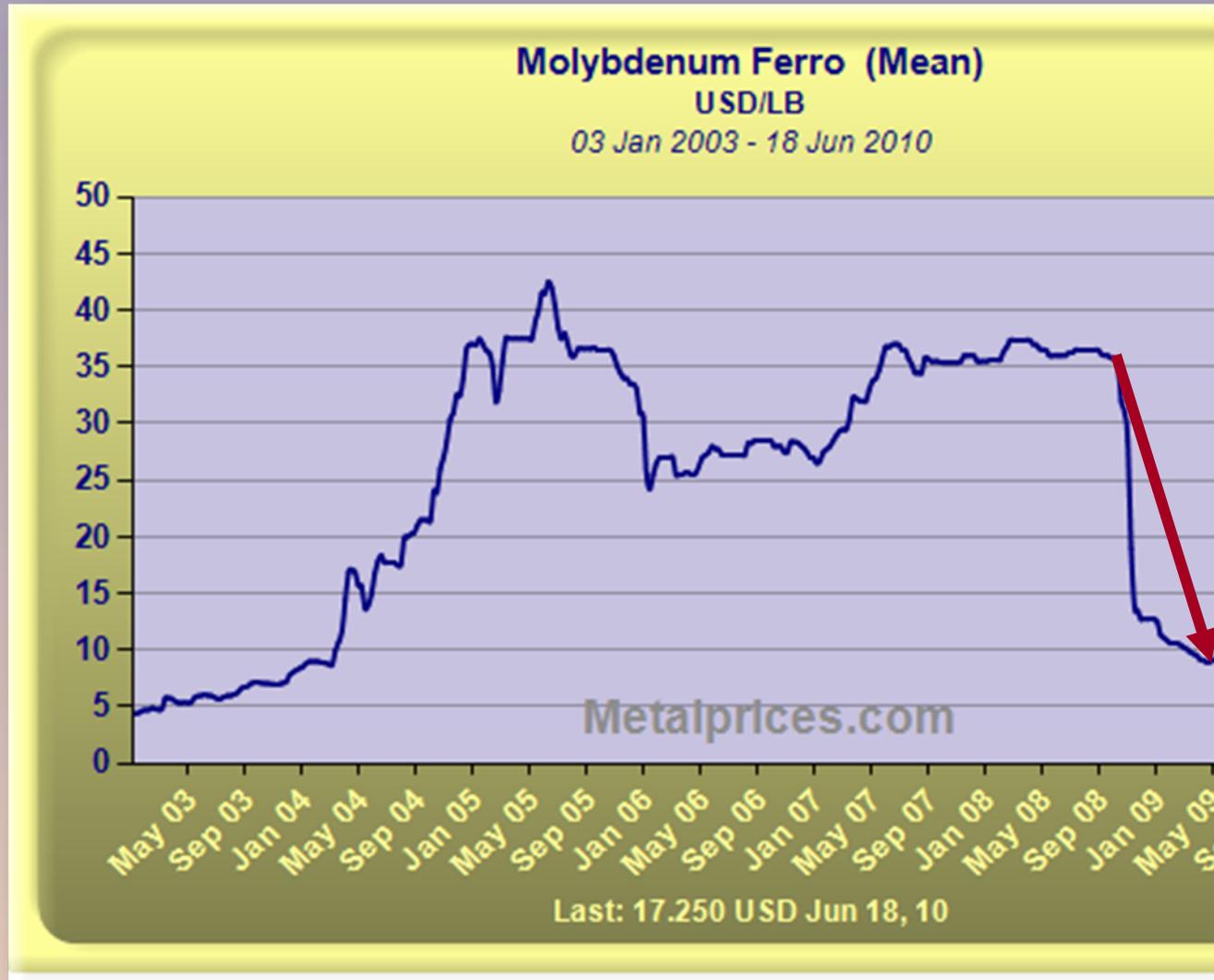


Image courtesy of Leadville Herald Democrat

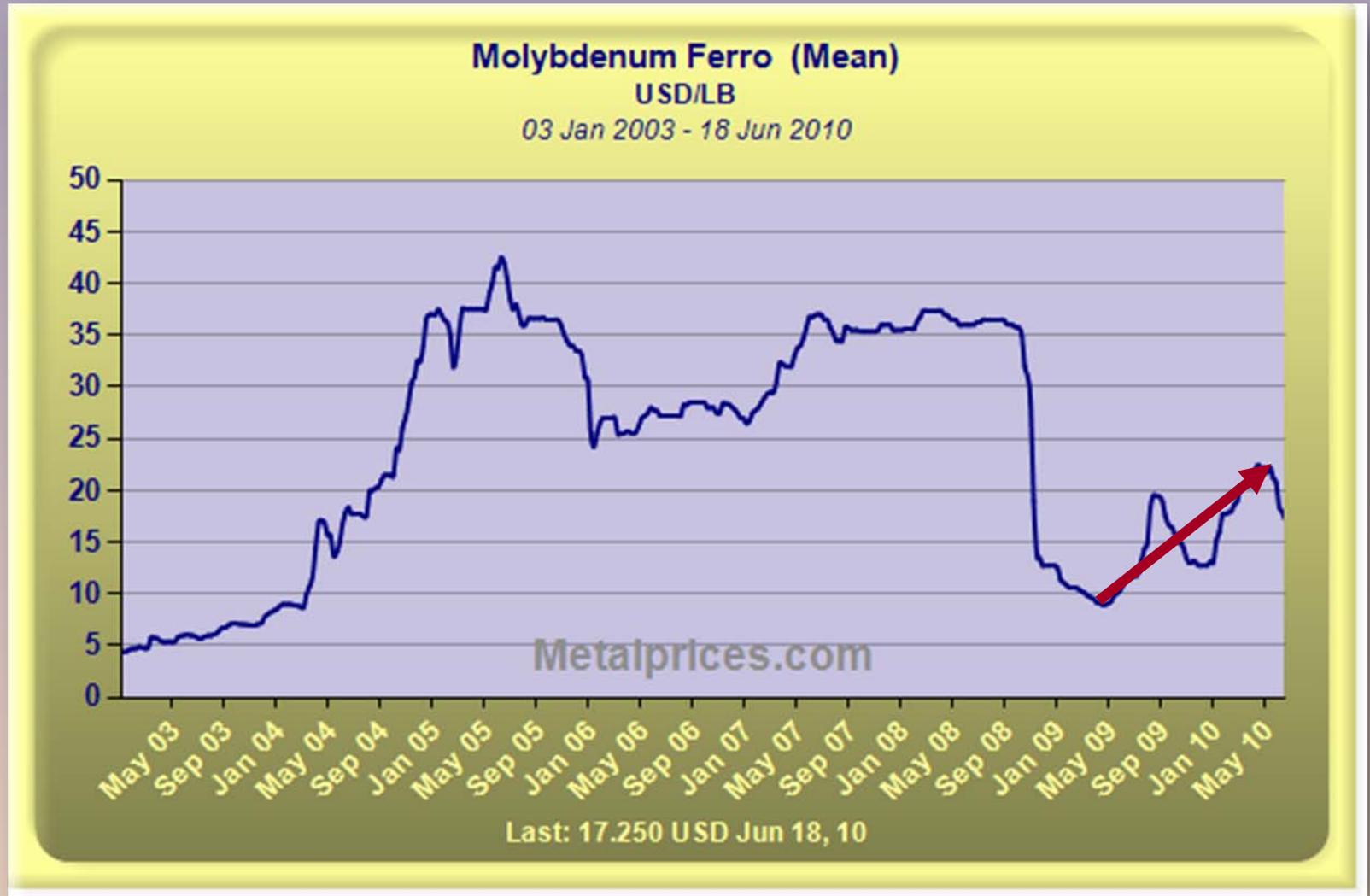
MOLYBDENUM Price



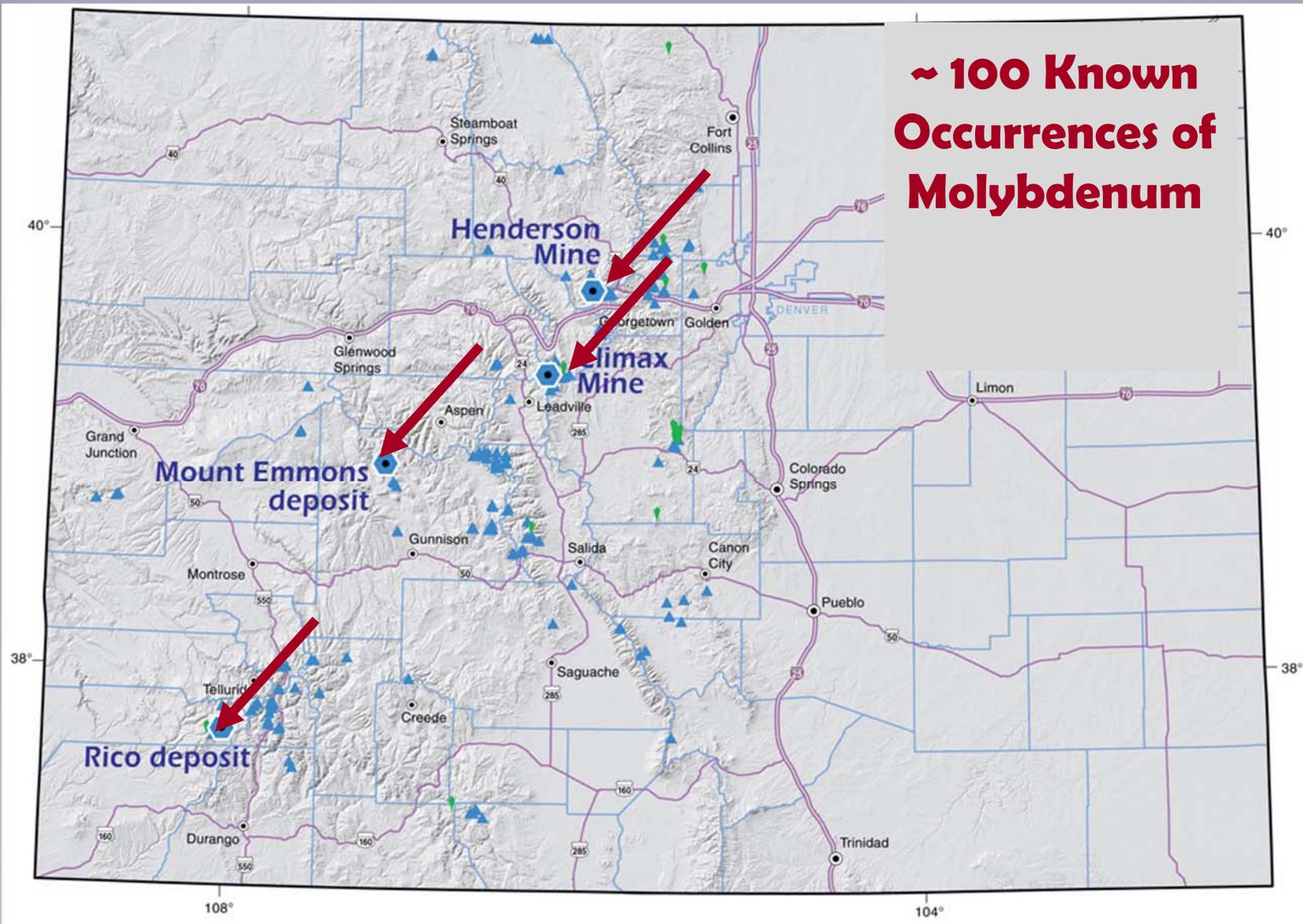
MOLYBDENUM Price



MOLYBDENUM Price



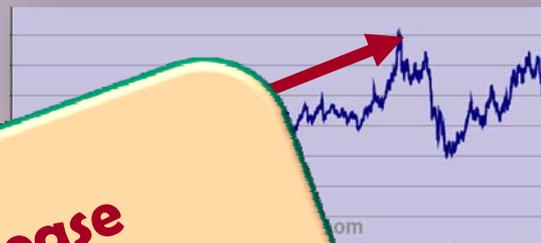
~ 100 Known Occurrences of Molybdenum



Precious & Base Metal Increases 01/03 - 04/13



Gold
274%



Silver
367%



Platinum
255%



Nickel 630%



Aluminum
144%



5%



Tin
229%



Zinc
497%

Average Price Increase
379%



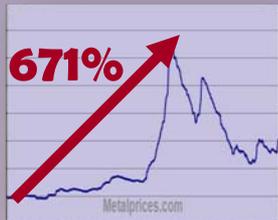
Antimony

245%



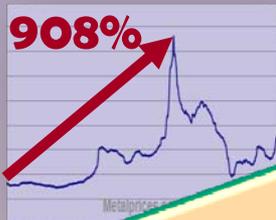
Bismuth

671%



Cadmium

908%



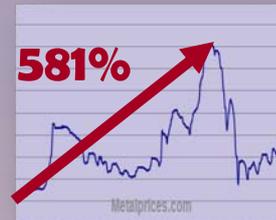
Chromium

719%



Cobalt

581%



Germanium

193%



Average Price Increase

746%

In

Rhenium

685%



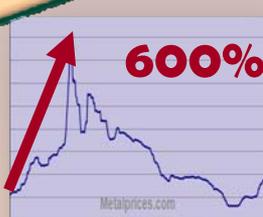
Selenium

1620%



ium

600%



Tungsten

531%

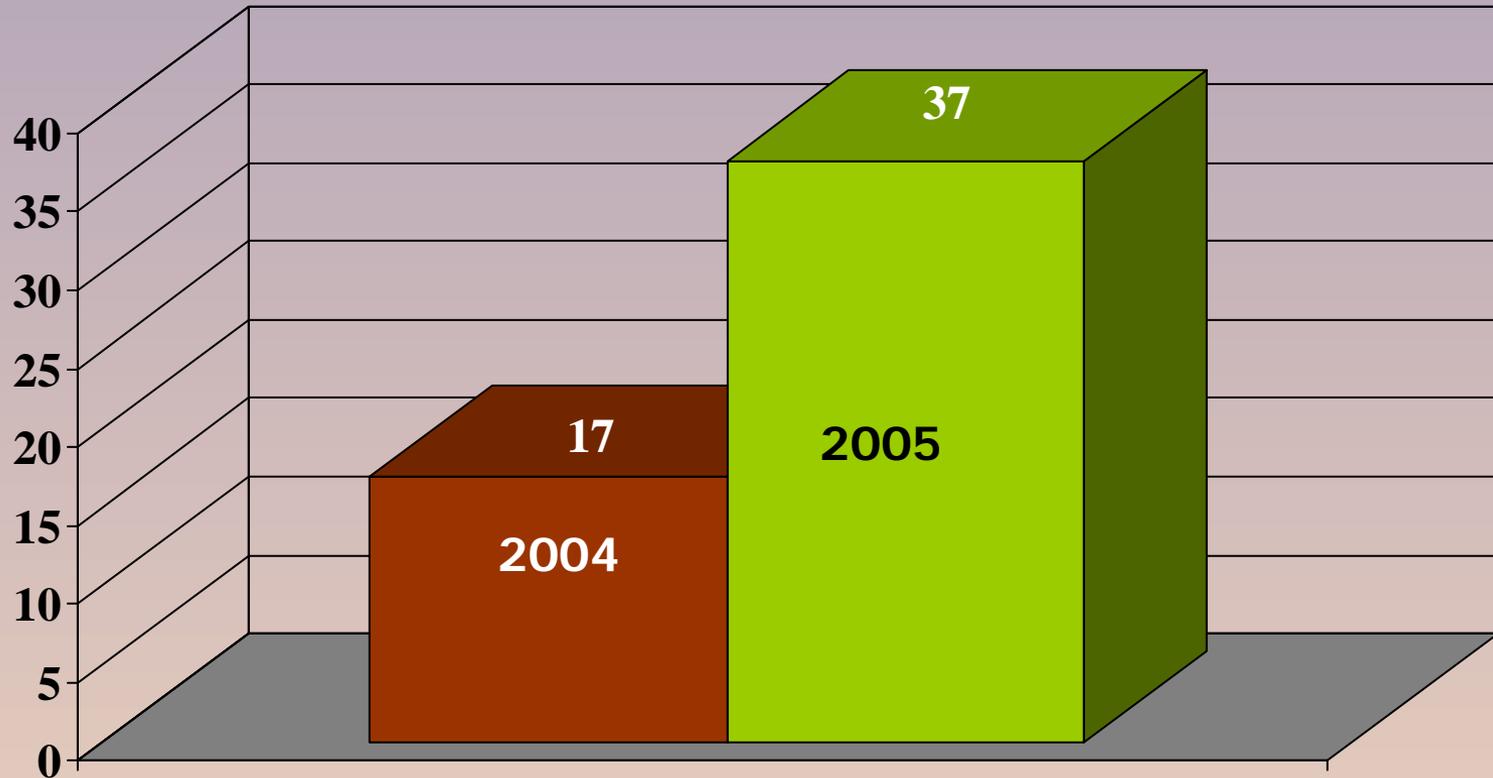


Vanadium

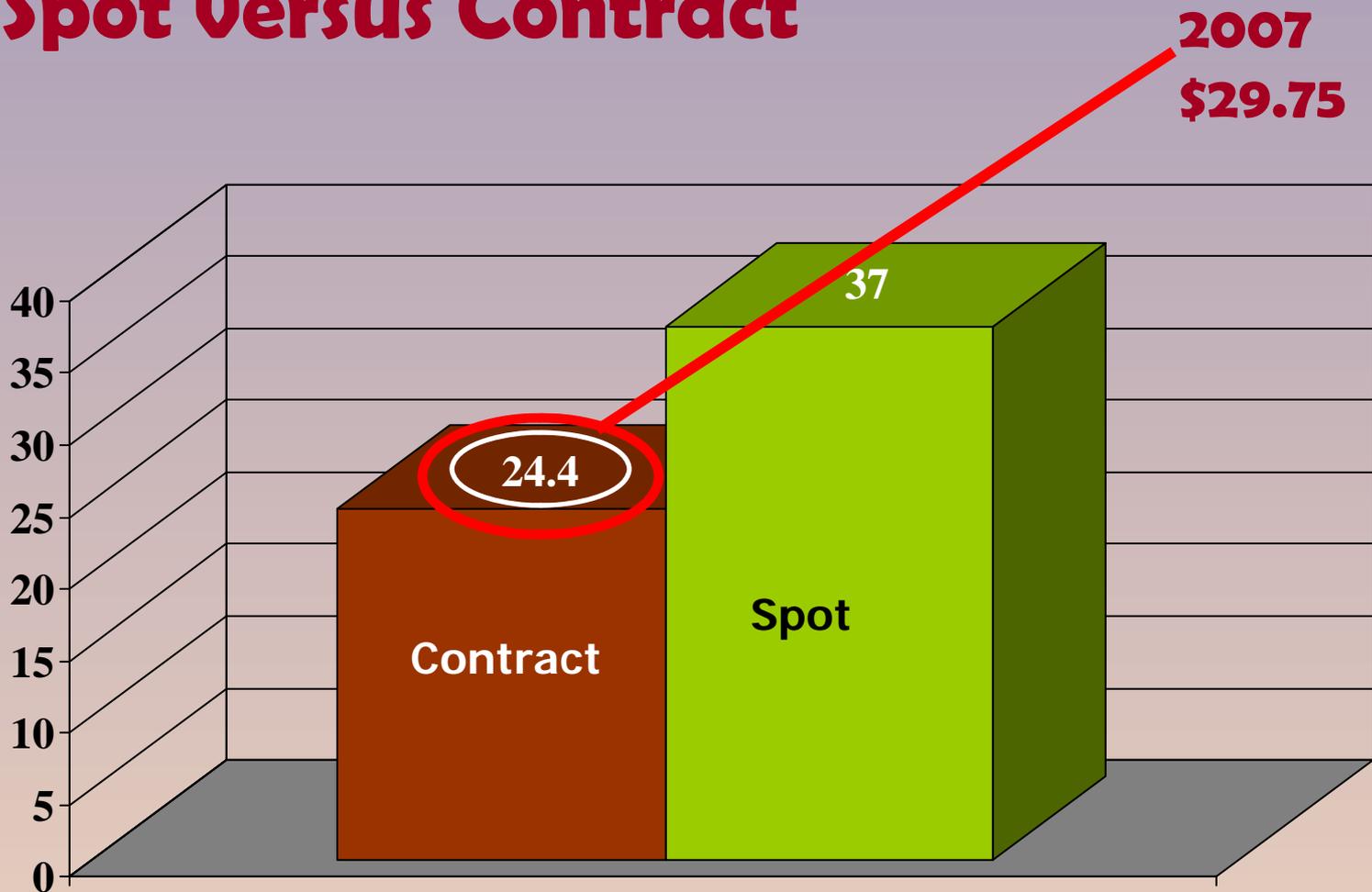
2060%



Increase in Coal Spot Price



2005 Coal Price Spot versus Contract



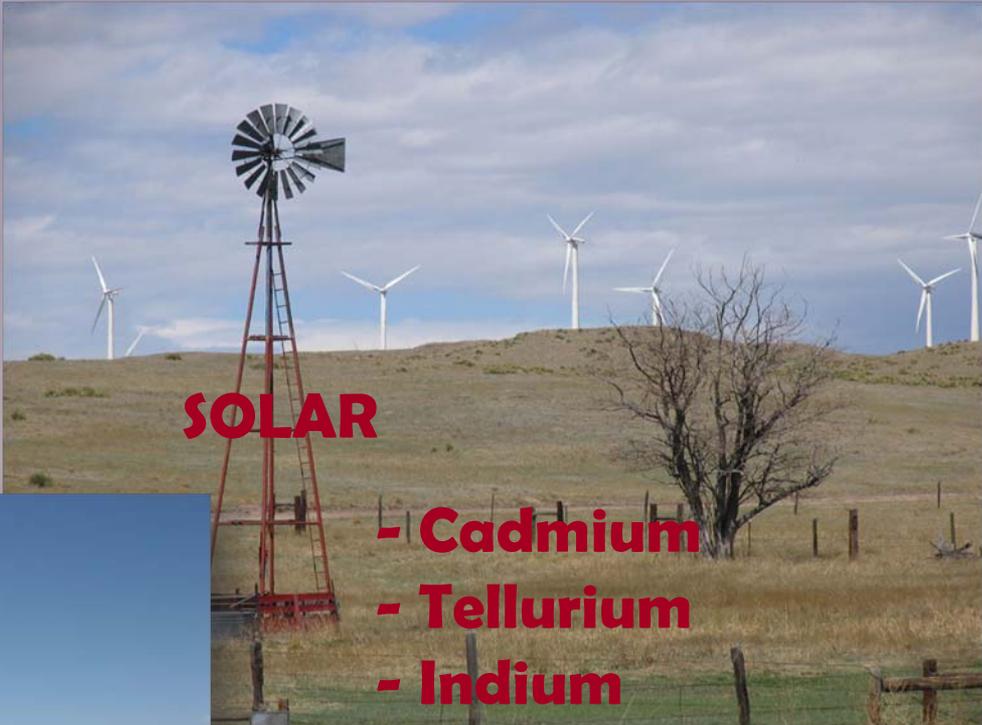
“Chinese companies and their rivals are scouring the globe from Australia to Africa for access to the raw materials needed to sustain the Asian nation’s growth as commodity prices surge.”

--June 23, 2006 (*Bloomberg*)

Renewable Energy

WIND

- Neodymium
- Molybdenum
- Iron Ore



SOLAR

- Cadmium
- Tellurium
- Indium
- Germanium
- Gallium
- Selenium
- Silicon
- Copper



Strategic and Critical Materials with uses in Alternative Energy applications for which the U.S. is dependent on imports for 50% or more of consumption

<u>Commodity</u>	<u>Primary Sources</u>	<u>Applications in Alternative Energy</u>
Antimony	China	Thermoelectric/paraelectric materials
Barium	China	Thermoelectric/paraelectric materials
Bismuth	China, Mexico	Thermoelectric/paraelectric materials
Cobalt	Kinshasa, Australia	Photovoltaics (solar cells)
Gallium	China	Photovoltaics, paraelectric materials
Germanium	Belgium, Canada	Photovoltaics (solar cells)
Indium	China, Canada	Solar cells, thermo/paraelectric
Manganese	Gabon, S. Africa	Photovoltaics
Nickel	Canada	Fuel cells
Platinum group	South Africa	Fuel cells, para/thermoelectric mtrls
Rare Earths	China	Fuel cells, para/thermoelectric mtrls
Scandium	China, Russia	Thermoelectric/paraelectric materials
Selenium	Canada	Solar cells, thermoelectric materials
Strontium	Mexico	Thermoelectric/paraelectric materials
Tantalum	Brazil	Thermoelectric/paraelectric materials
Tellurium	Belgium, Germany	Solar cells, thermoelectric,
Tin	Peru	Thermoelectric materials
Titanium	Australia, S. Africa	Solar cells
Vanadium	Czech Rep., S. Africa	Fuel cells
Zinc	Canada, Mexico	Photovoltaics, fuel cells, thermoelectric

Percent imported



REE = Rare Earth Elements = 15 + 2

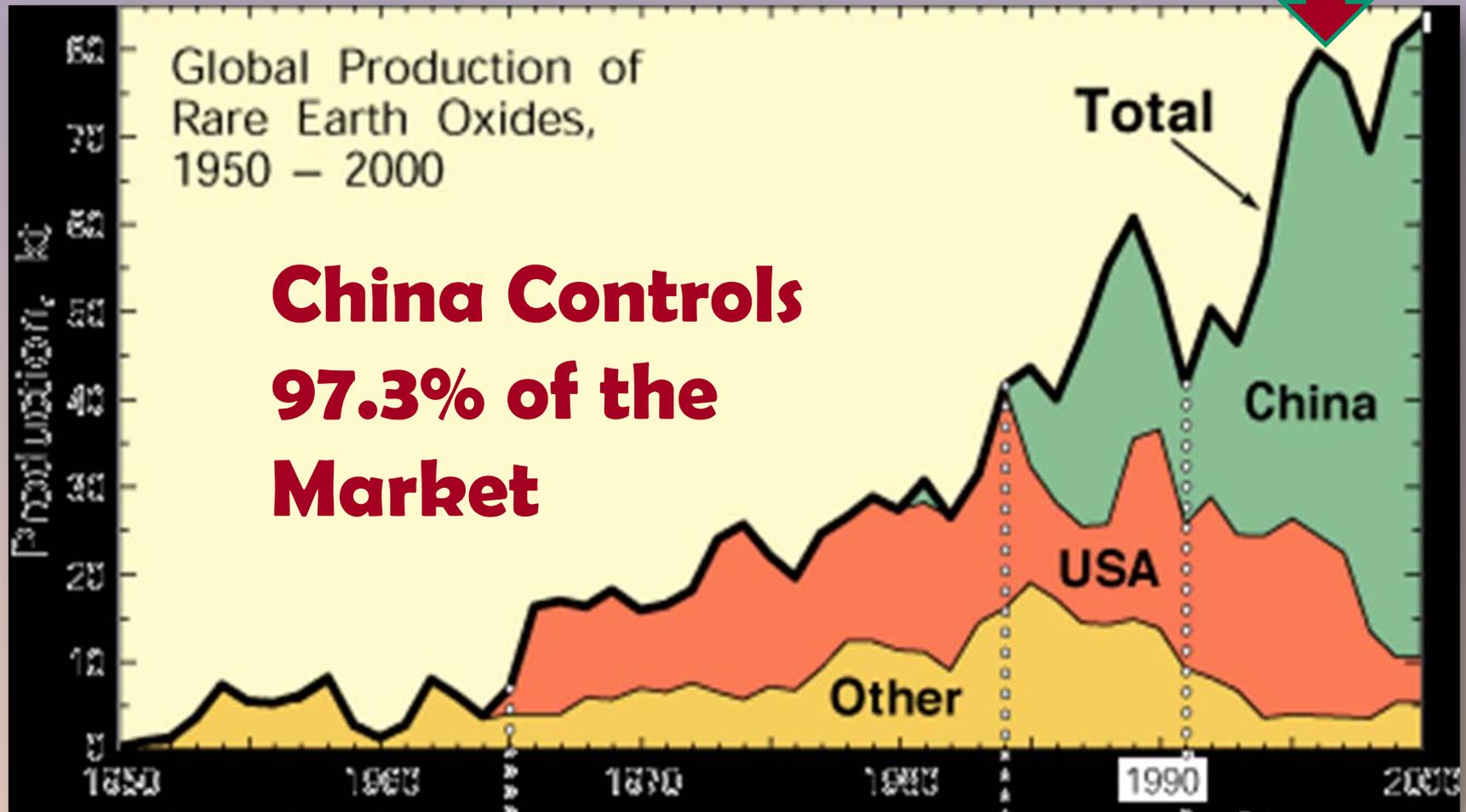
neodymium,
lanthanum,
terbium,
dysprosium,
cerium,
europium,
yttrium,
praesodymium



Toyota Prius



China Grabs the Market





COLORADO GEOLOGICAL SURVEY



HONG KONG — China is set to tighten its hammerlock on the market for some of the world's most obscure but valuable minerals.

--August 31, 2009 (The New York Times)

COLORADO GEOLOGICAL SURVEY



**World faces hi-tech crunch as China eyes
ban on rare metal exports** –August 24, 2009 (*London
Telegraph*)

**As hybrid cars gobble rare metals,
shortage looms** –August 31, 2009 (*Reuters*)

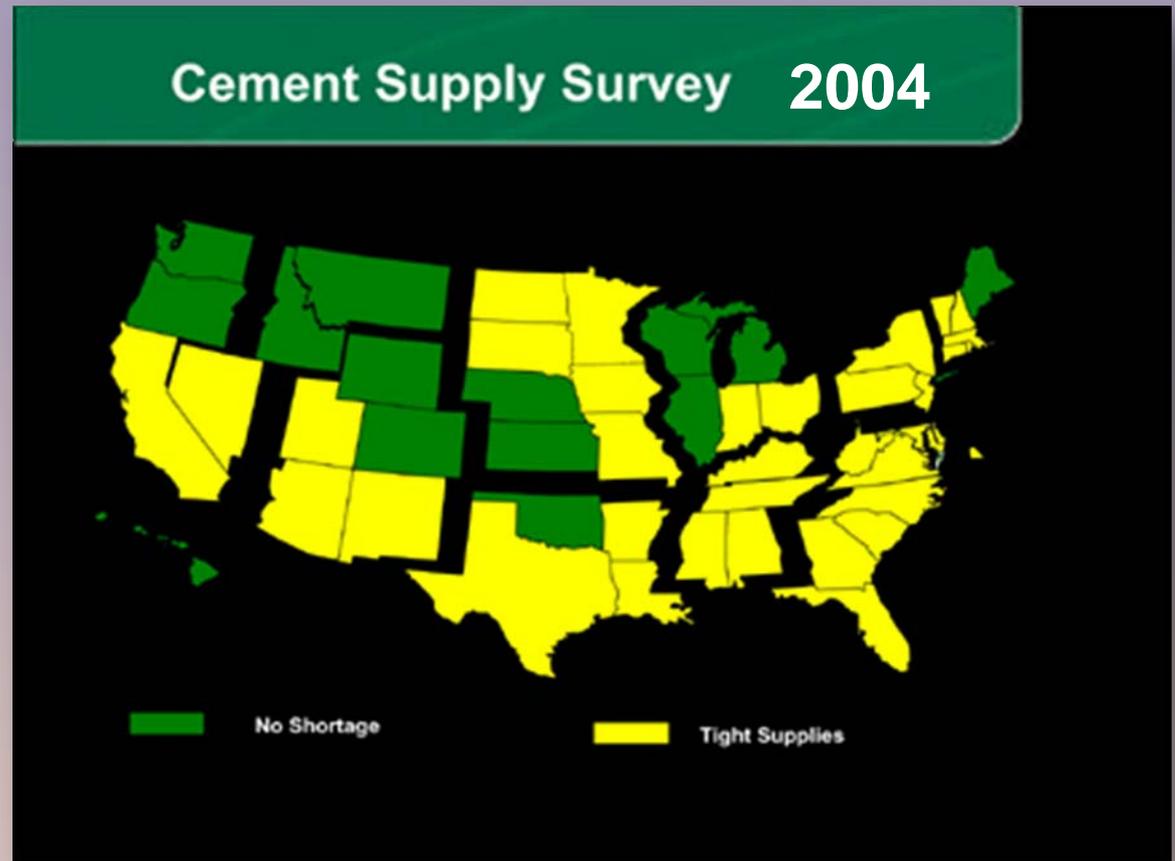
**China Considers Rare-Earth Reserve in
Inner Mongolia** –September 2, 2009 (*Bloomberg News*)

Cement Supply Survey 2004

Cement producers

1. China
2. India
3. U.S.

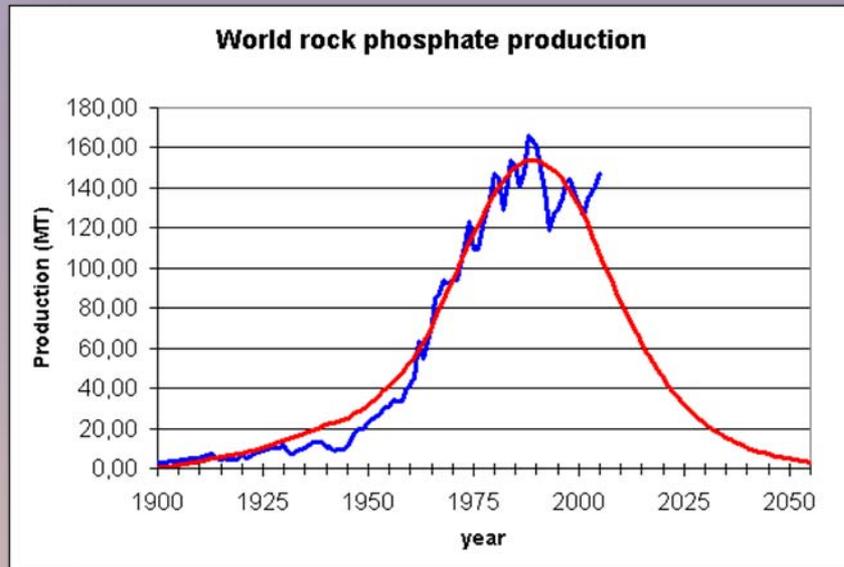
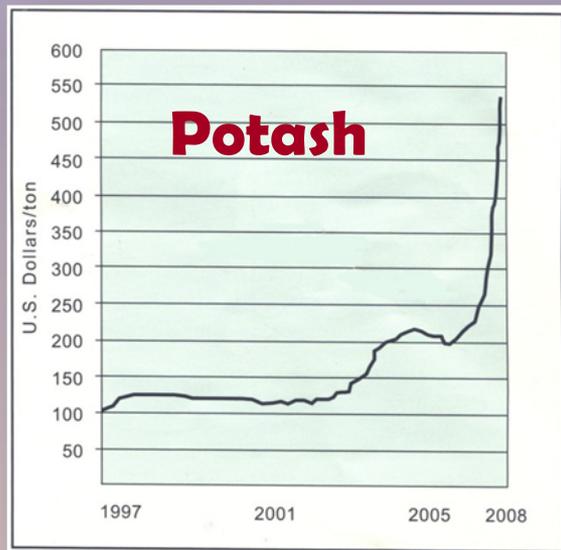
22% Imported



China Consumes 1/2 of all the concrete in the world

U.S. cement manufacturing is 81% foreign owned

Fertilizers



\$50/ ton > \$200/ ton in 2008

Nitrogen urea \$1000/ ton.

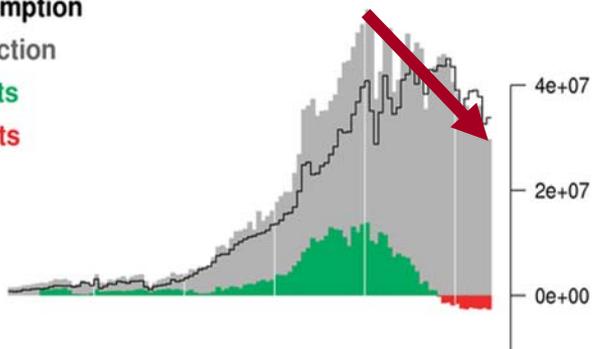


\$50/ ton > \$500/ ton in one year

Annual US production of phosphate

metric tons

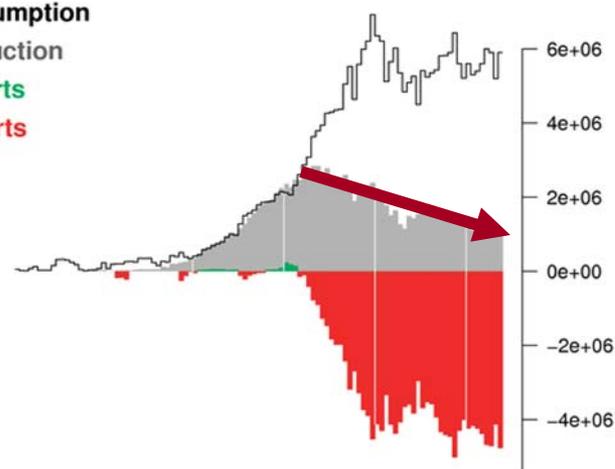
US consumption
US production
net exports
net imports



Annual US production of potash

metric tons

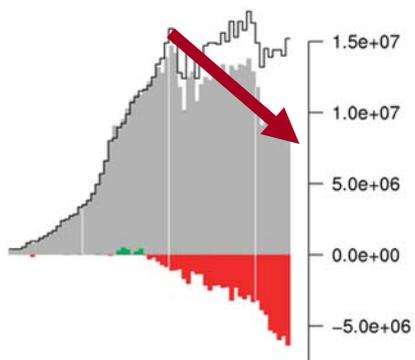
US consumption
US production
net exports
net imports



Annual US production of nitrogen

metric tons

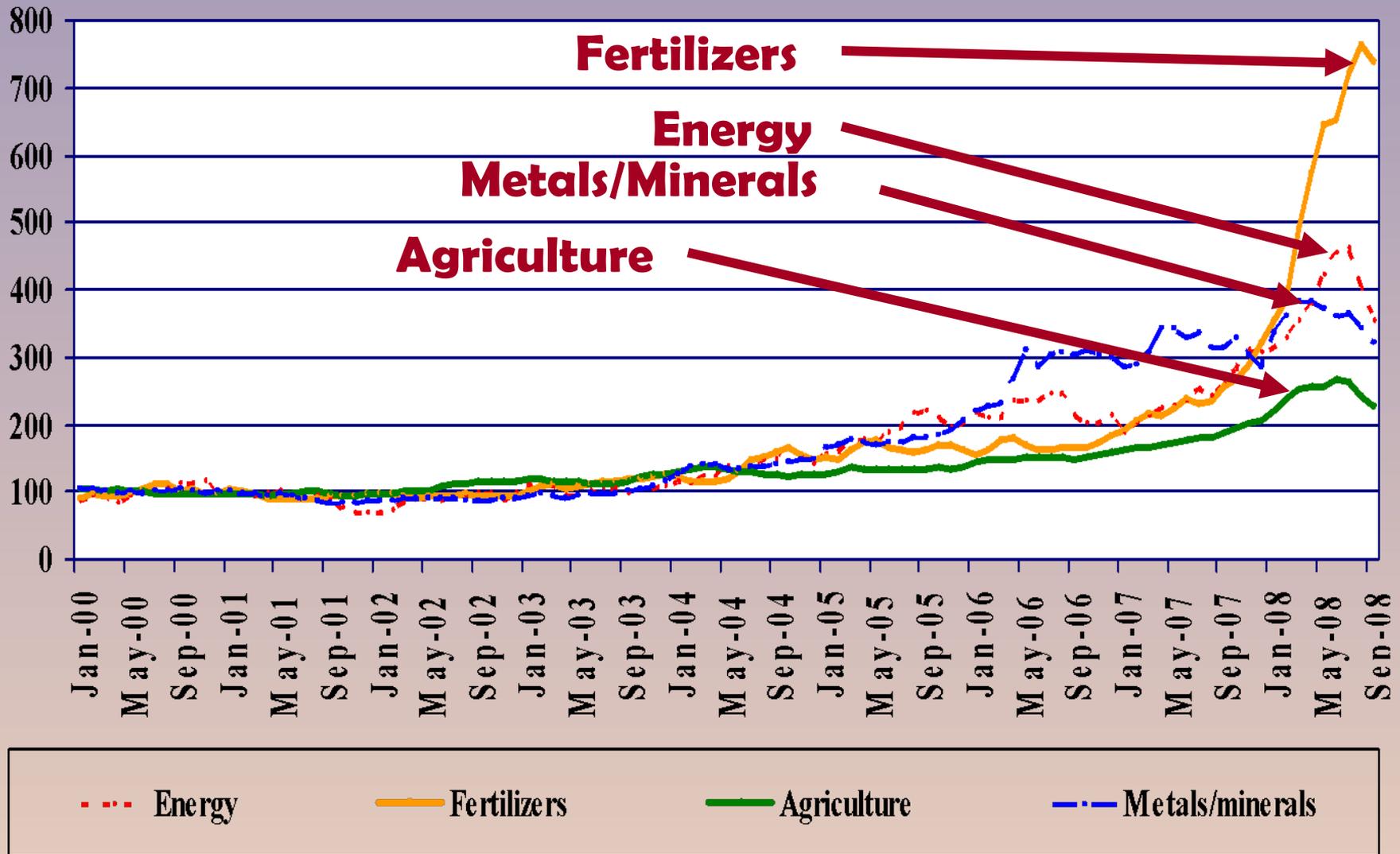
US consumption
US production
net exports
net imports



Sources: USGS Data Series 140– Graphing: mazamascience.com

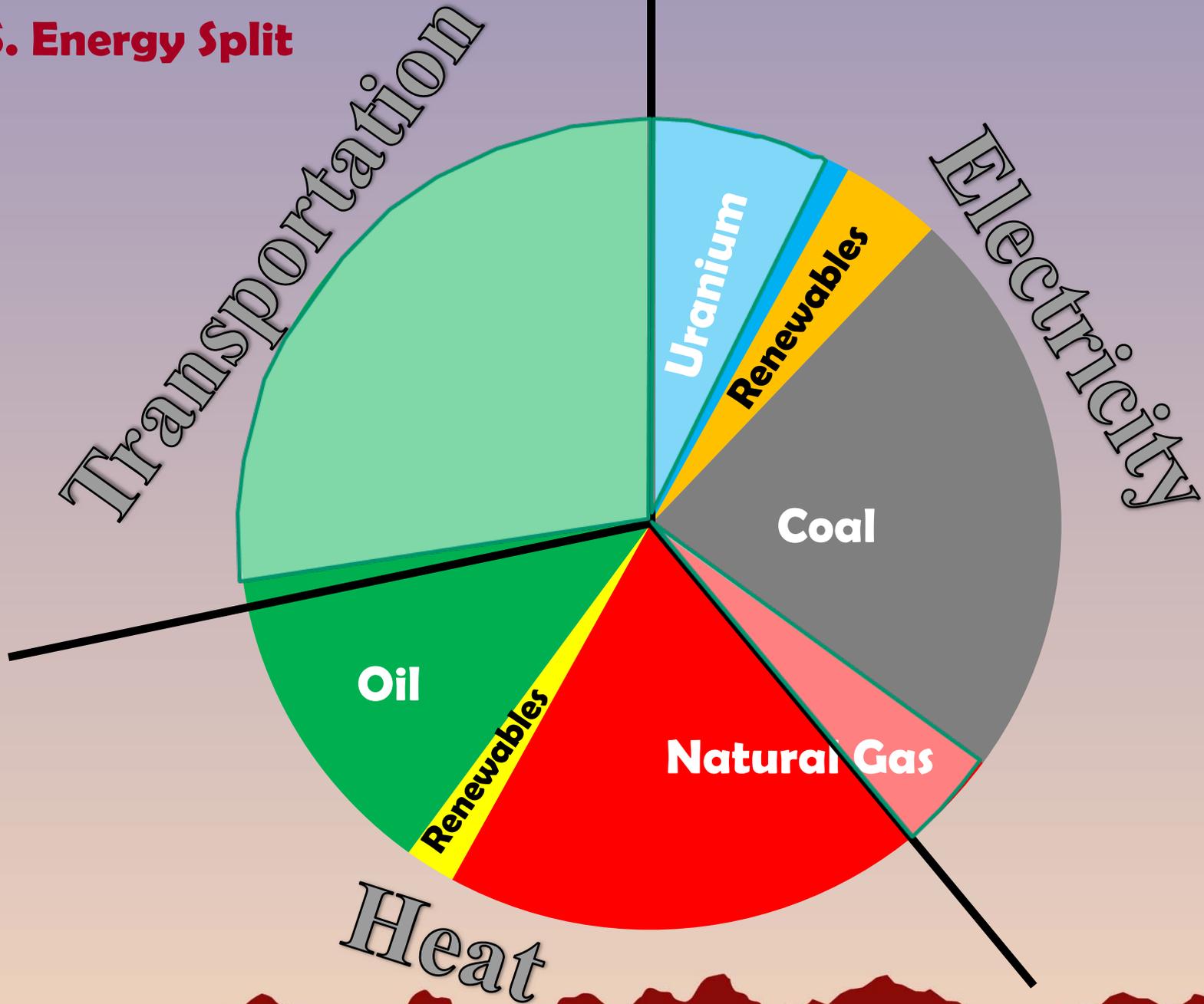


(2000 = 100)



Dr Colin Thirtle, Professor of Development Economics, Imperial College London

U.S. Energy Split



U.S. Energy Split

93%

Commodity	Percent of U.S. energy supply	Percentage Price Increase 2003-07	Percent Imported (2007 Net)
Coal	24	381	0
Oil	37	306	67
Uranium	9	481	89
Natural Gas	24	206	16

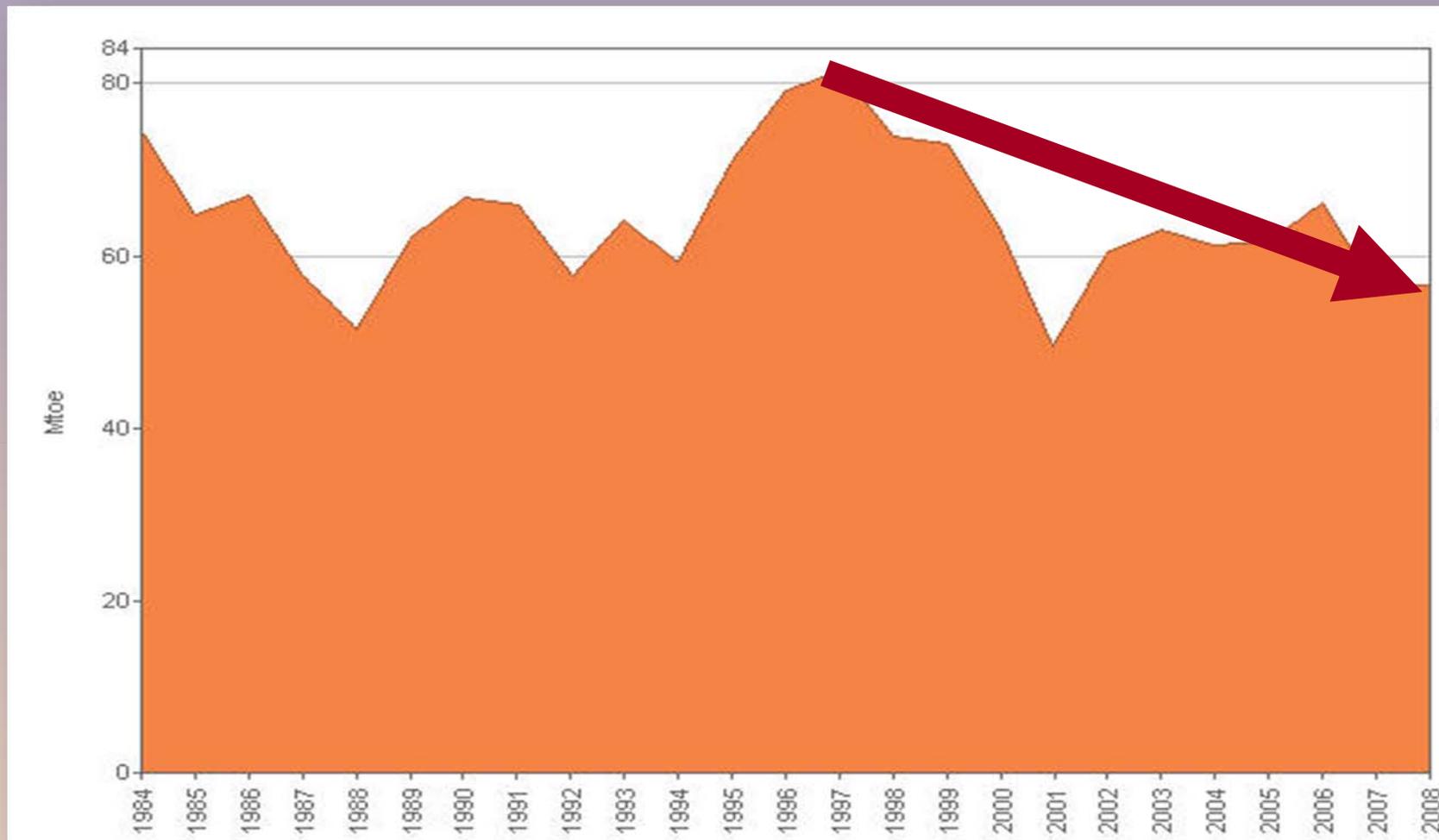
7%

Hydroelectric	2.5	-	-
Biomass	3.6	-	-
Solar	.1	-	-
Wind	.5	-	-
Geothermal	.3	-	-

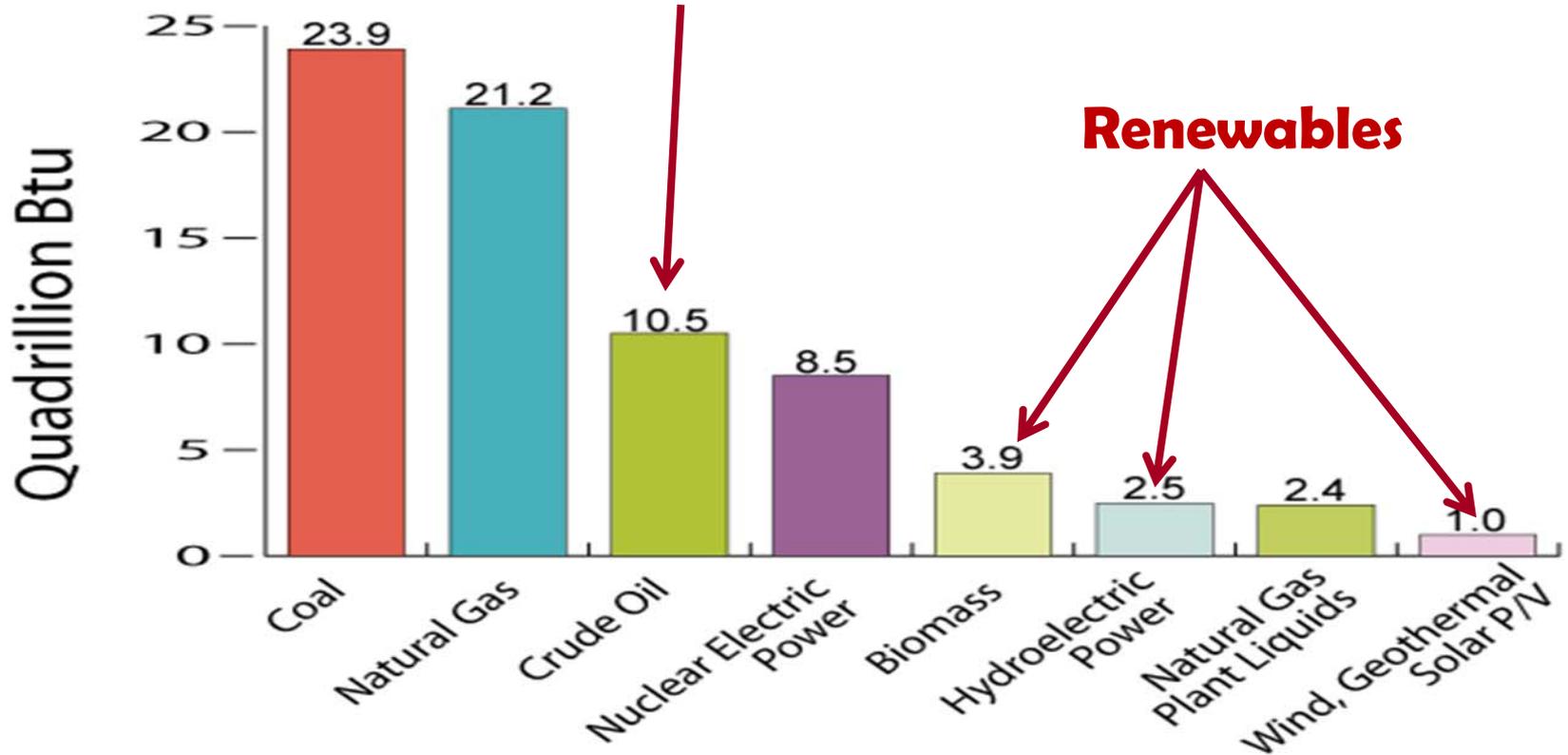
Source: EIA, Annual Report 2009



Hydro Generation – U.S.

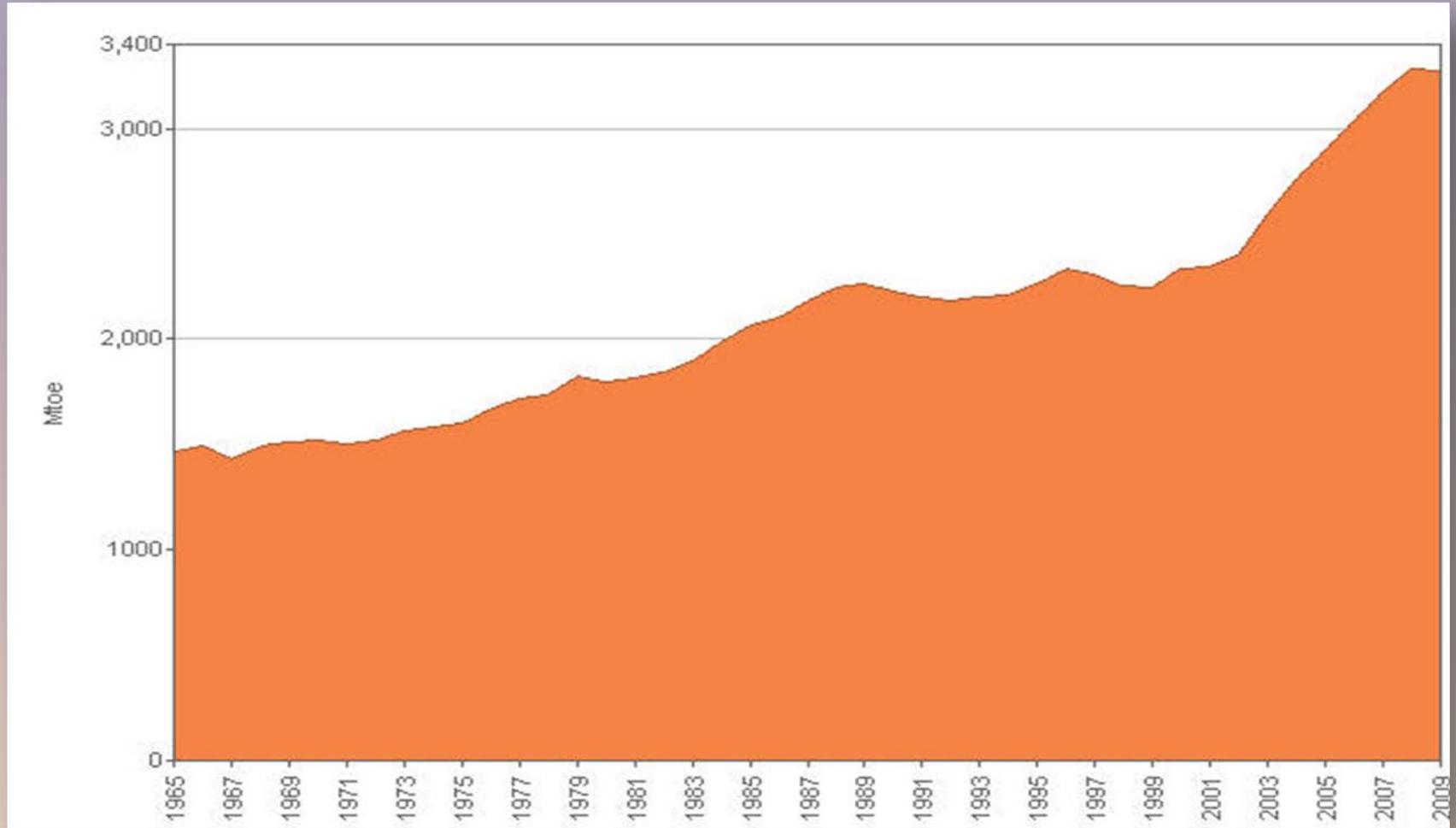


U.S. Primary Energy Production by Major Source (2008)

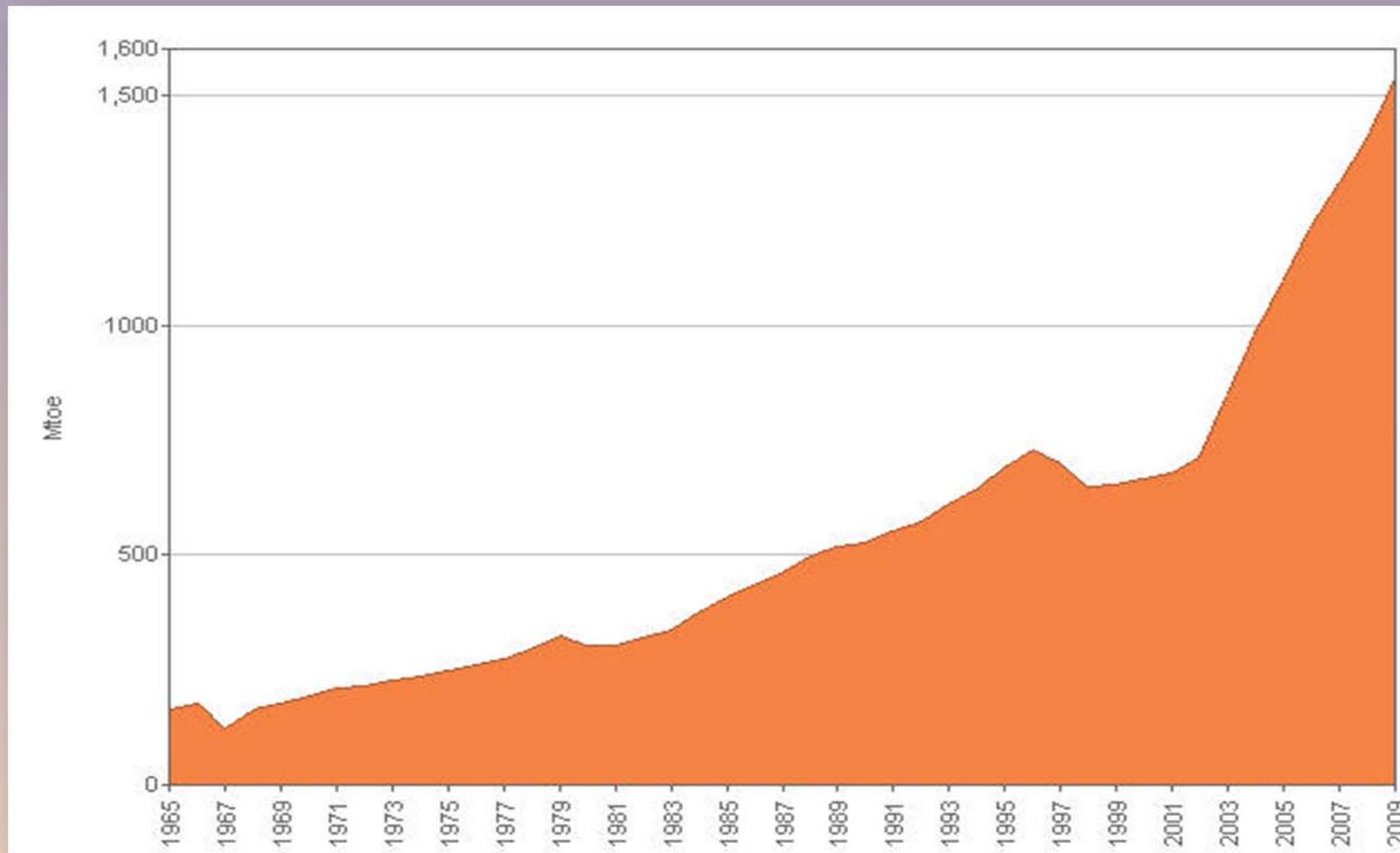


Source: Energy Information Administration, *Annual Energy Review 2008*, Table 1.2. (June 2009)

World Coal Consumption



COAL Consumption- China



China's Production and Consumption of Coal

China's Coal Production and Consumption,
1988-2008



Source: EIA International Energy Annual

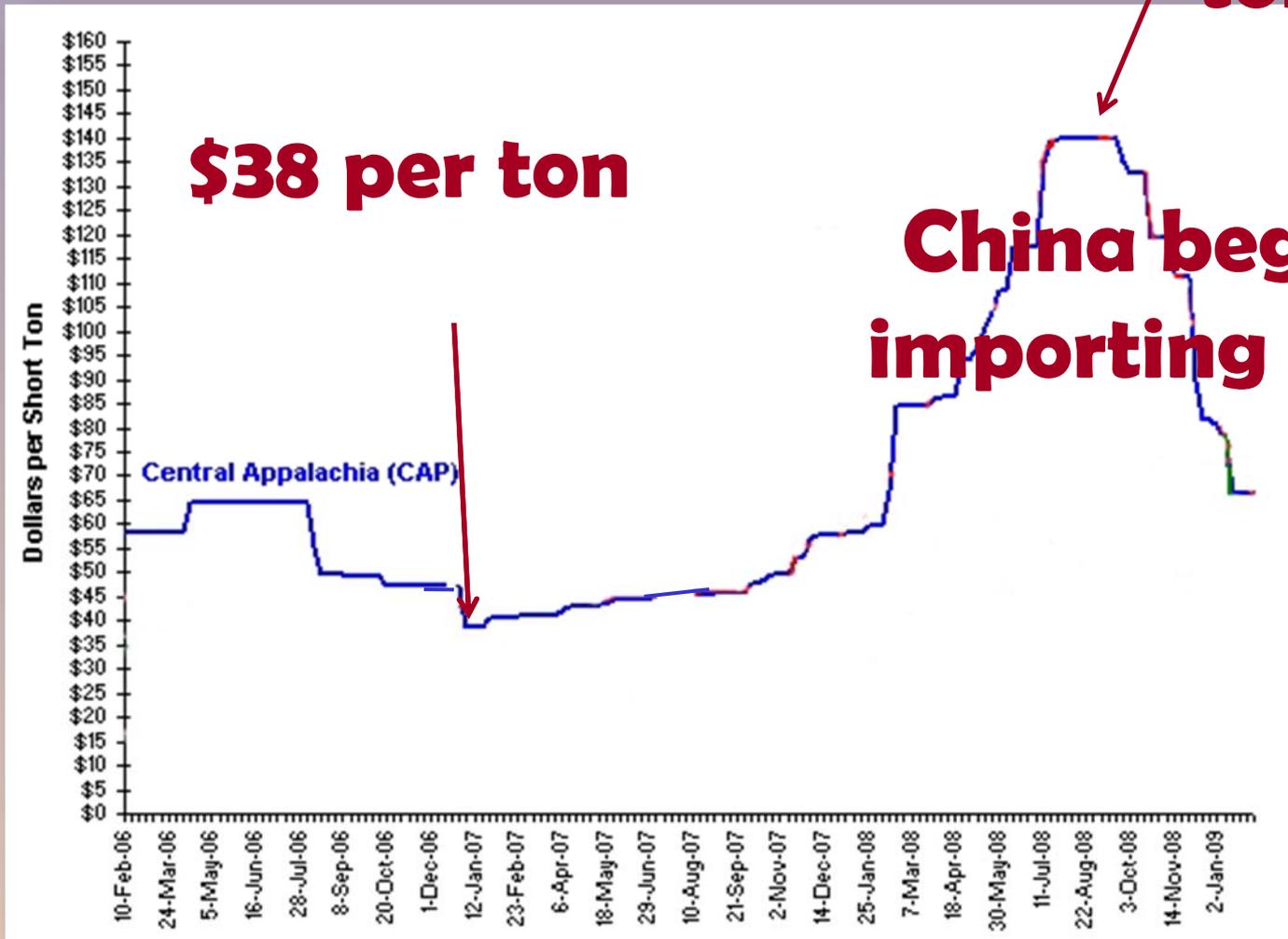
2008 estimated

Coal Spot Price 2/06 – 2/09

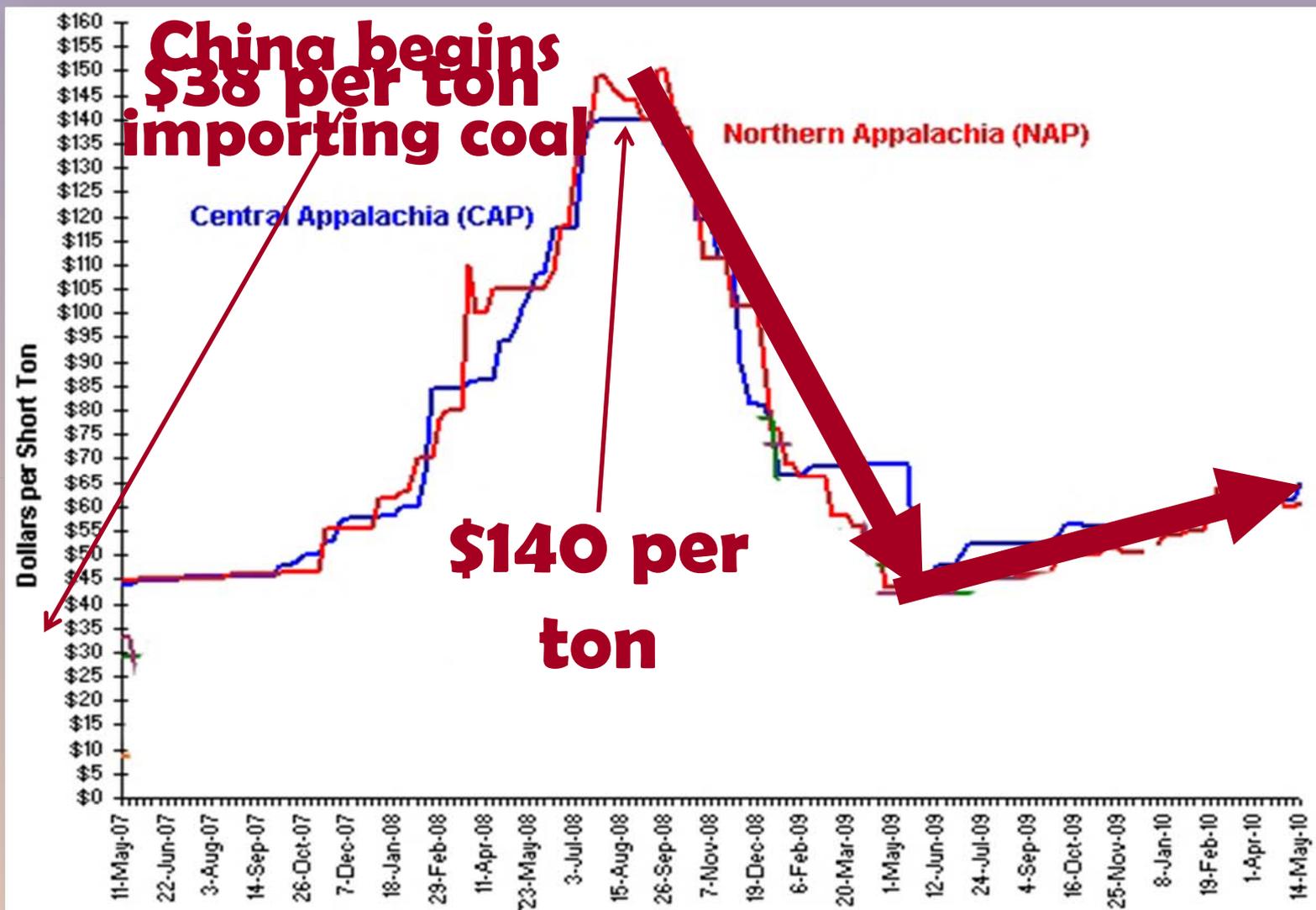
\$140 per ton

\$38 per ton

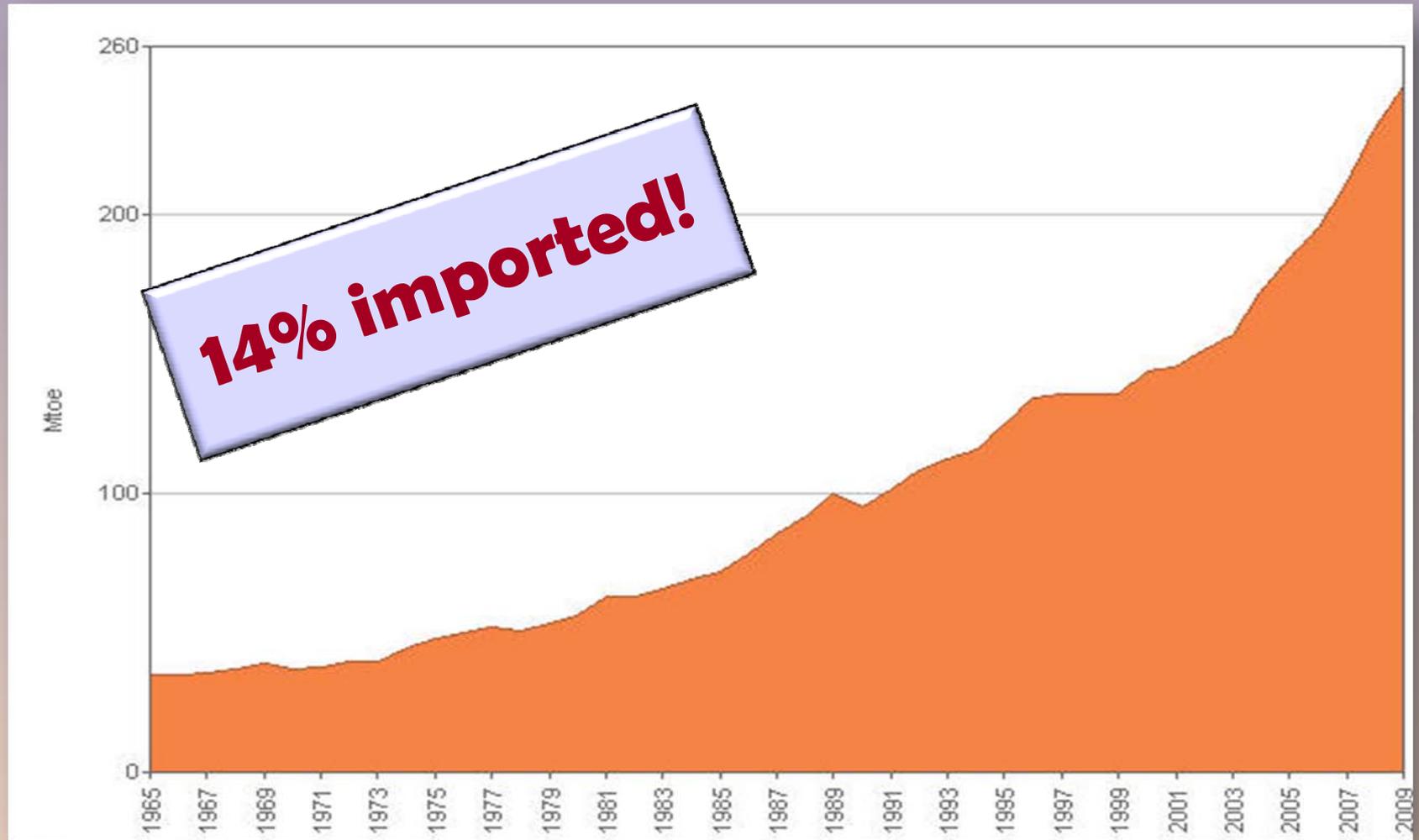
China begins importing coal



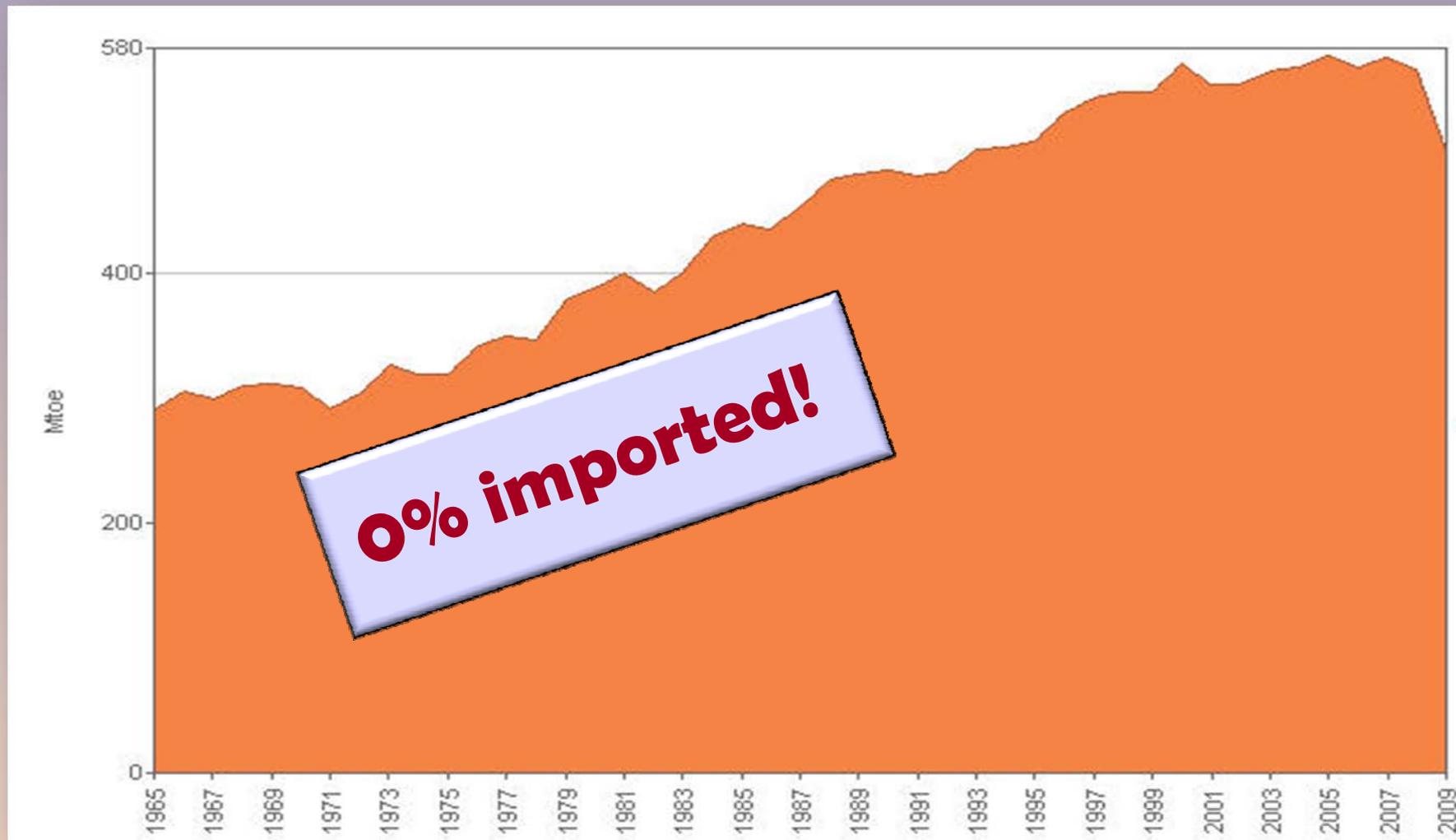
Coal Spot Price 5/07 – 5/10



COAL Consumption- India



COAL Consumption- U.S.



China/U.S. Coal

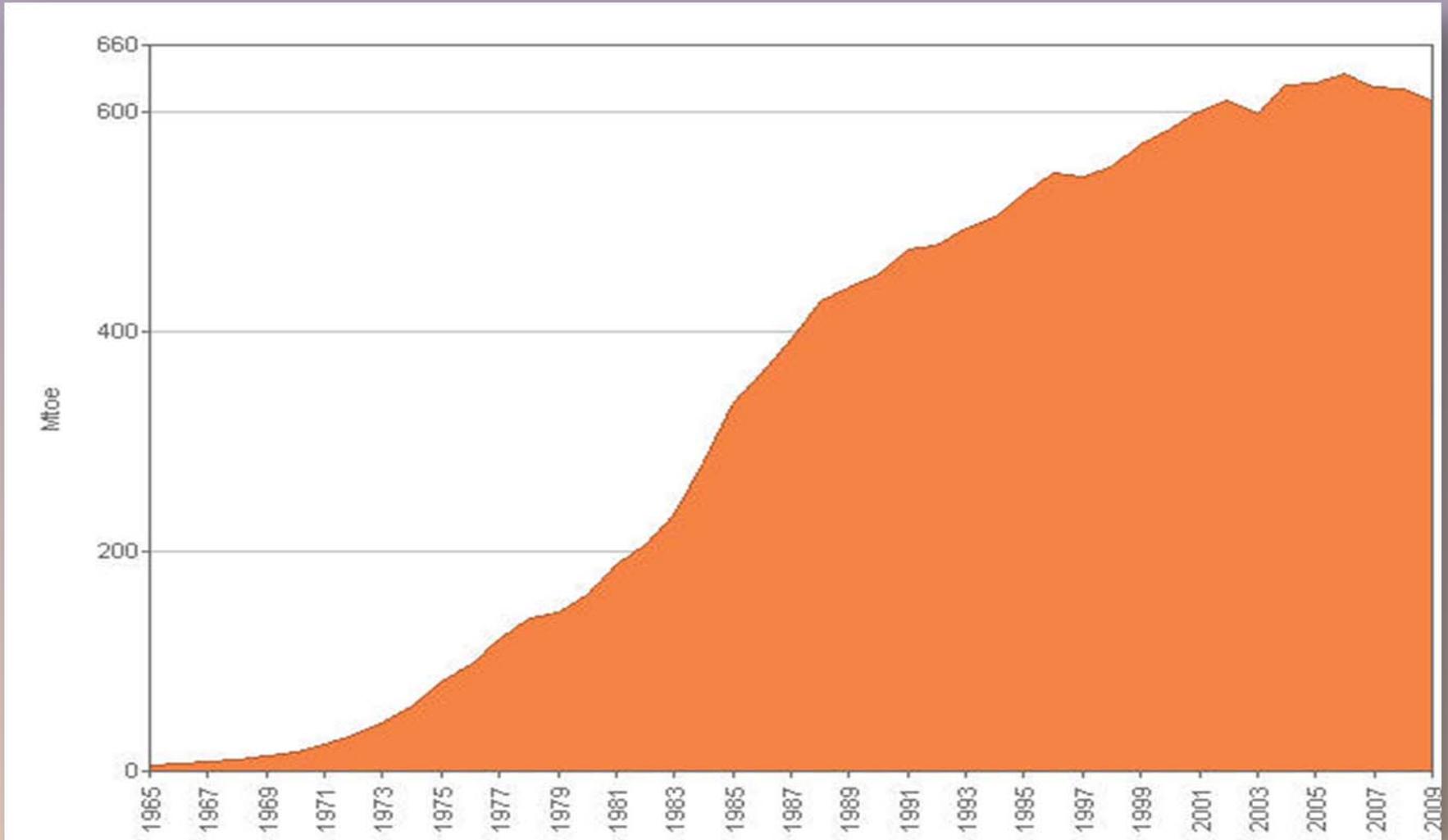


54% of world production.

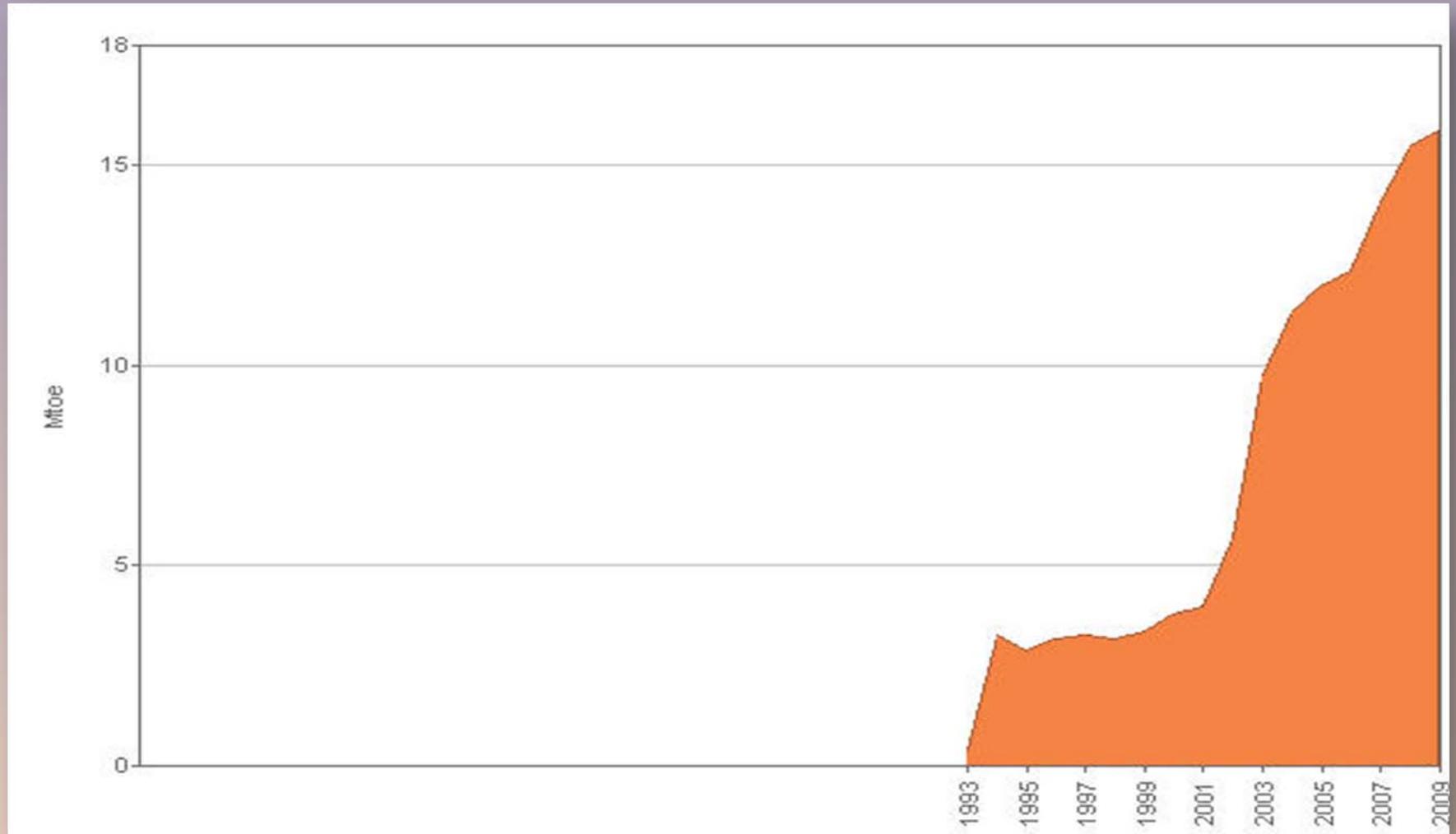
51% of world consumption.



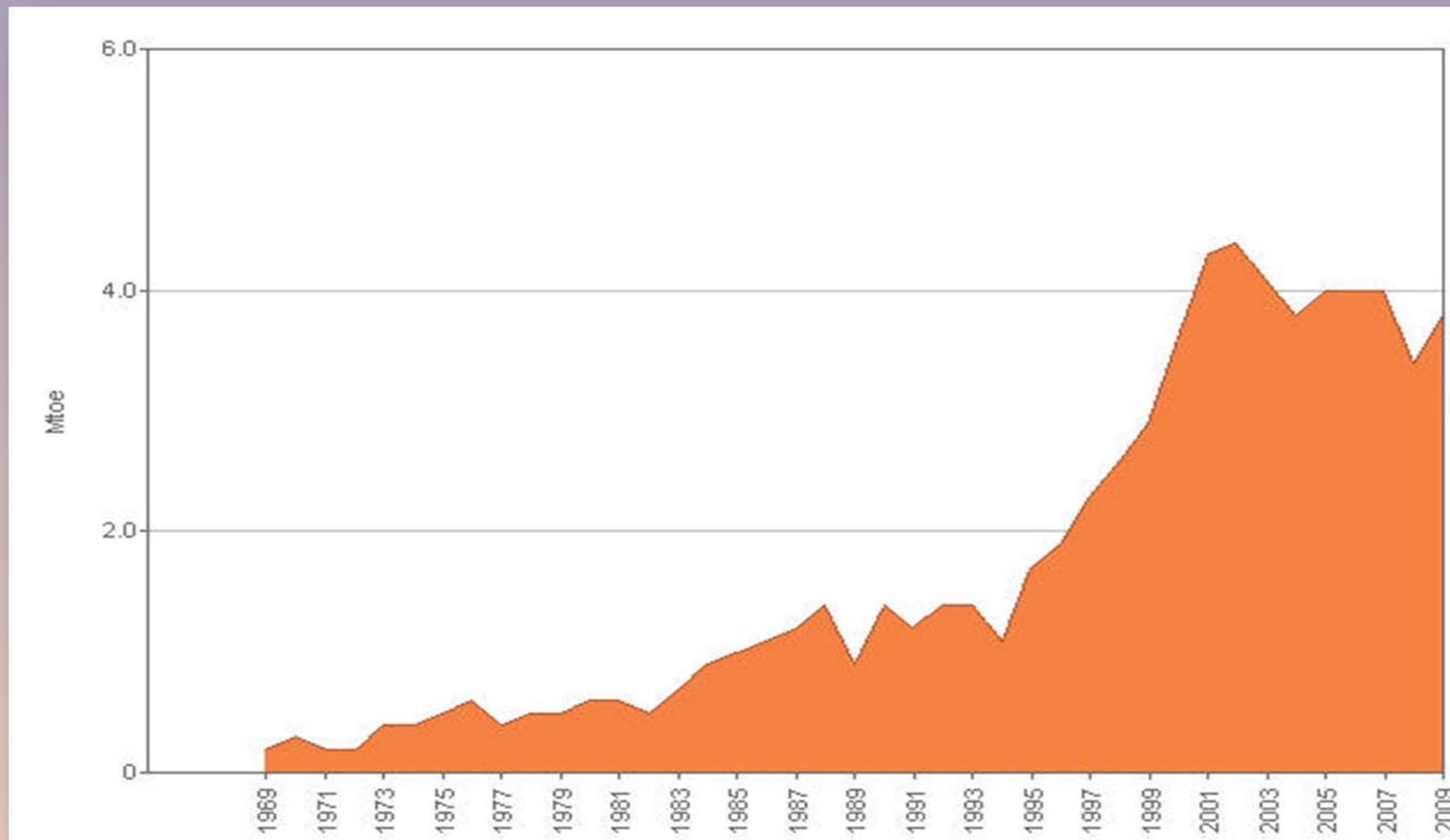
World Nuclear Consumption



NUCLEAR- China



NUCLEAR- India



China : 32 new plants by 2020

**4 per year through 2015
9 GW to 60 GW**

India: 17 new reactors by 2012

NUCLEAR- U.S.

**The last nuclear power plant came on line
in 1996**

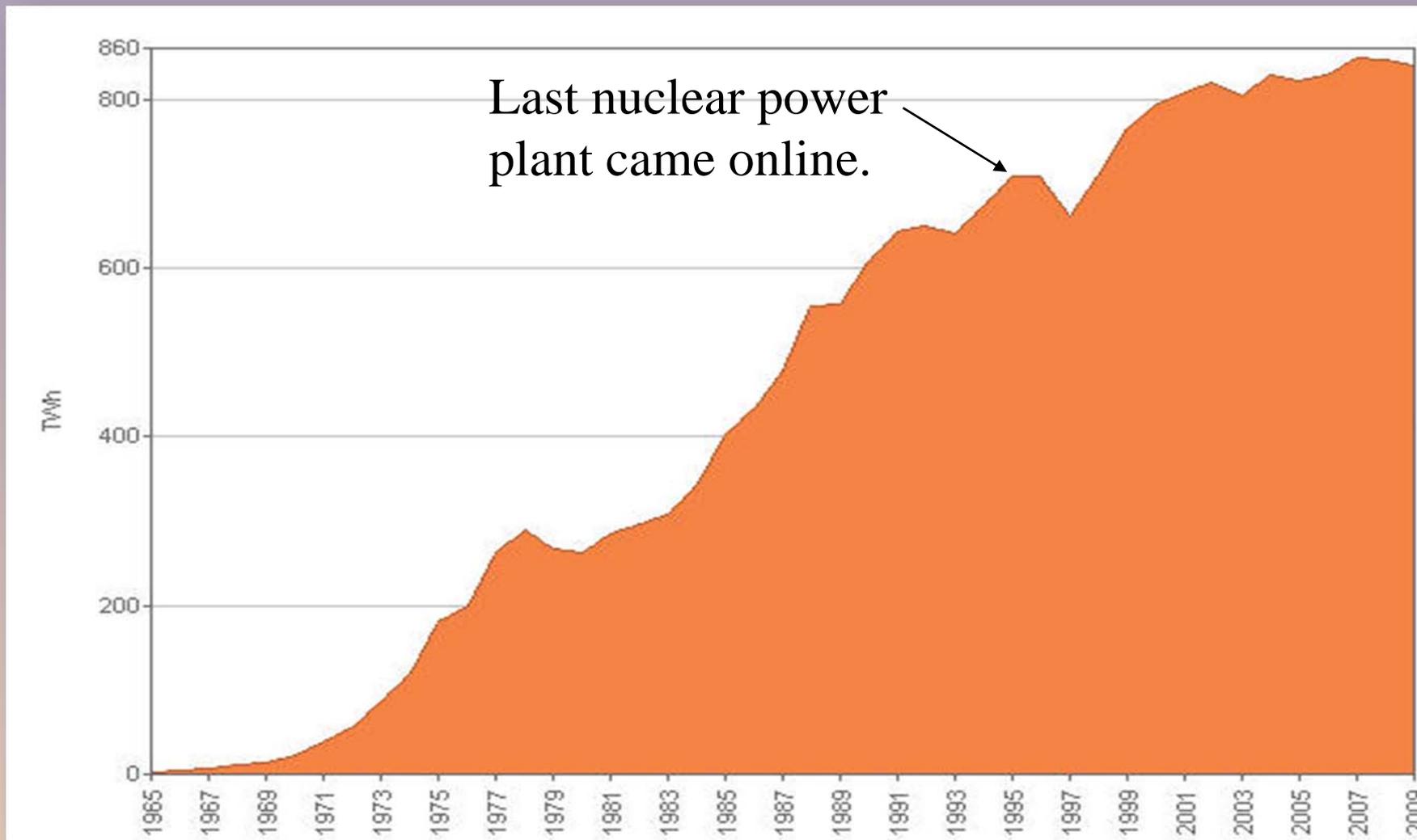
Since then has U.S. nuclear generation --

Increased?

Decreased?

Remained flat?

NUCLEAR- U.S.



And, the largest nuclear power generator in the world?

COLORADO GEOLOGICAL SURVEY



**The United States generates as much
nuclear energy as—**

France,

Germany,

Spain,

Sweden,

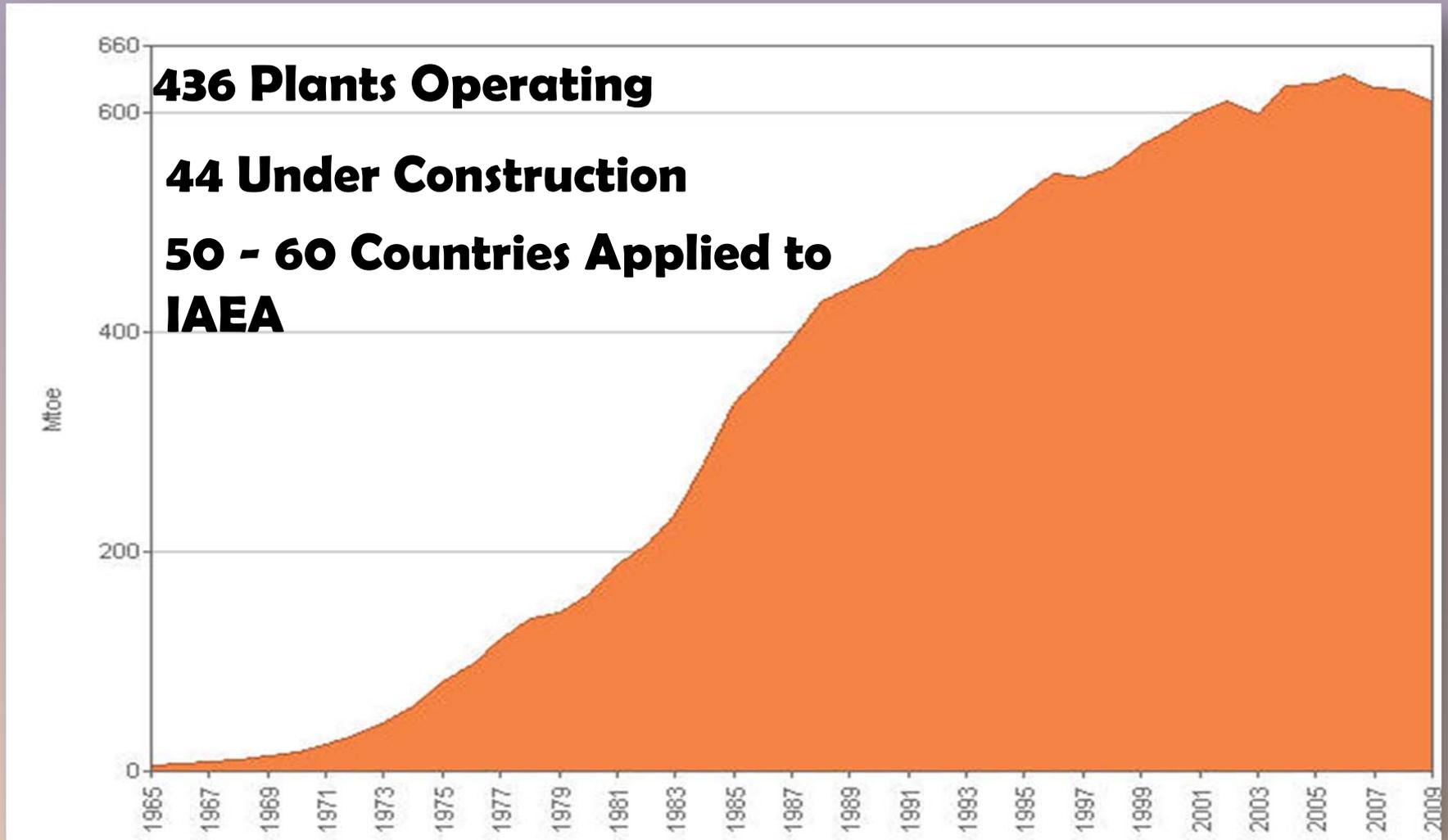
United Kingdom

combined!

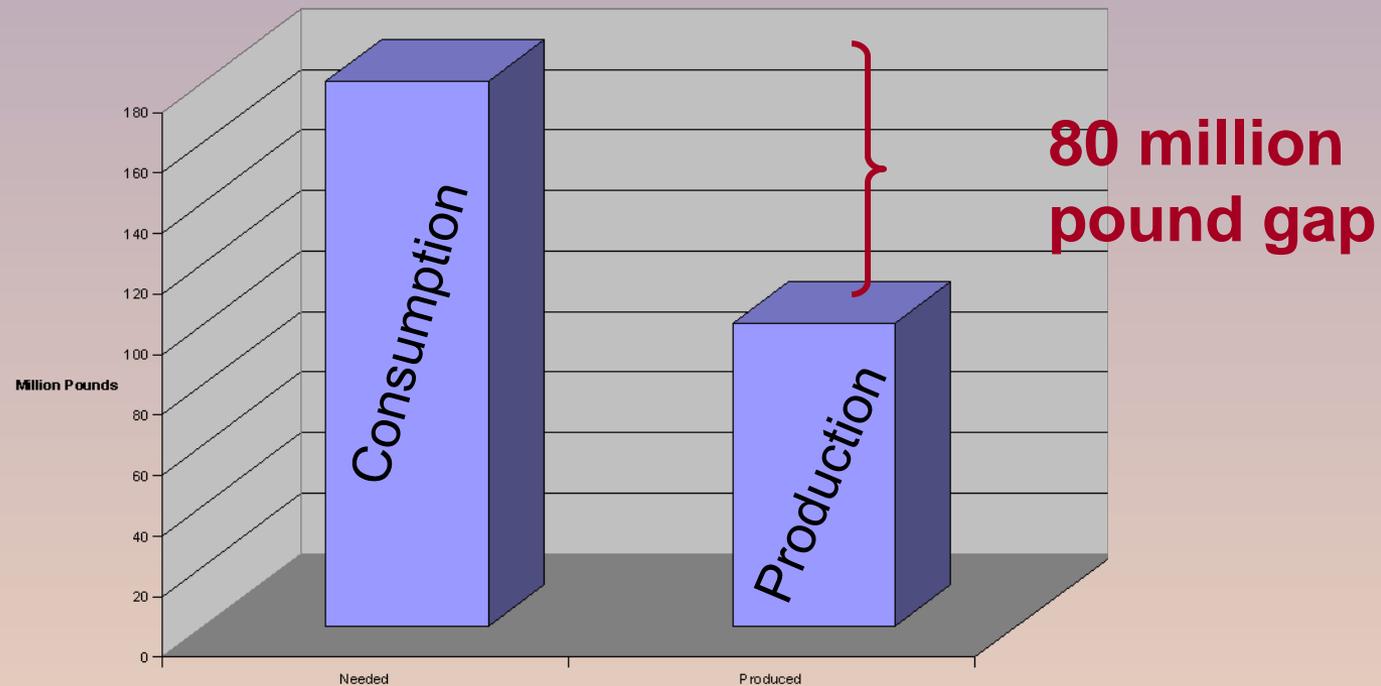
COLORADO GEOLOGICAL SURVEY



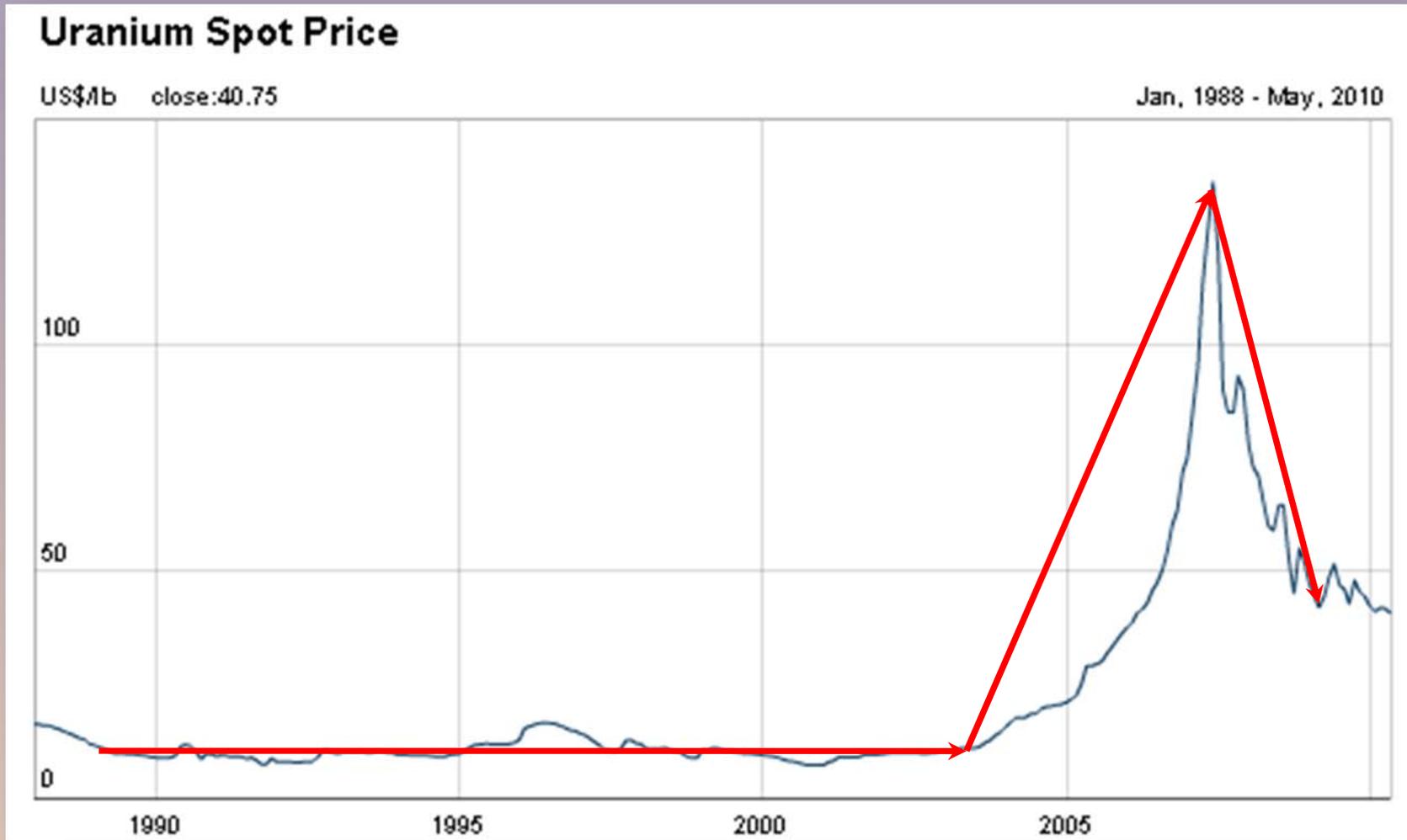
World Nuclear Power Consumption



The world's existing 436 nuclear reactors currently need 180 million pounds of uranium each year.

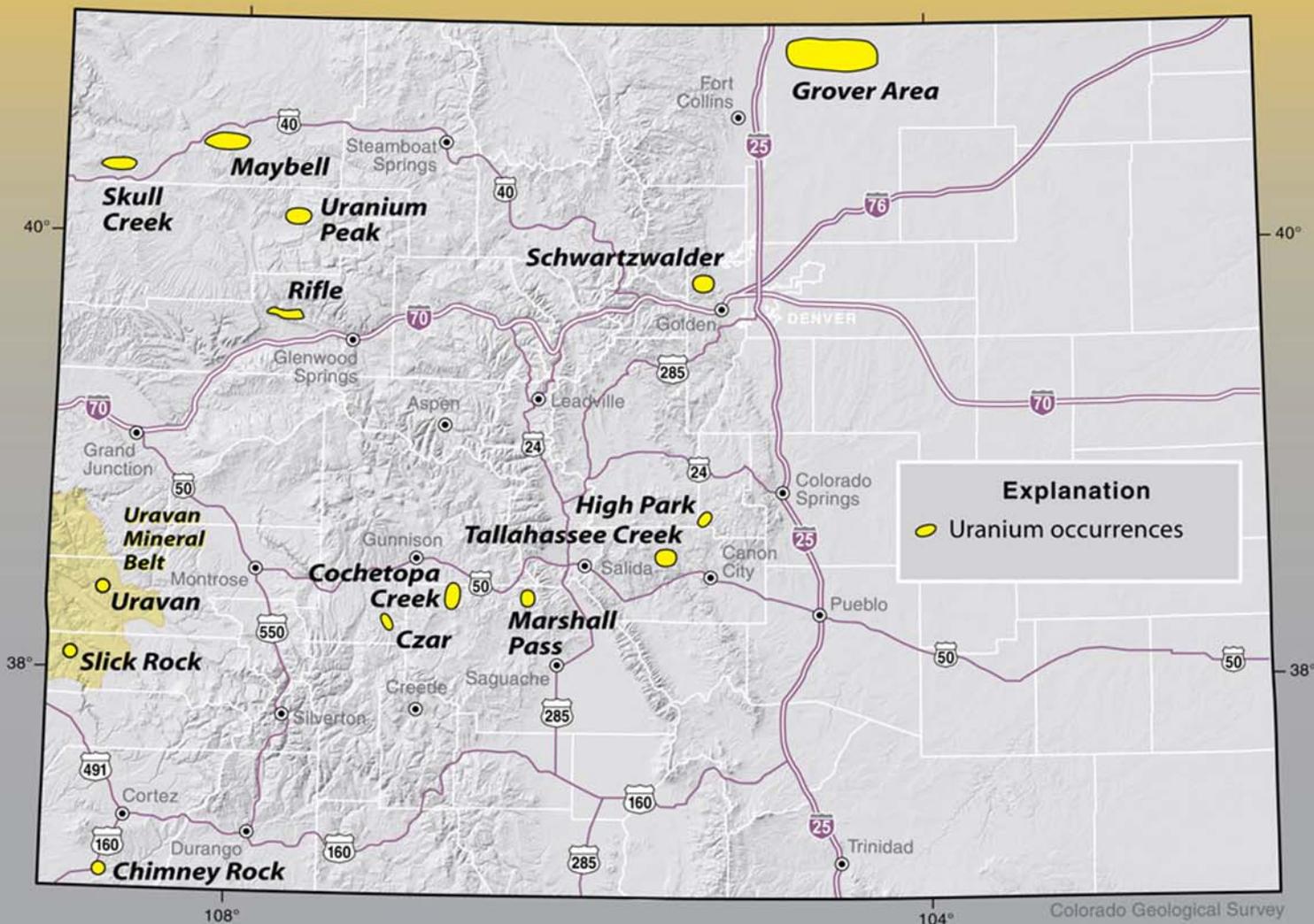


Uranium prices

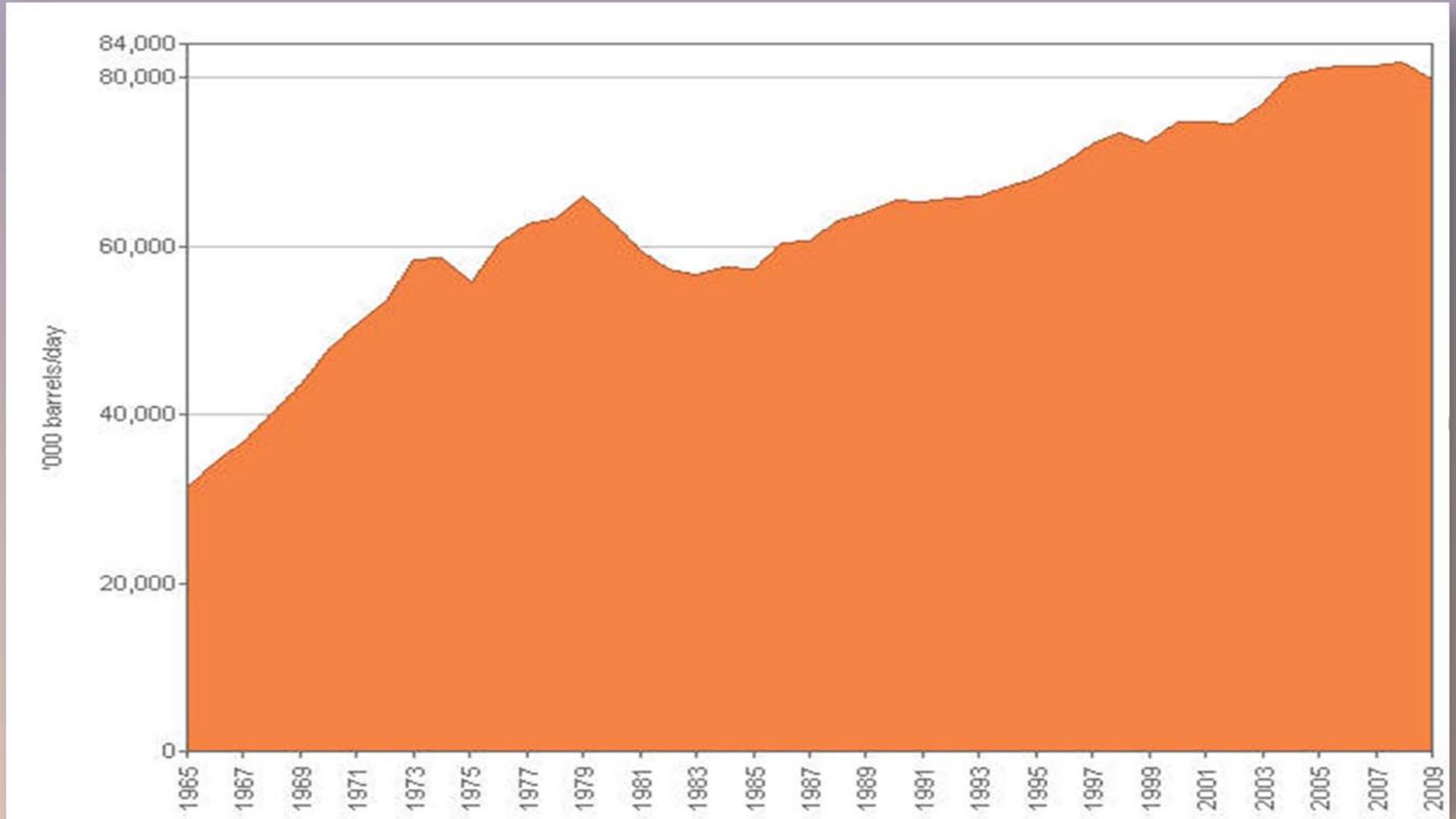


Source: Cameco

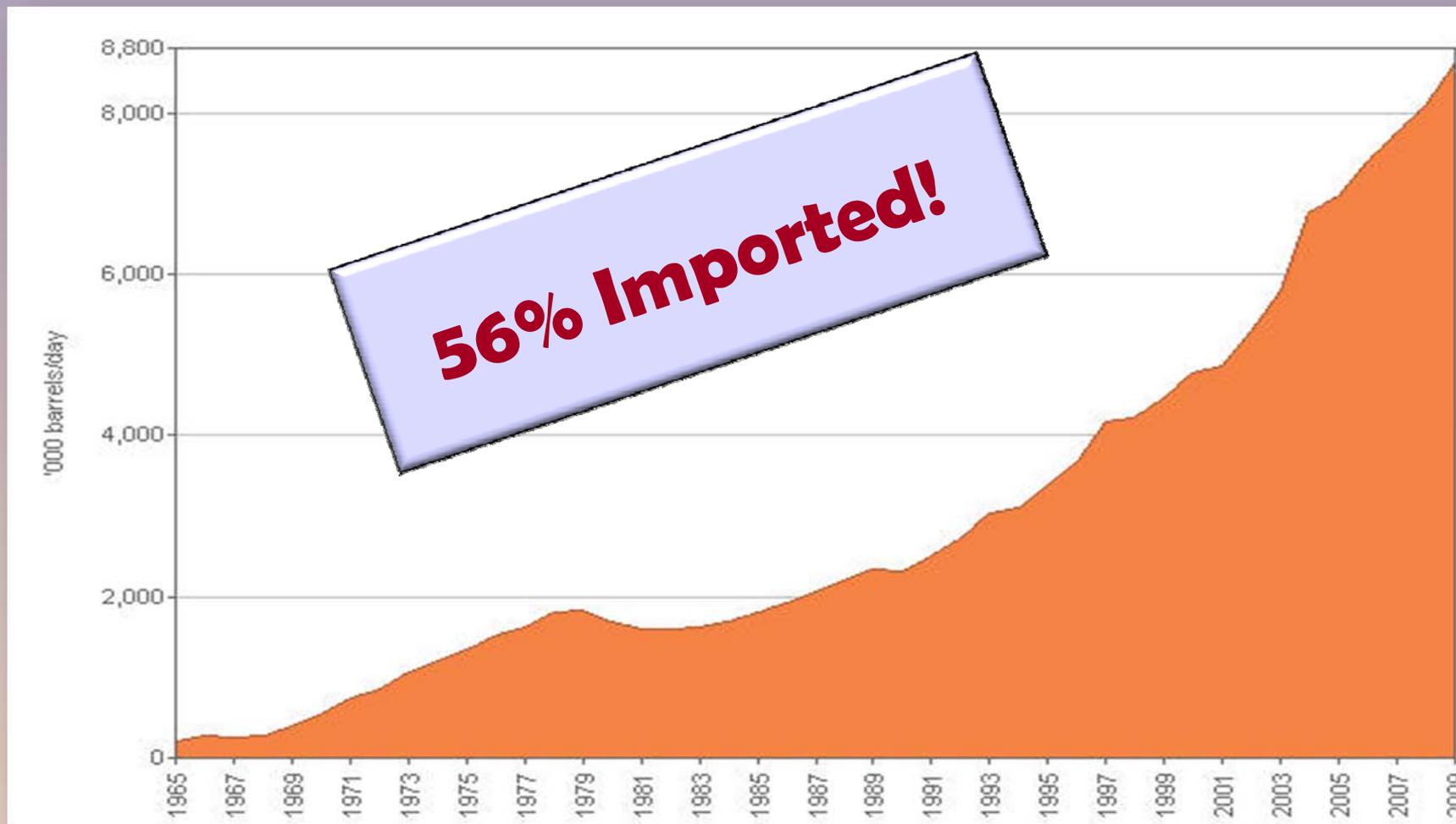
Uranium Districts



World Oil Consumption



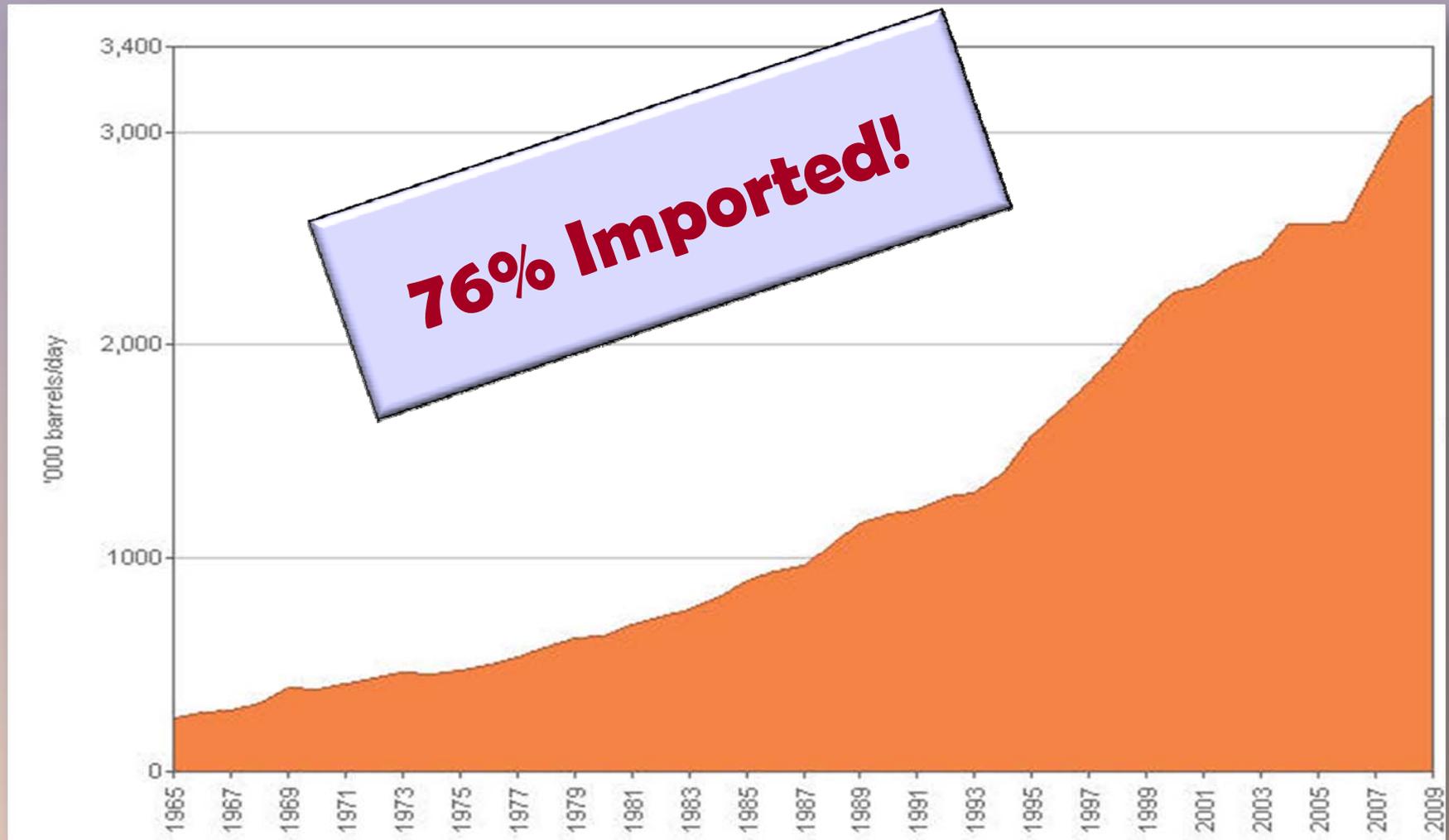
OIL CONSUMPTION- China



Source: BP

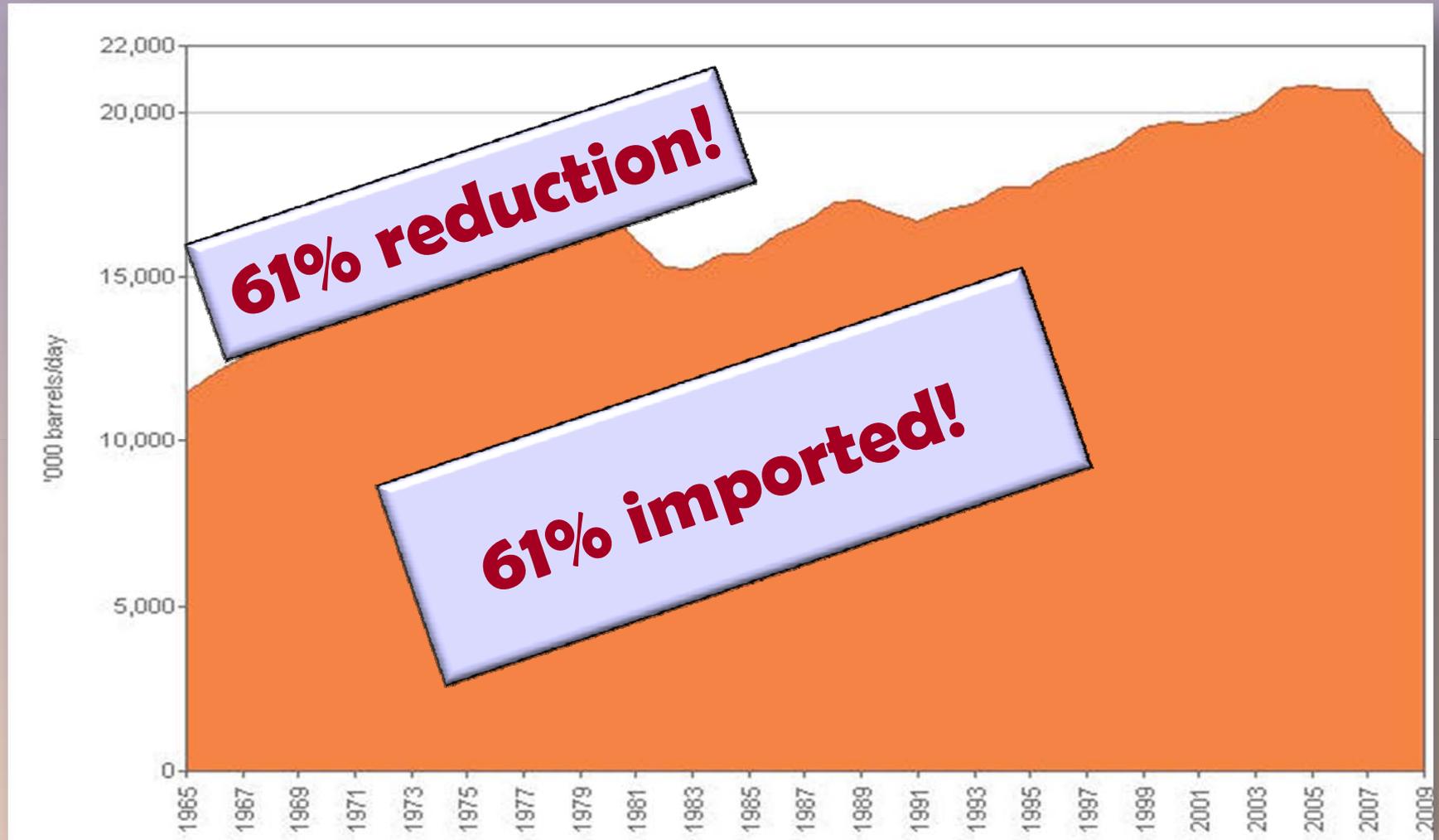


OIL- CONSUMPTION India

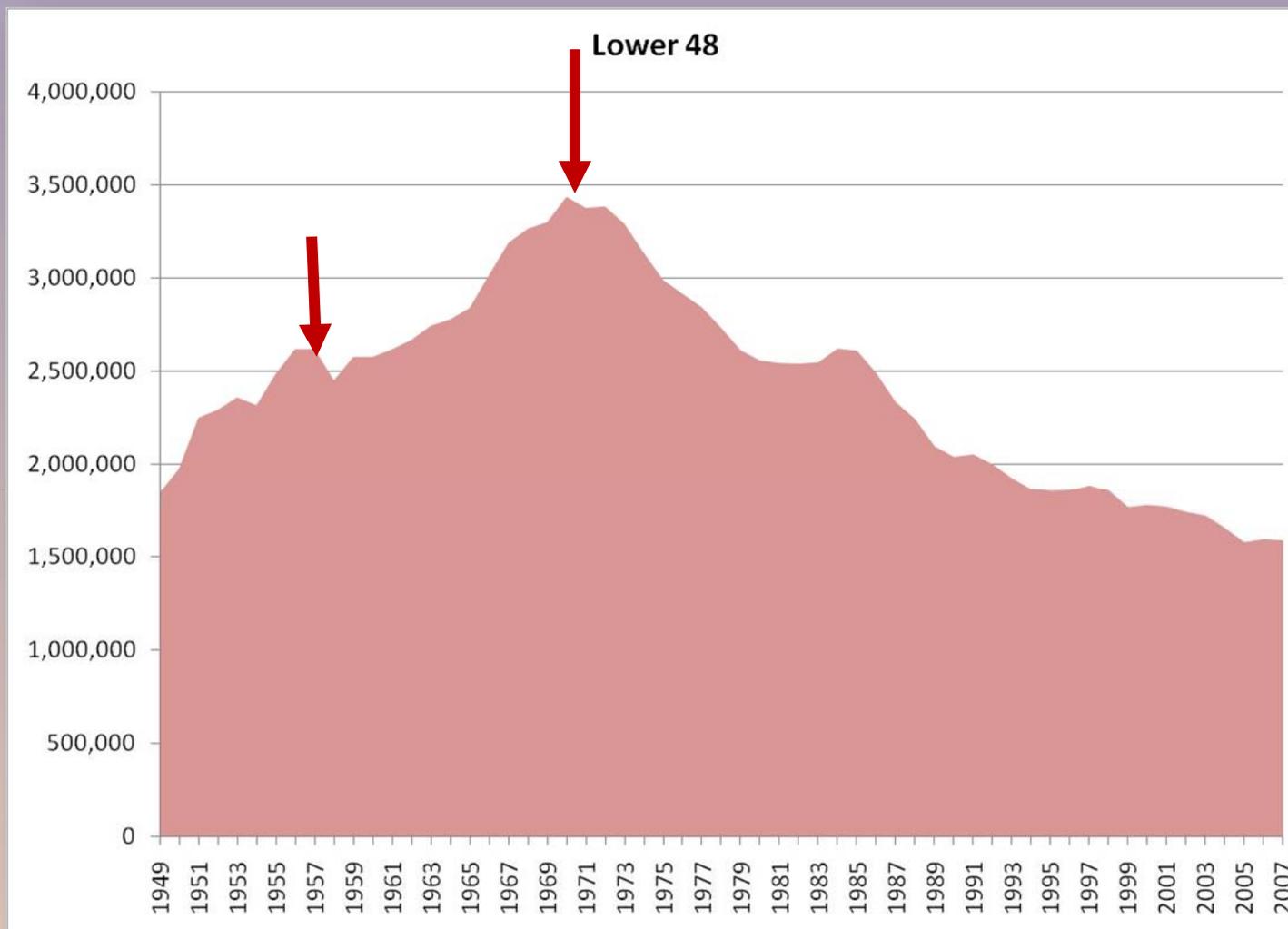


Source: BP

OIL- U.S. Consumption



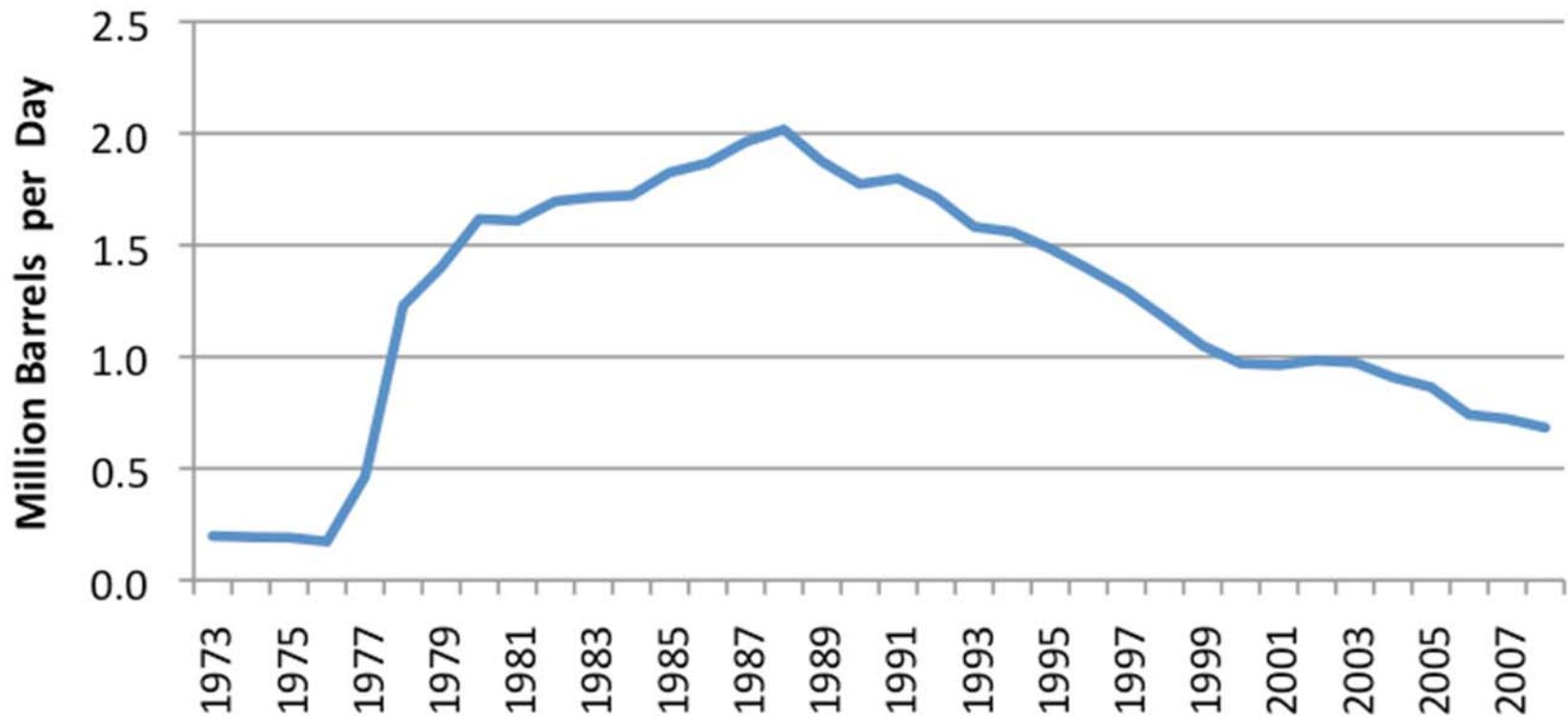
OIL- U.S. Production



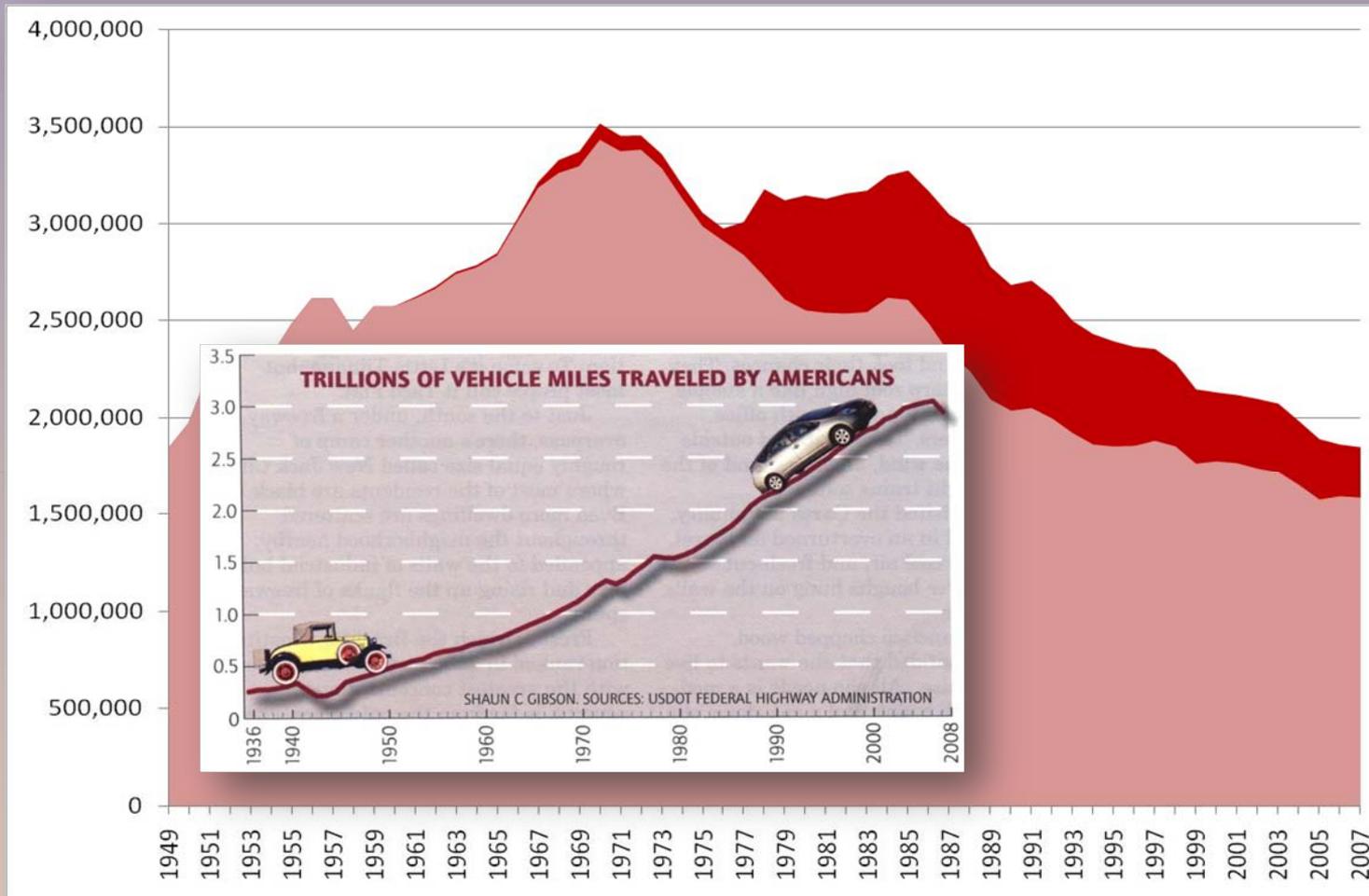
Source: EIA



Alaska production was ramped up after the US 48 decline, but it too began to decline



OIL- U.S. Production

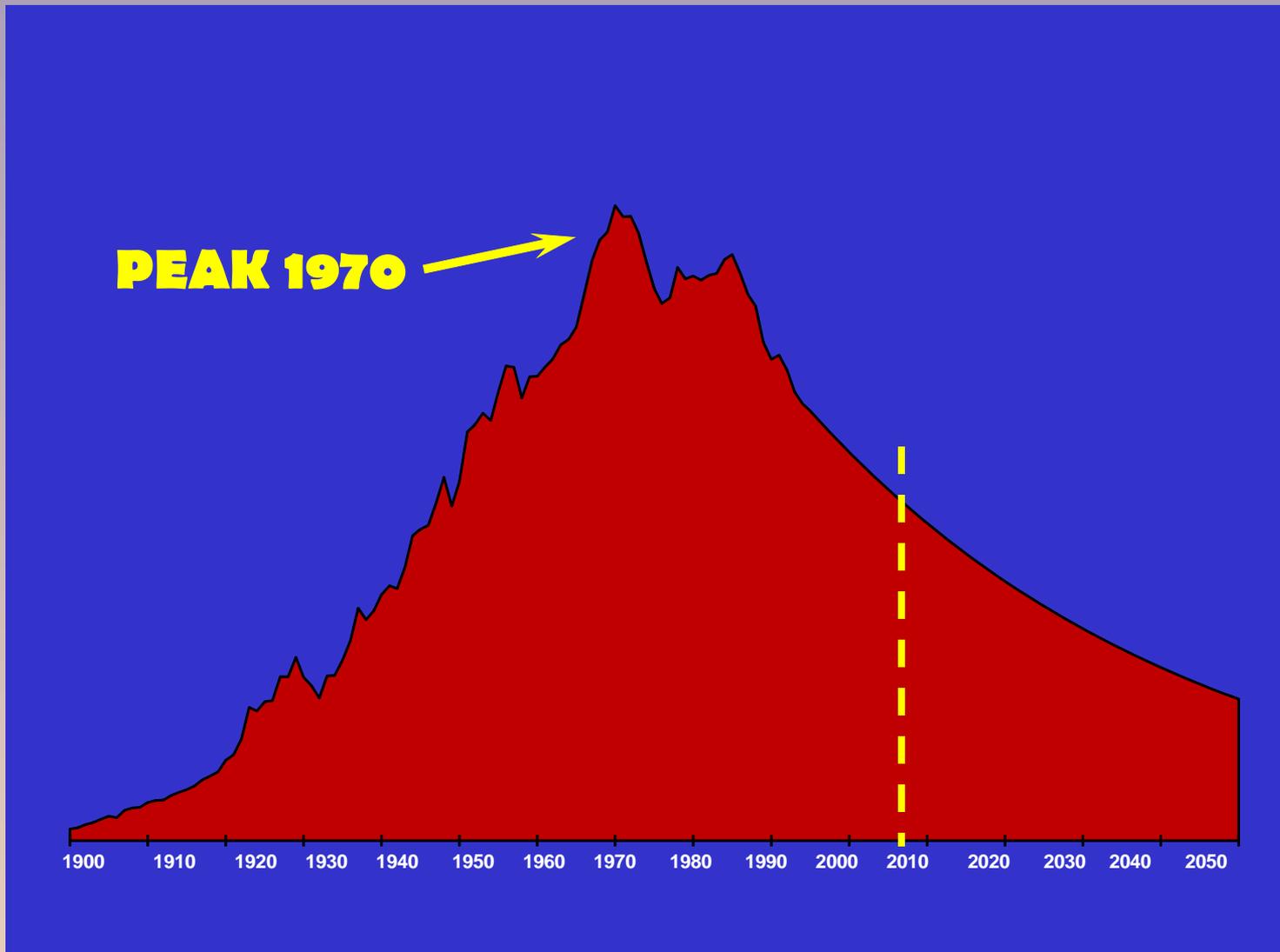


46%
Less

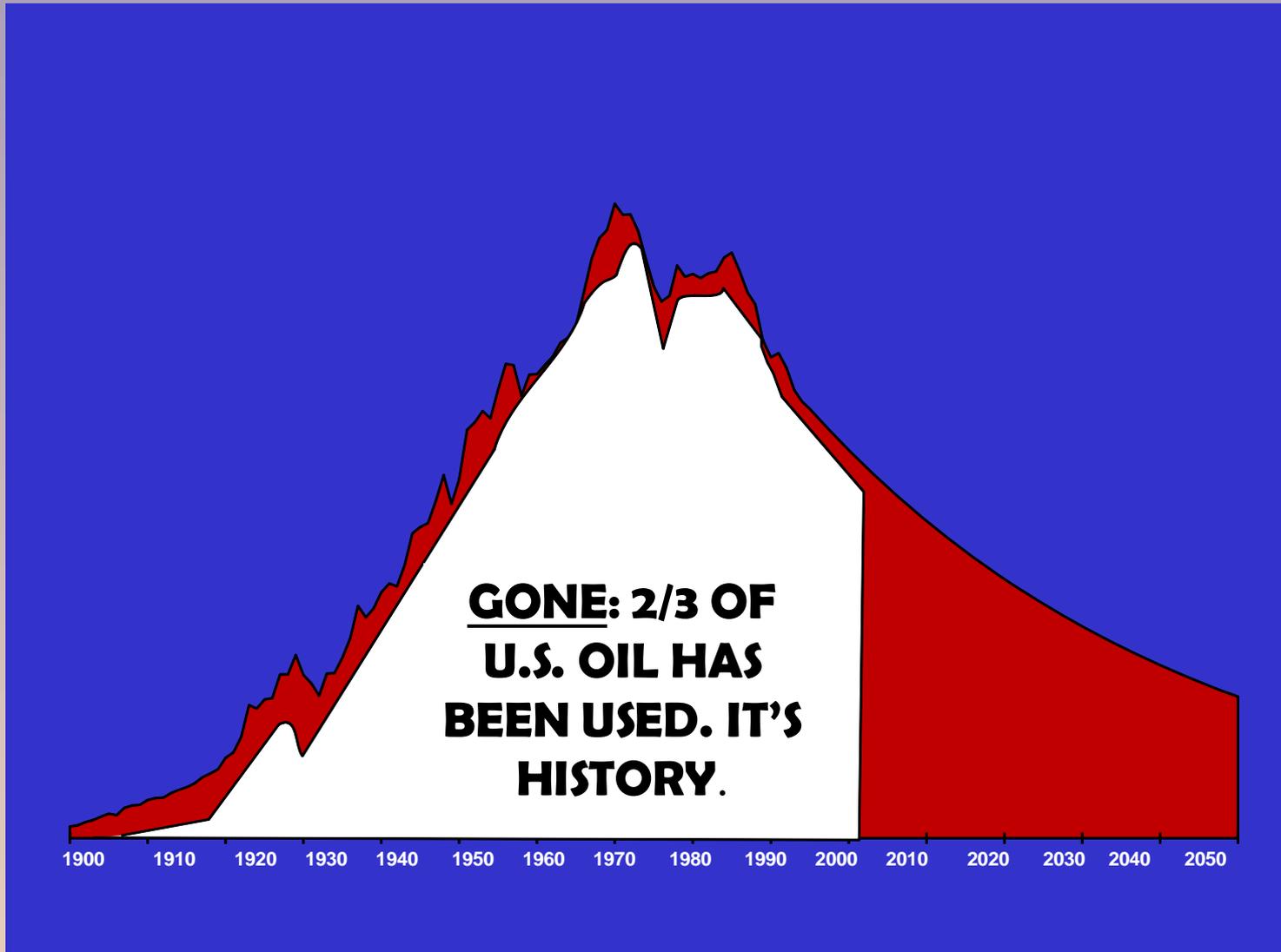
Source: EIA



U.S. OIL PRODUCTION - 1900 to 2050



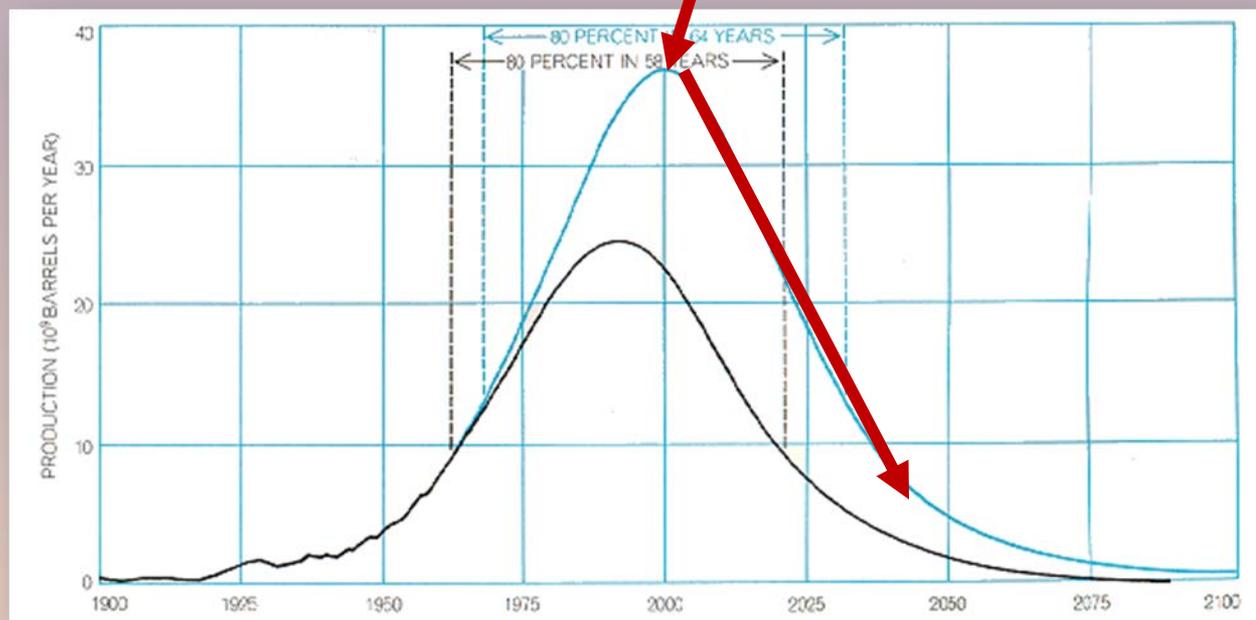
U.S. OIL PRODUCTION - 1900 to 2050



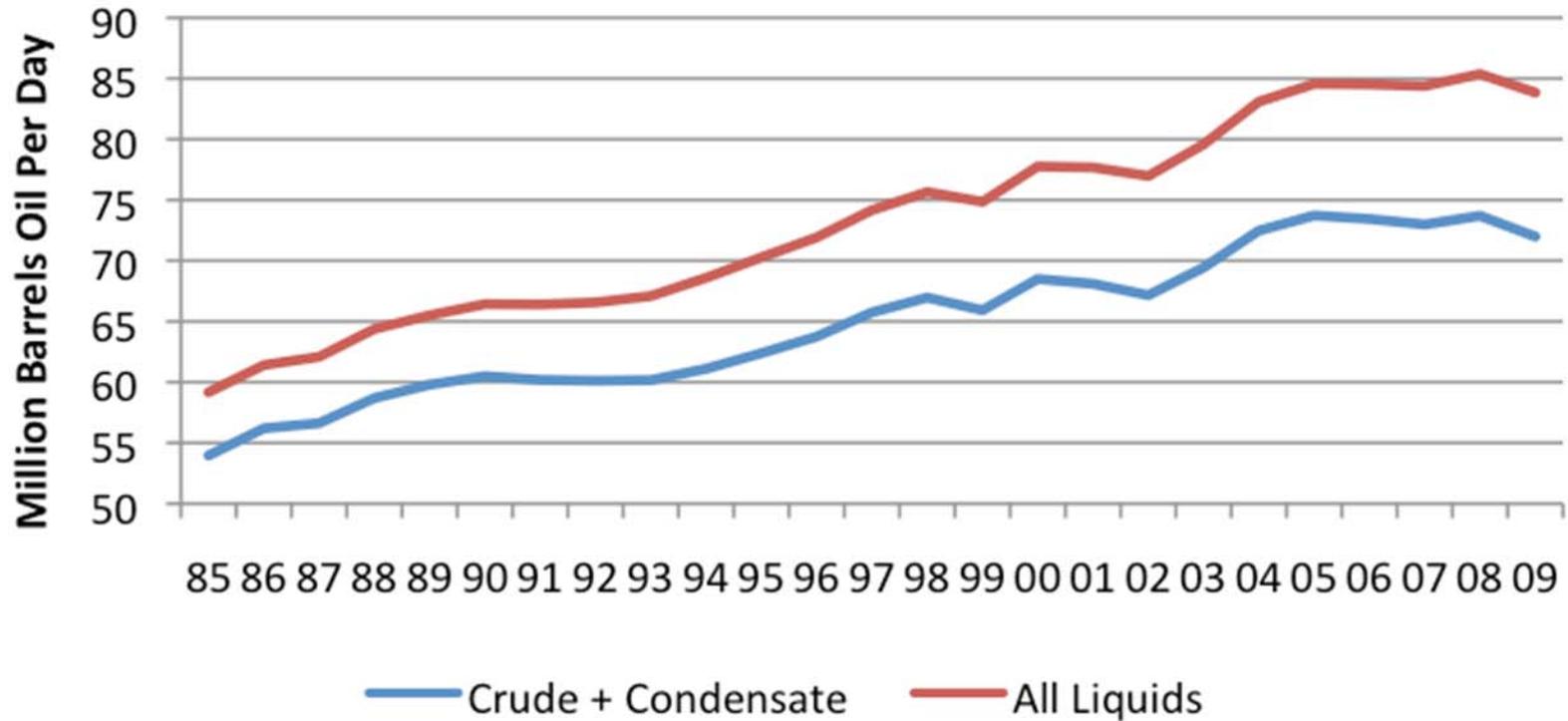
How do you communicate what “2/3 of something gone” means?



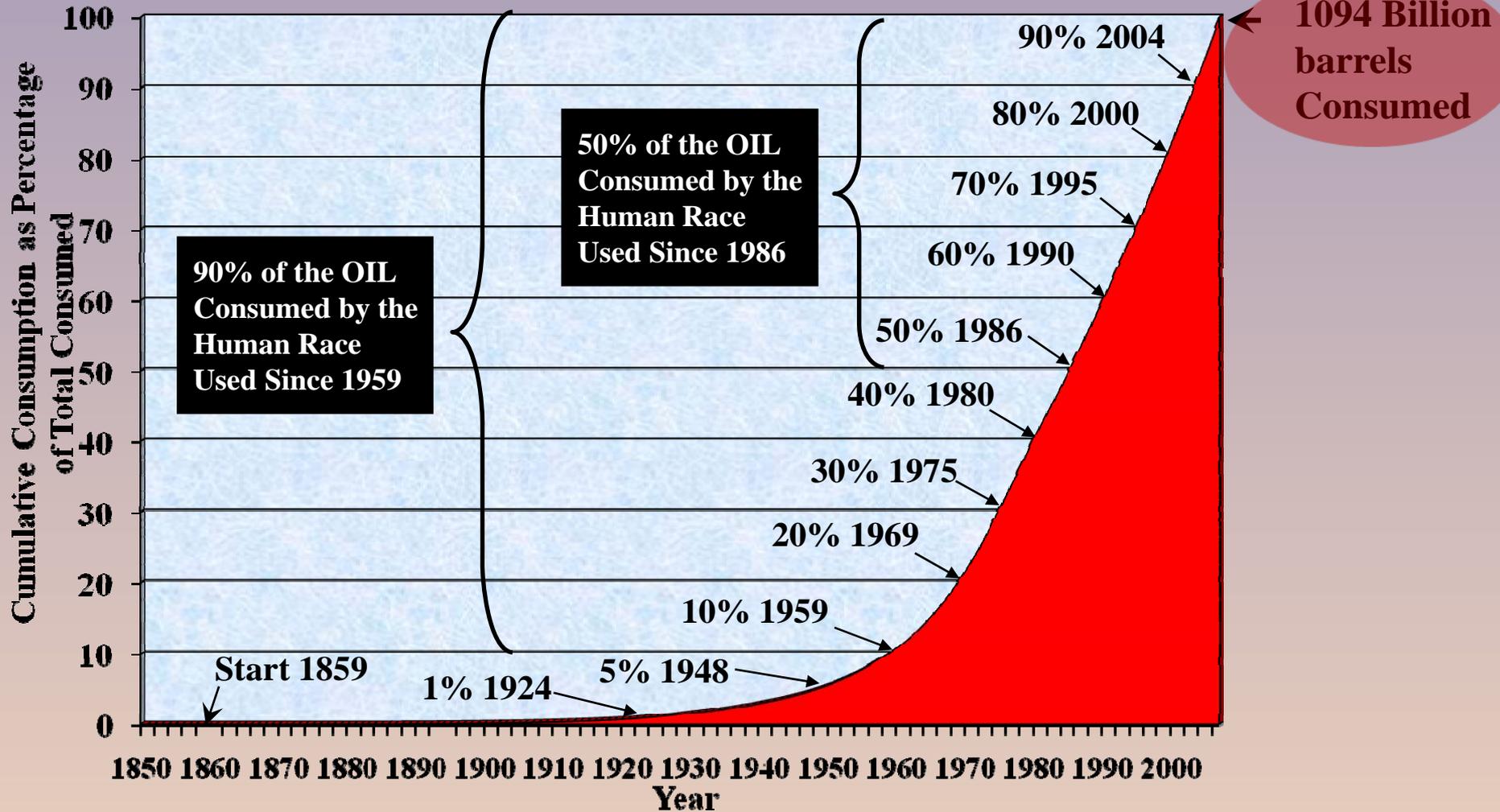
In 1969, M. King Hubbert Predicted that World Production would Begin Declining in 2000.



World oil production has been on a plateau since 2005



Cumulative *OIL* Consumption by the Human Race as a Percentage of Total Consumption through Yearend 2007



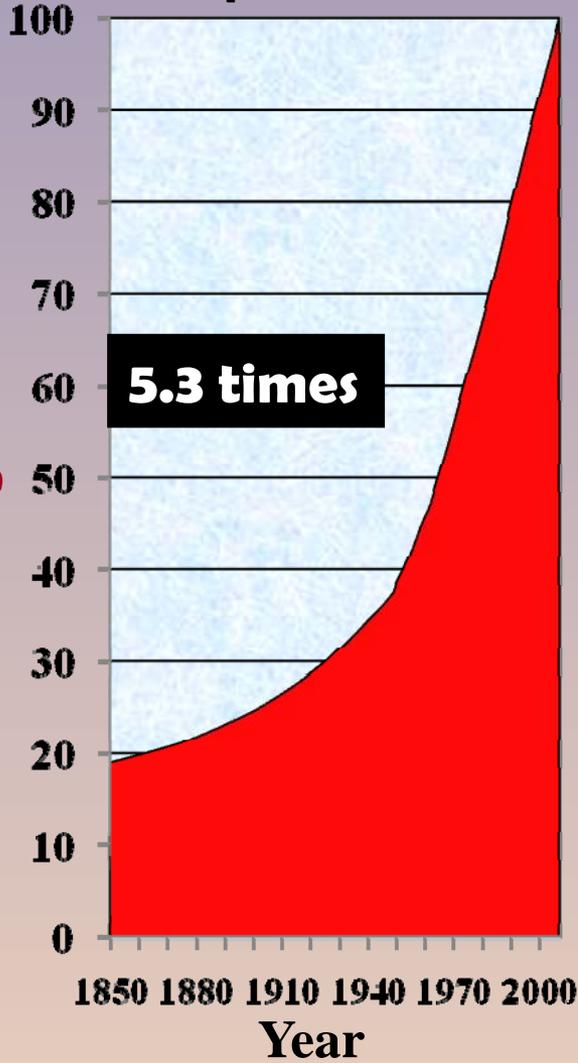
(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2008)

Copyright J. D. Hughes GSR Inc, 2008

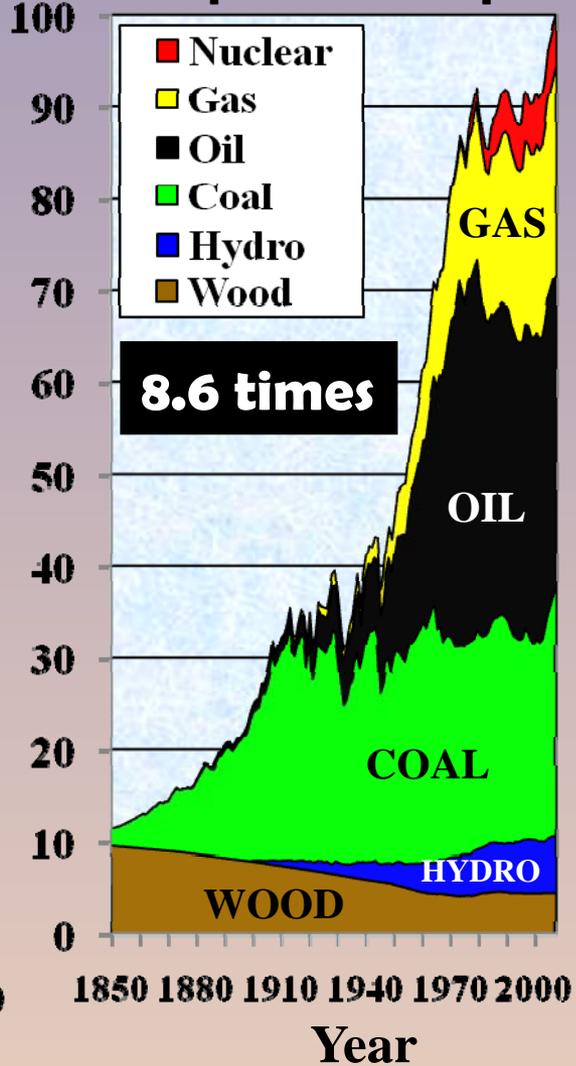
COLORADO GEOLOGICAL SURVEY



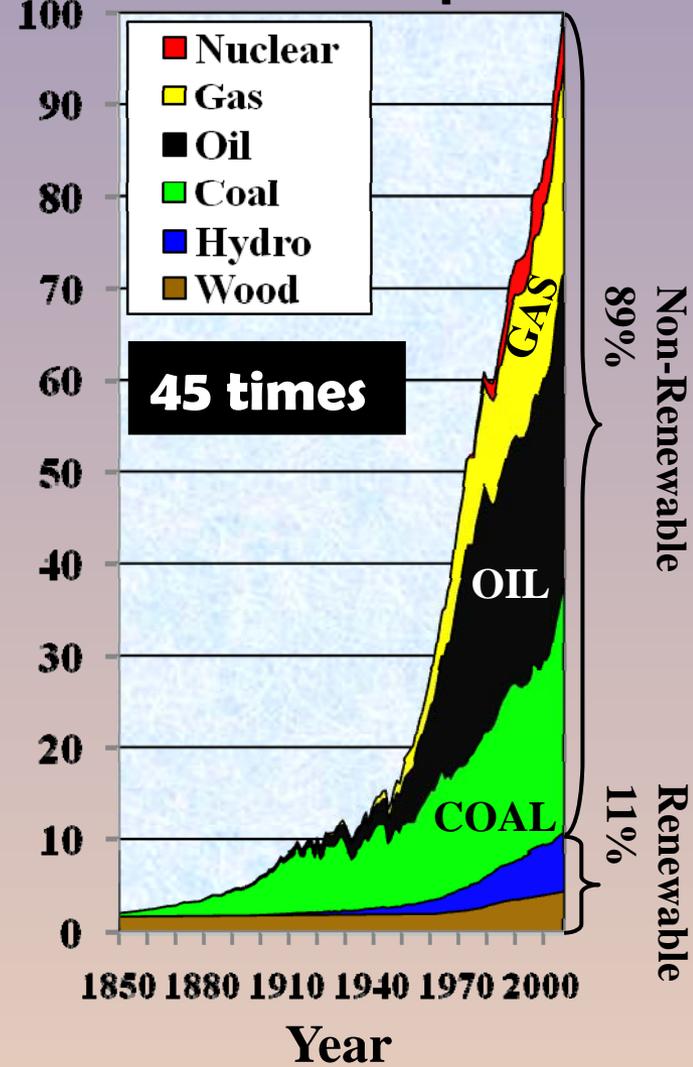
Population



Per Capita Consumption



Total Consumption



(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2008; U.S. Bureau of Census, 2008)

Copyright J. D. Hughes GSR Inc, 2008



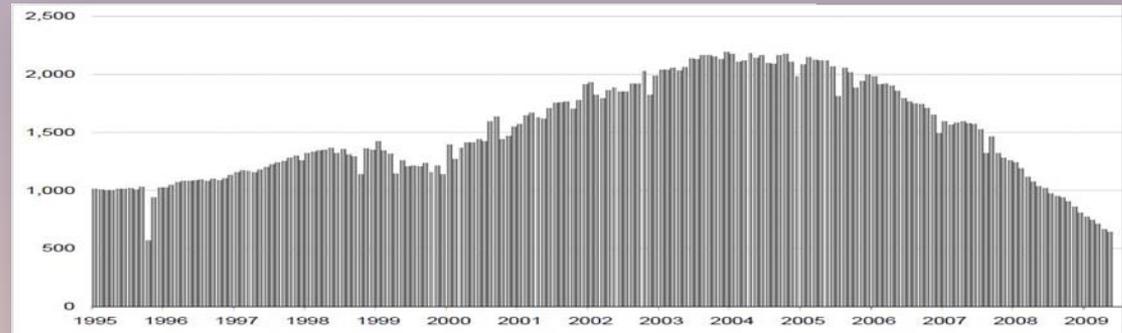
**85% of the world's oil comes from just 20
of the 65 producing countries**

54 of the 65 producing countries are in decline

**Mexico's declining
production
at Cantarell field
accelerating**

**2005 producing 2.2 million
barrels per day**

**2009 producing 0.6 million
barrels per day**



**Mexican state oil company
Pemex said Wednesday
that production at its
Cantarell oil field, the
world's second-largest, will
drop faster than expected.**

08/03/06

2007-- IEA says existing fields have 3.7% decline

2008-- IEA says existing fields have 6.7% decline

At 5% decline rate

In only five years

The world will need

19 million barrels!

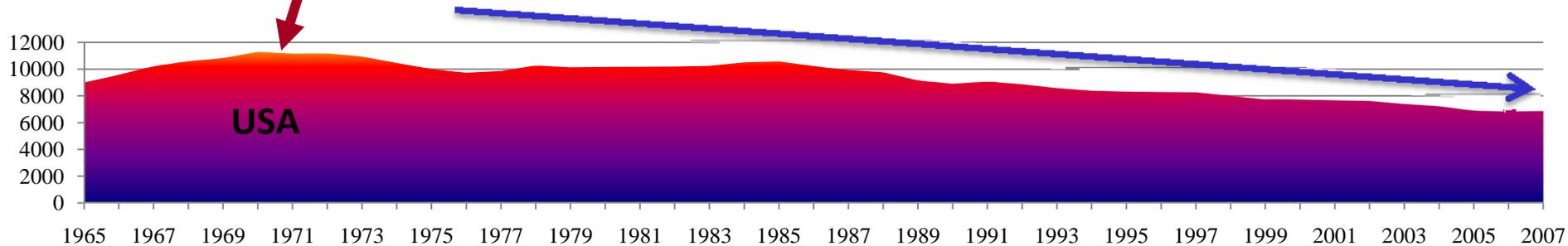
Declines never sleep!

1 of 65 producing countries

USA

Peak 1970

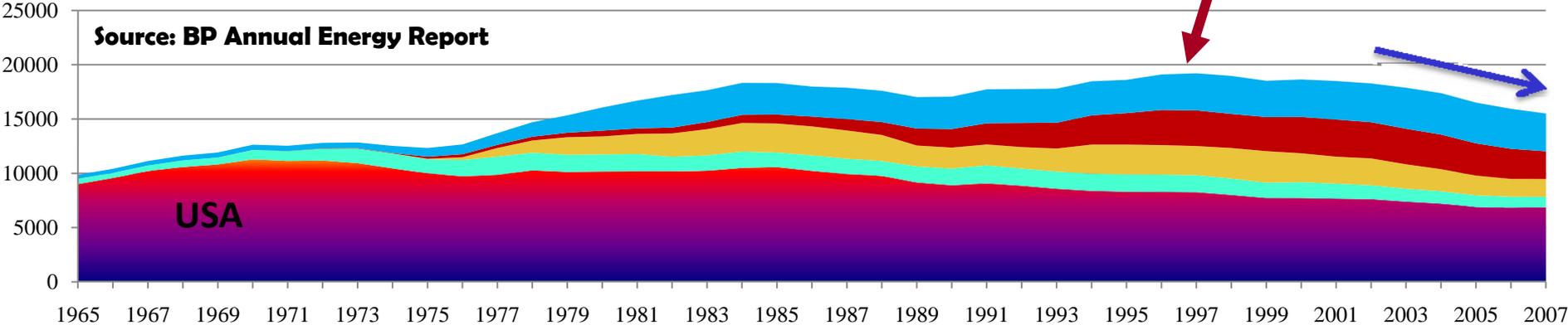
Source: BP Annual Energy Report



5 of 65 producing countries

Mexico
Norway
UK
Indonesia

Peak 1997



50 of 65 producing countries

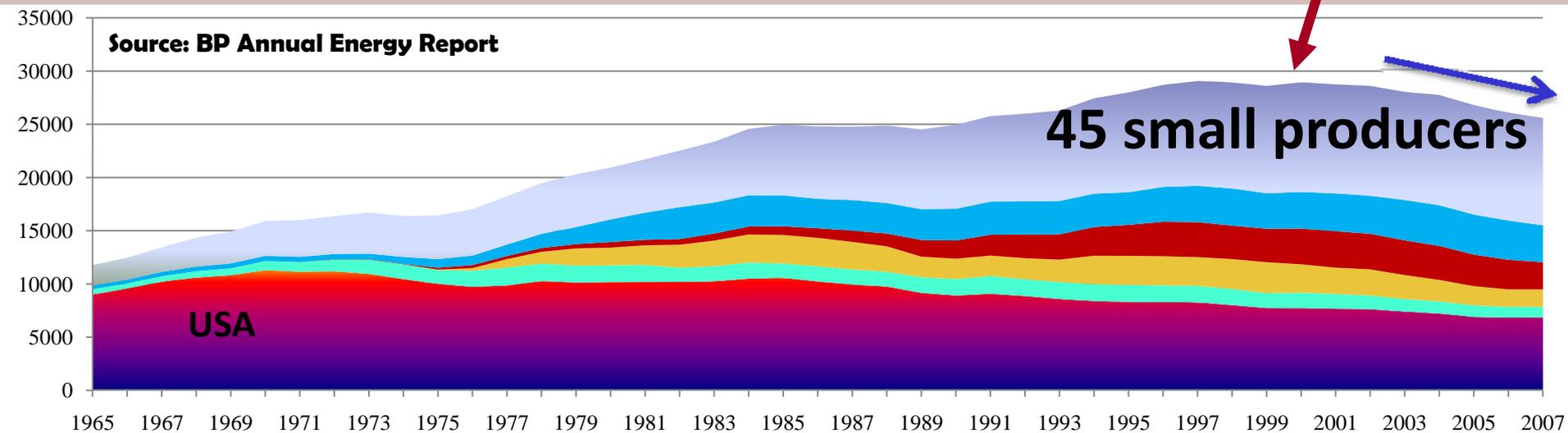
Peak ~2000



45 small producers

Source: BP Annual Energy Report

USA



61 of 65 producing countries

Brazil Kuwait Iraq
Algeria UAE Venezuela
Canada Nigeria Iran
China Libya

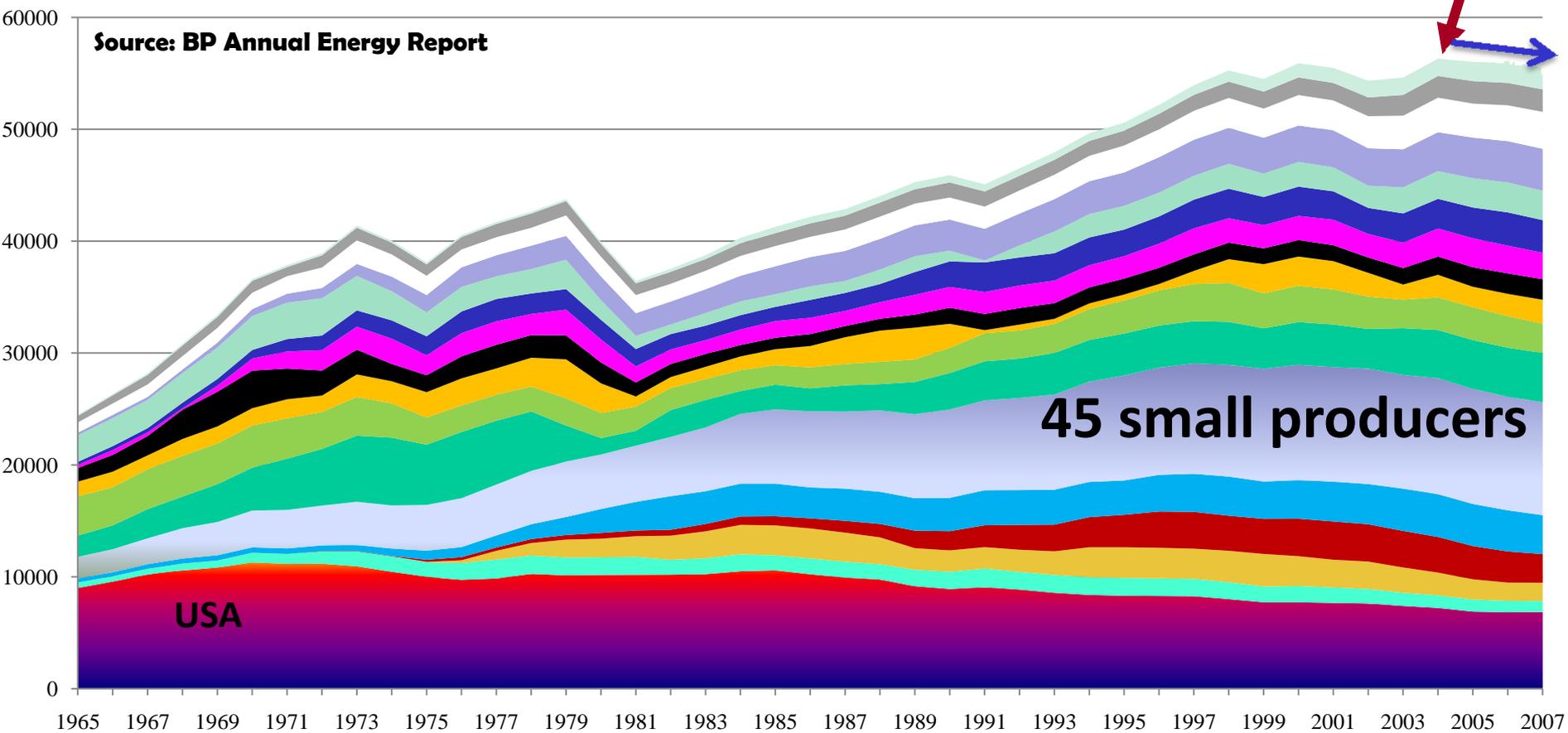
Peak 2004



Source: BP Annual Energy Report

45 small producers

USA



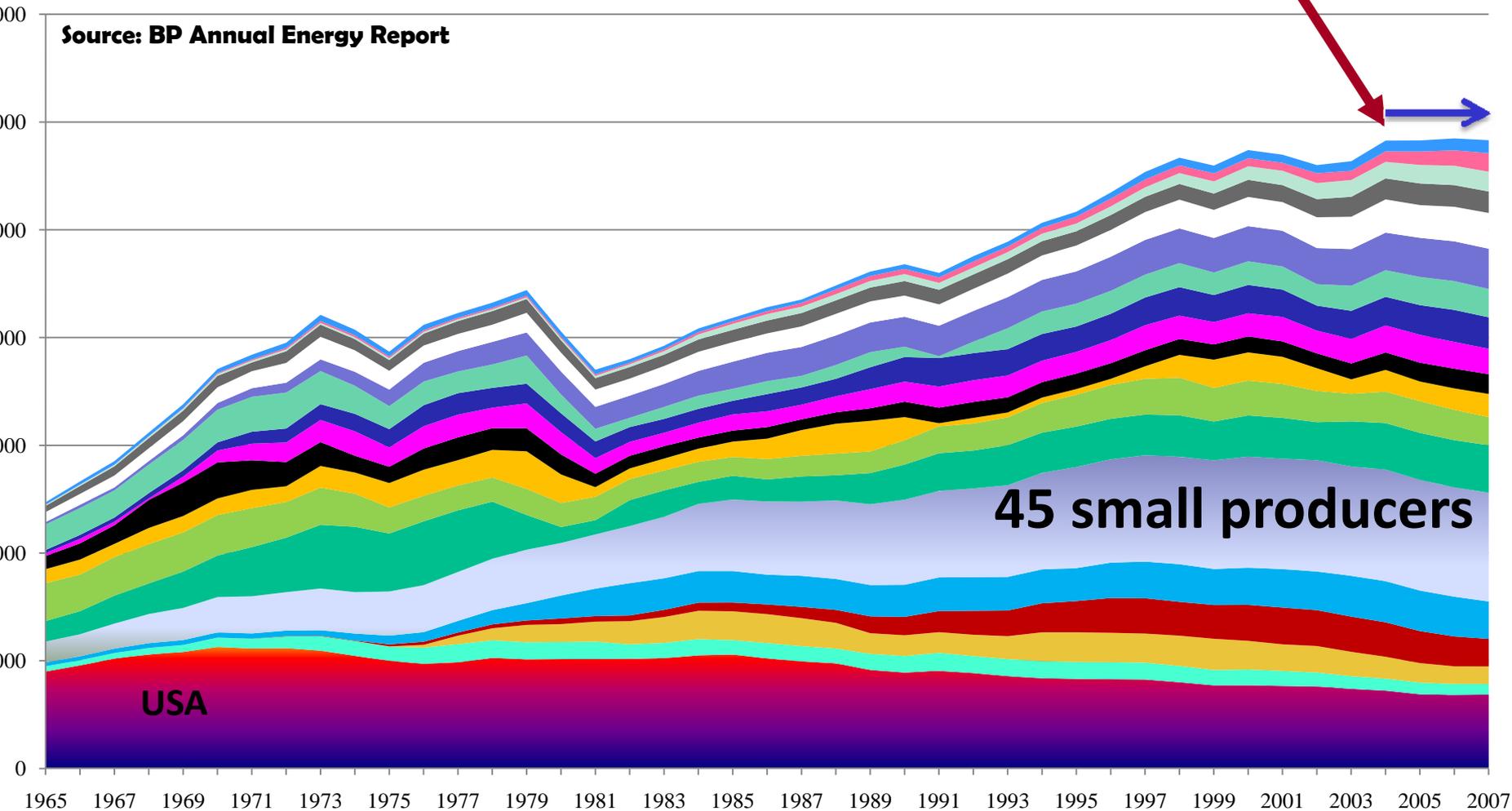
63 of 65 producing countries

Qatar

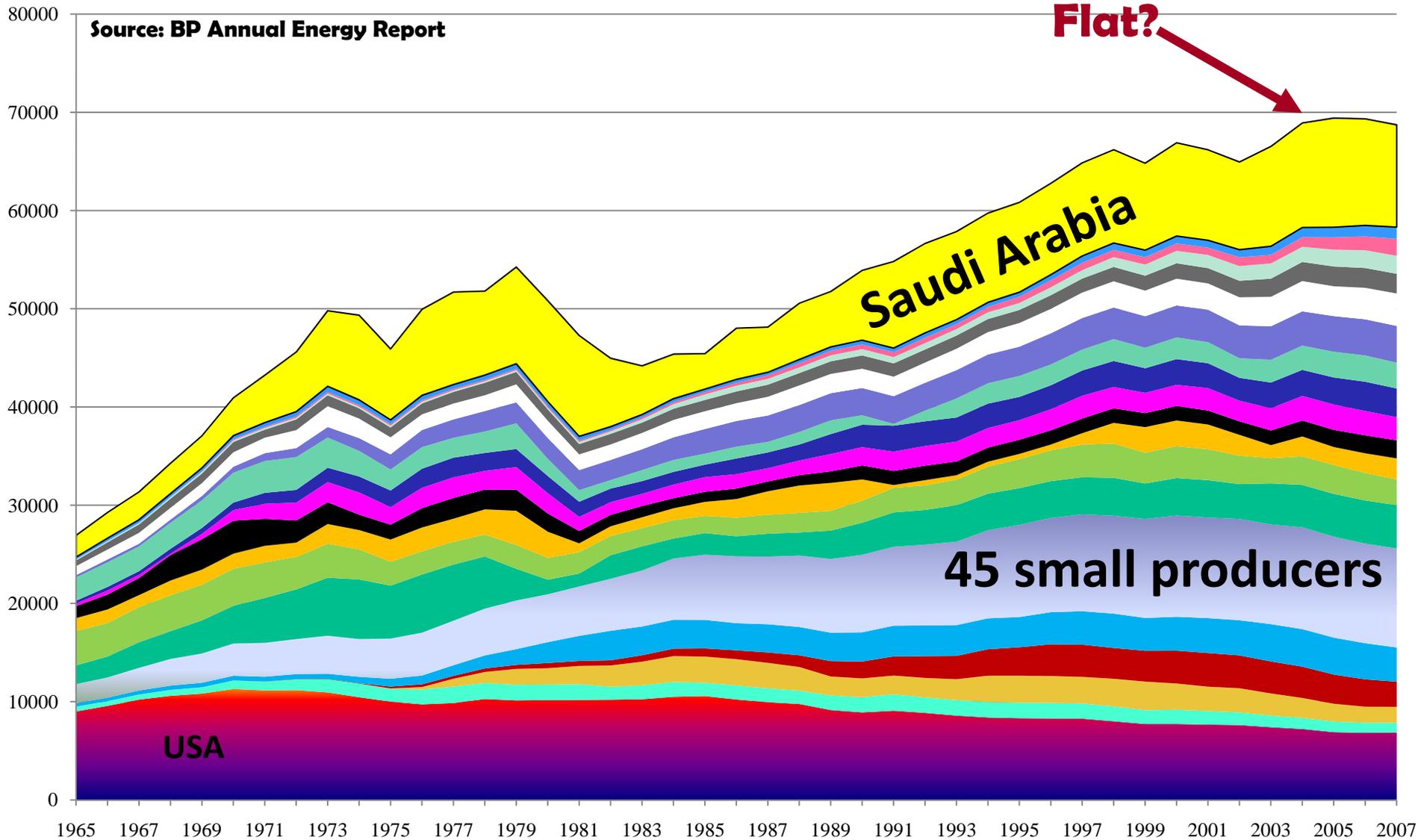
Angola

Flat 2004

Source: BP Annual Energy Report



64 of 65 producing countries



65 of 65 producing countries

Source: BP Annual Energy Report

Slight Increase

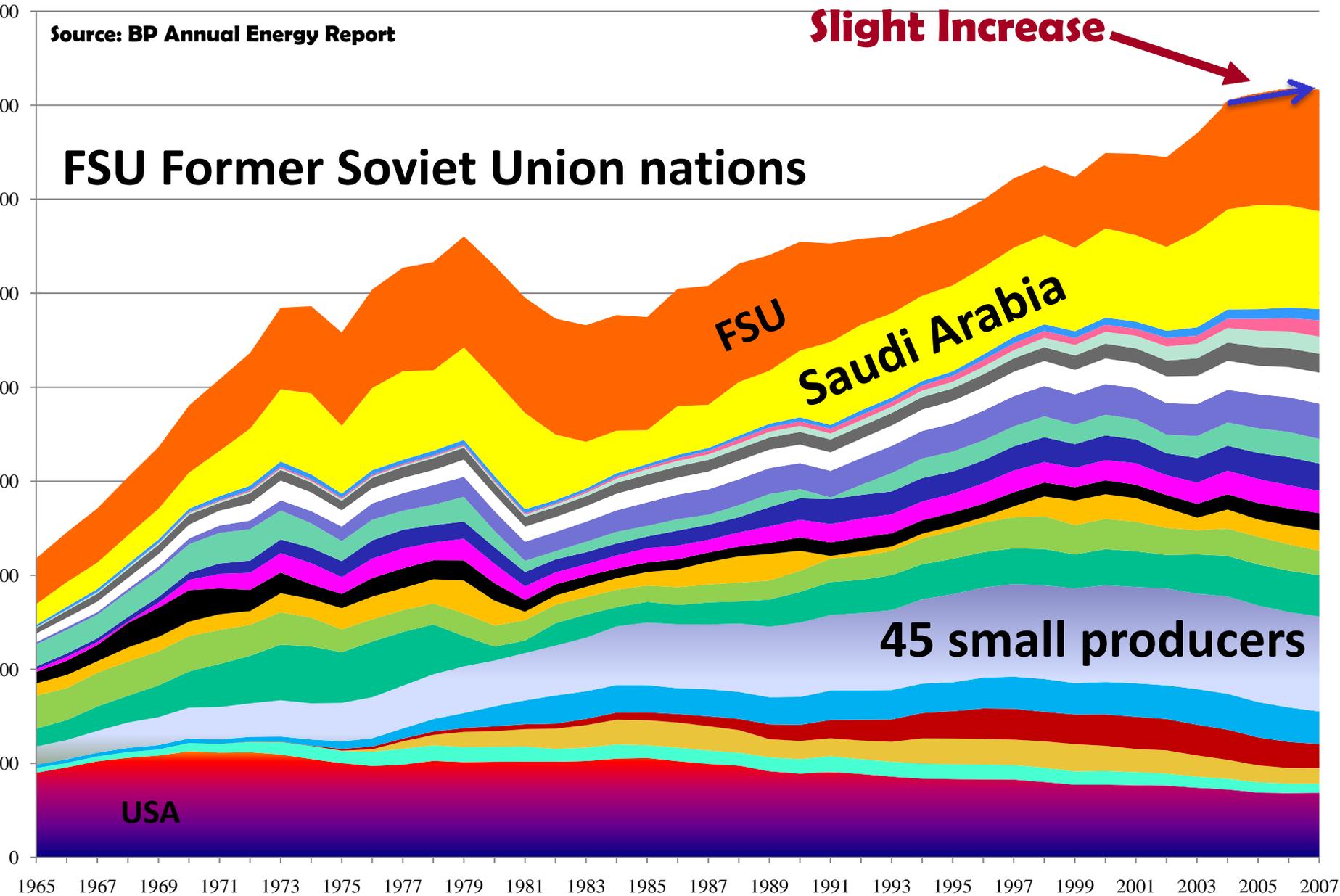
FSU Former Soviet Union nations

FSU

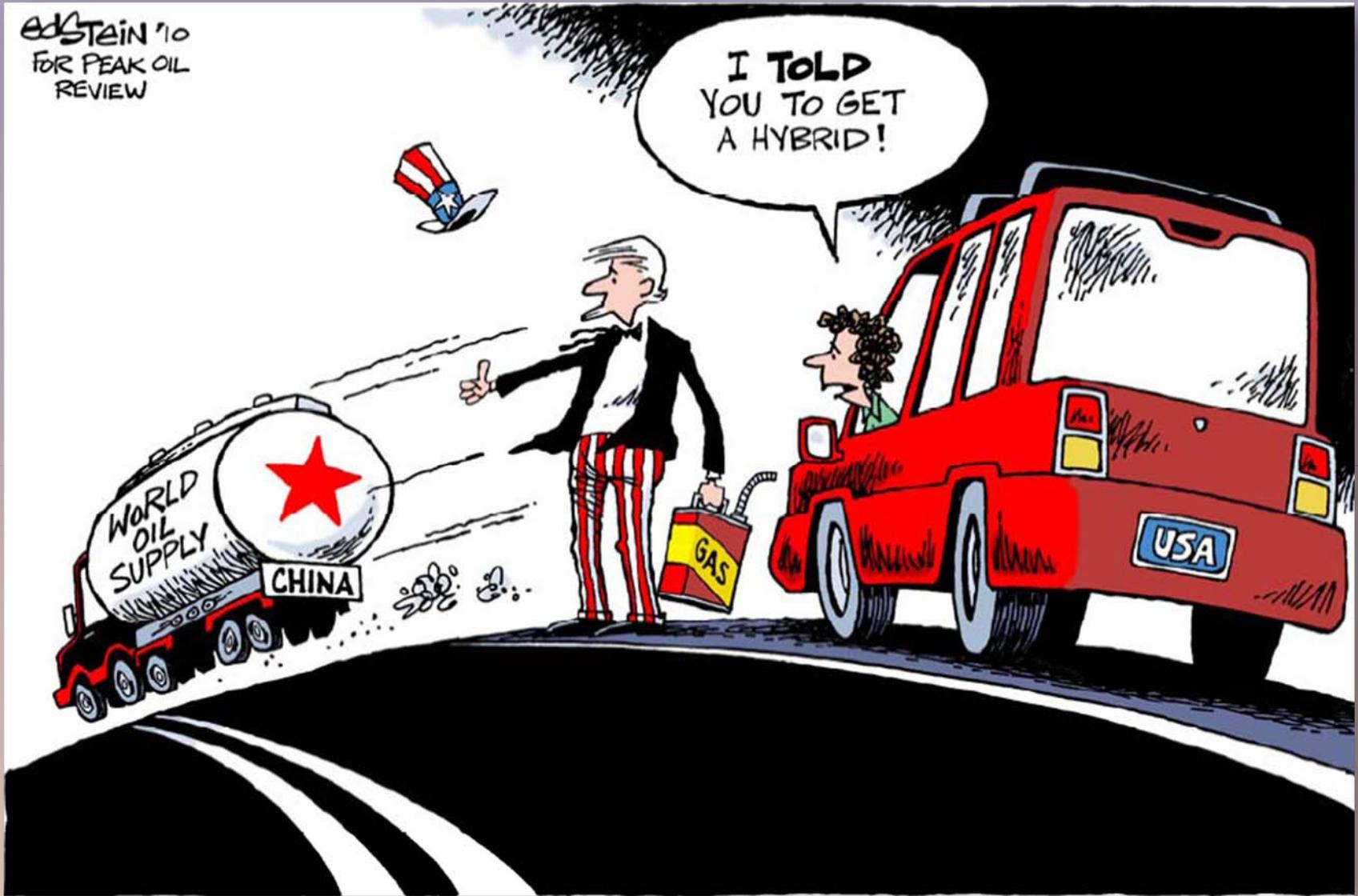
Saudi Arabia

45 small producers

USA



edSTEIN '10
FOR PEAK OIL
REVIEW



COLORADO GEOLOGICAL SURVEY



Crude Oil Prices

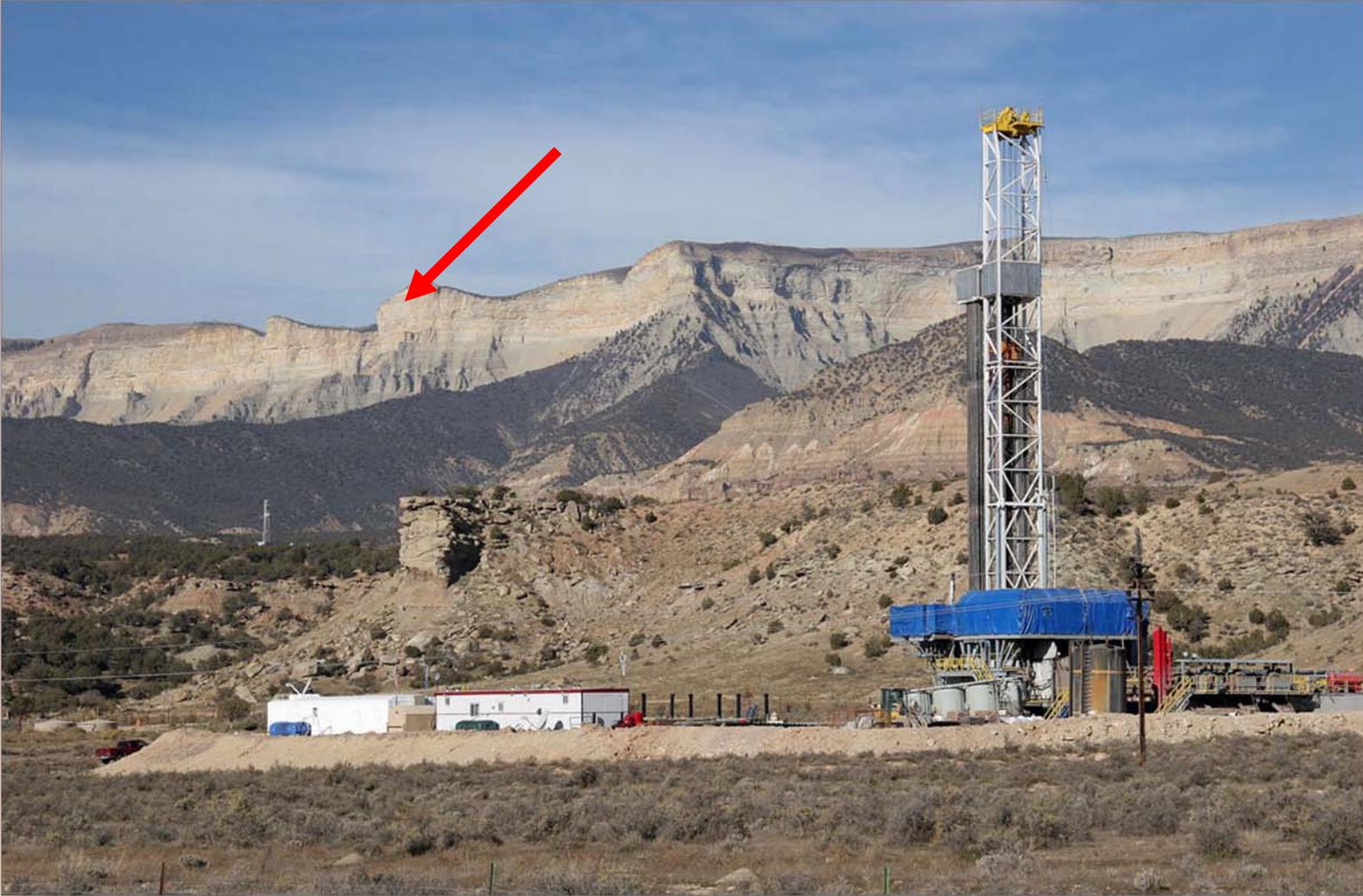
Monthly Cushing, OK WTI Spot Price FOB



Source: U.S. Energy Information Administration



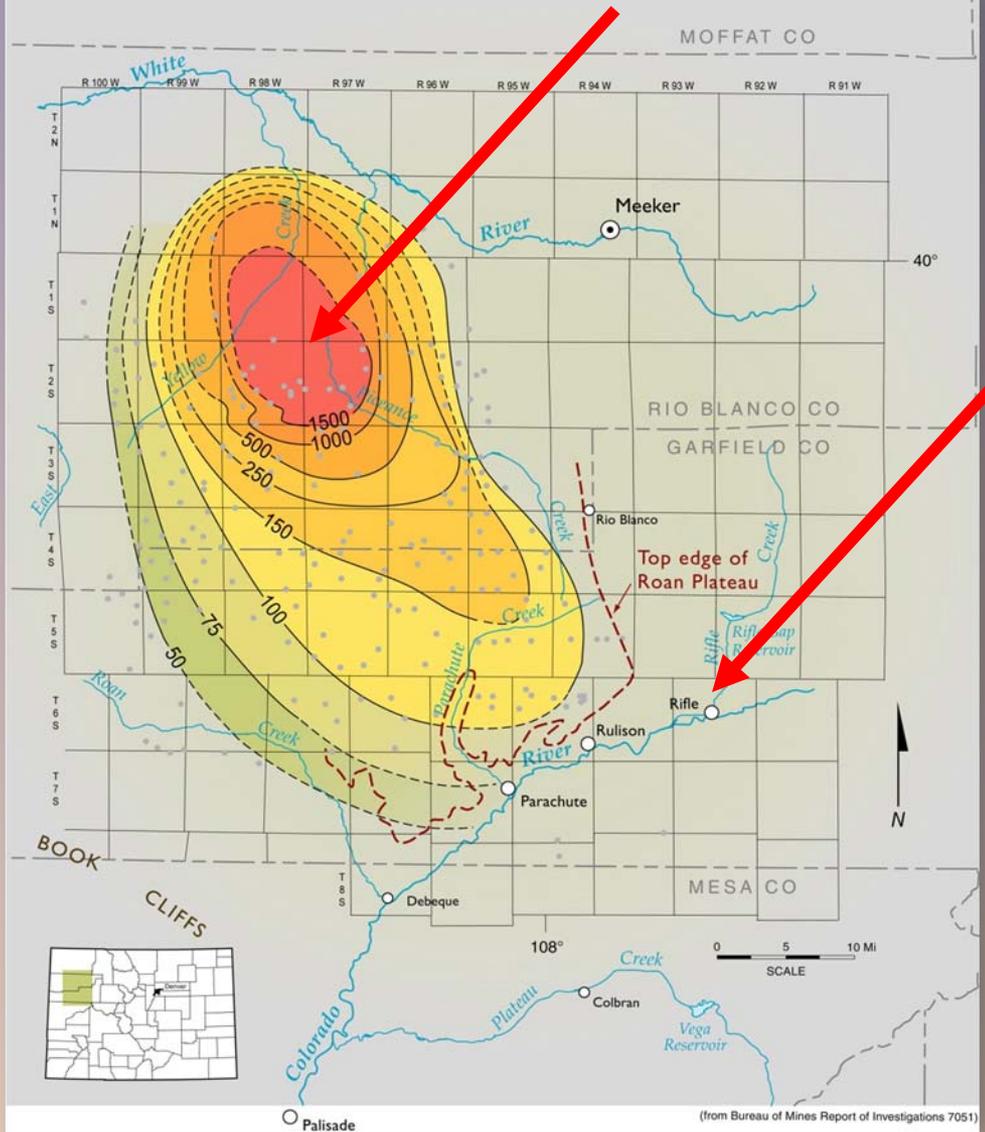
Oil shale is being seriously re-appraised.



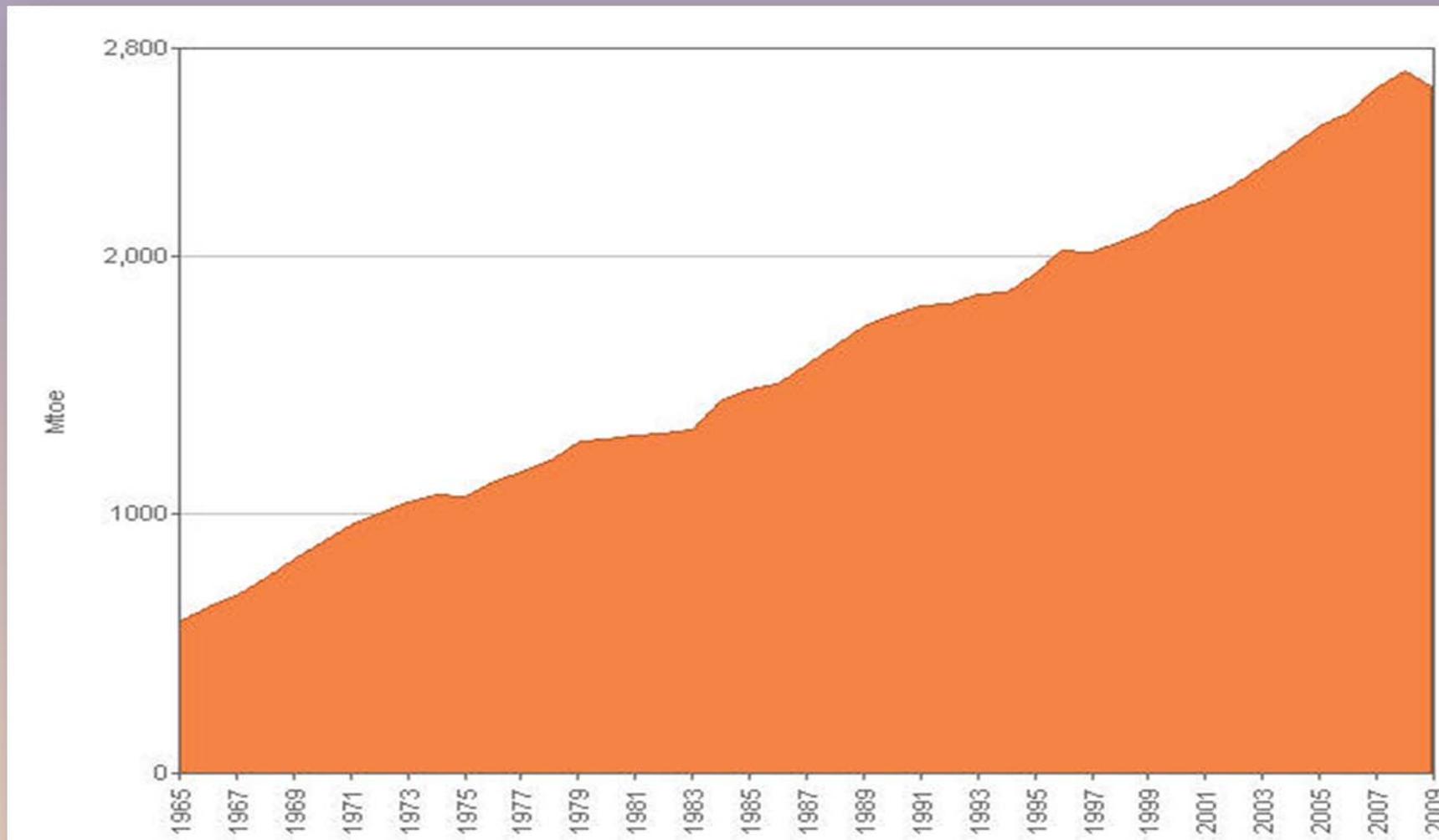
COLORADO GEOLOGICAL SURVEY



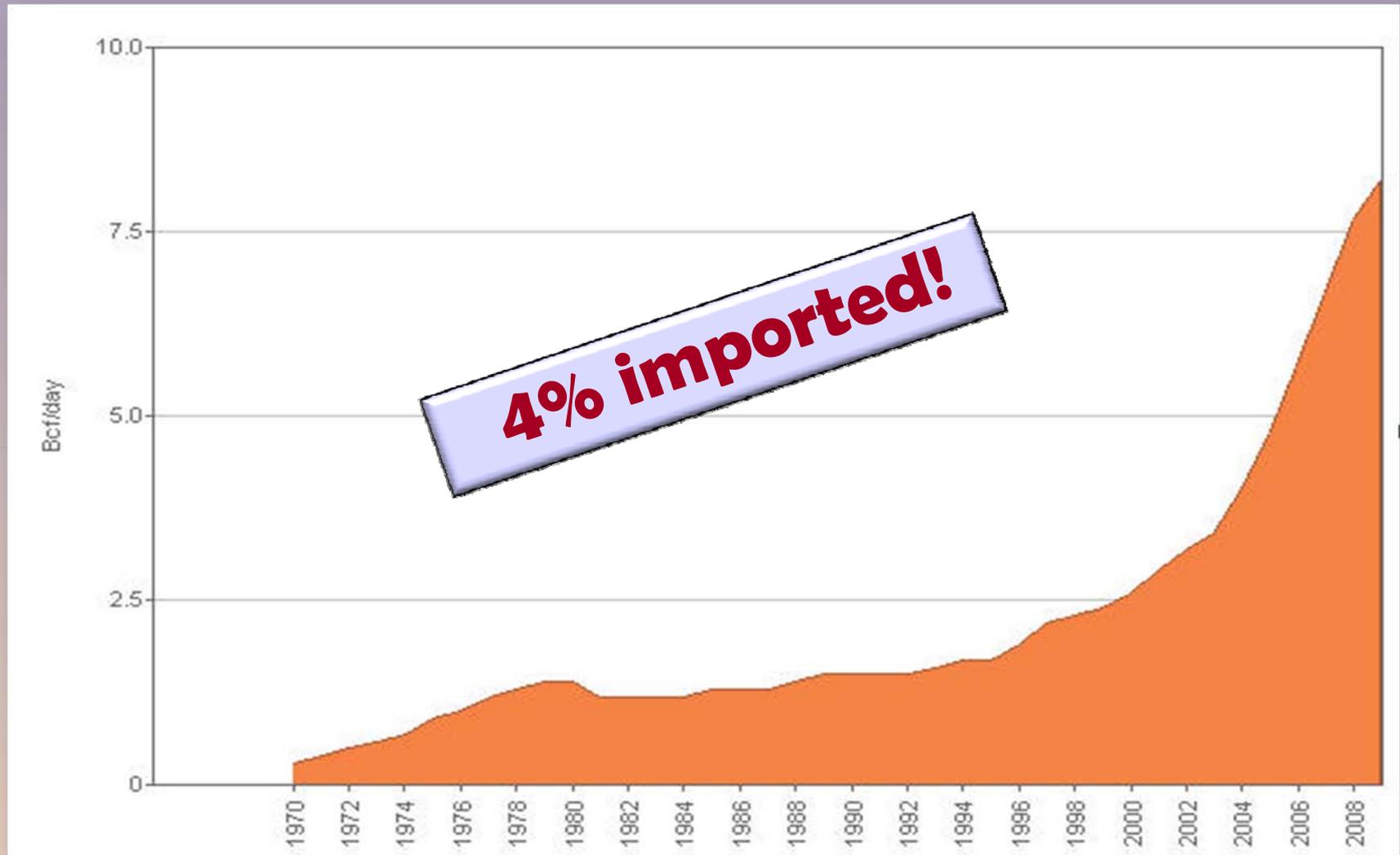
Thickness (in feet) of 25-Gallon-per-Ton Oil Shale, Piceance Basin, Colorado



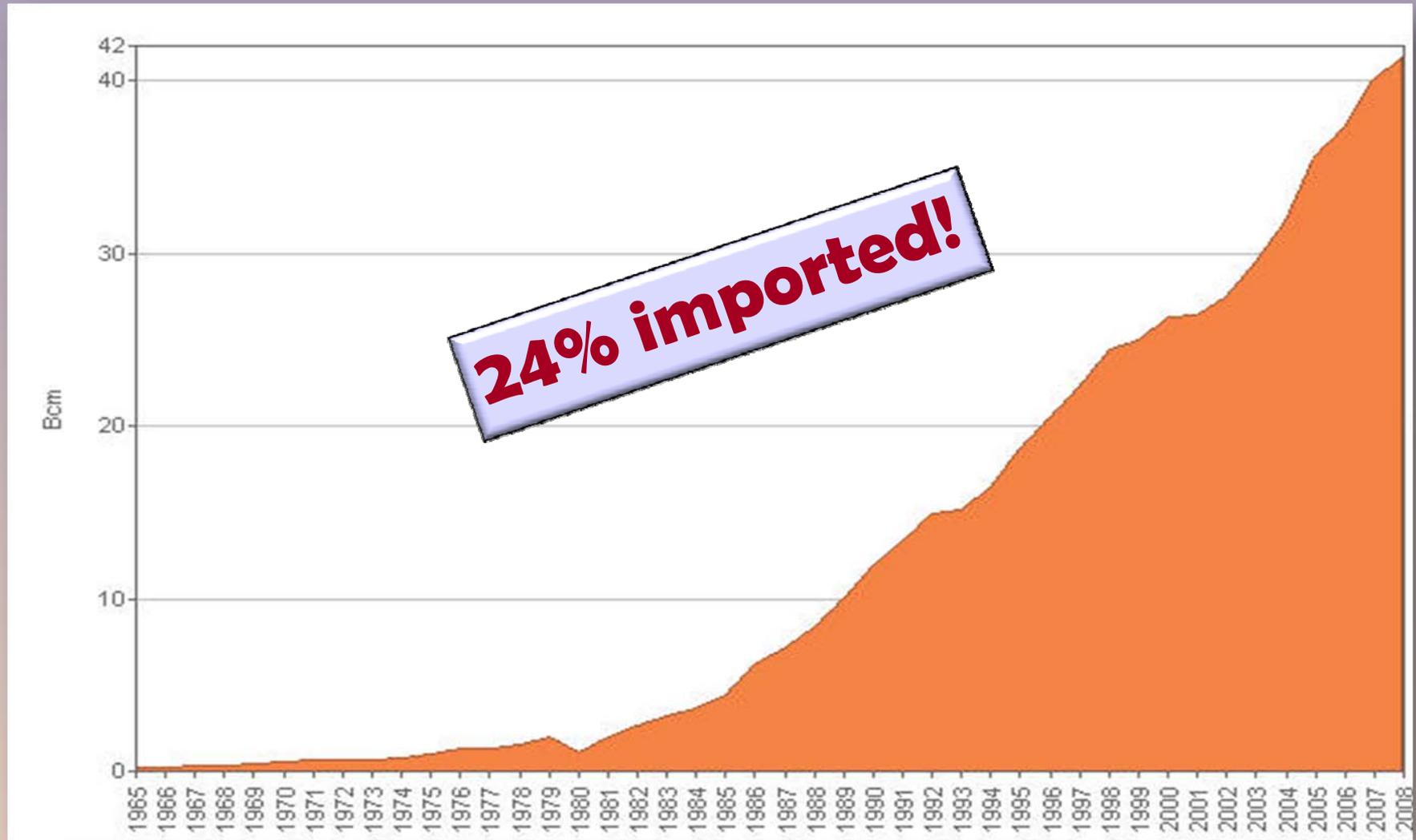
World Natural Gas Consumption



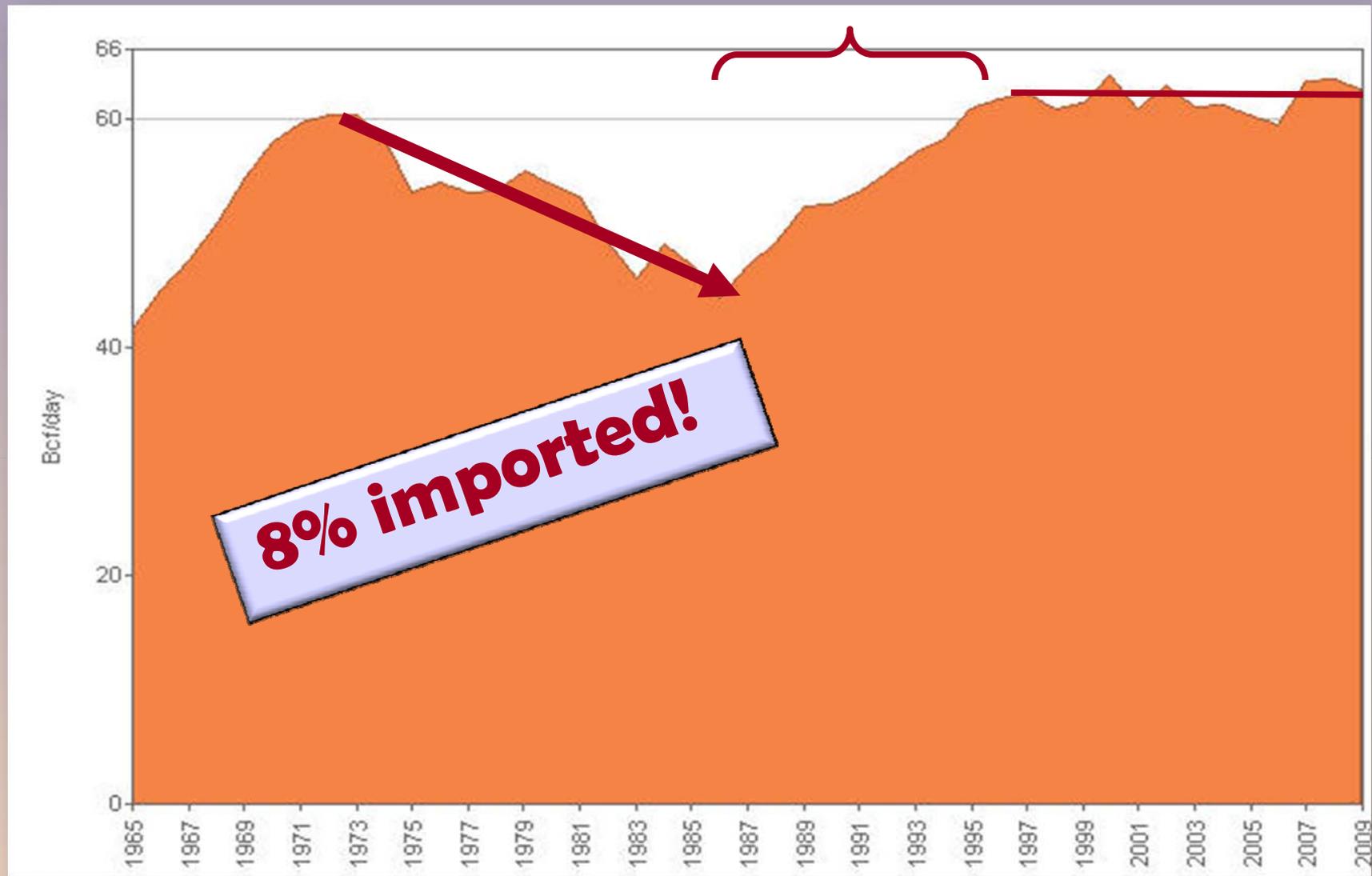
NATURAL GAS CONSUMPTION - China



NATURAL GAS CONSUMPTION - India



NATURAL GAS CONSUMPTION - U.S.



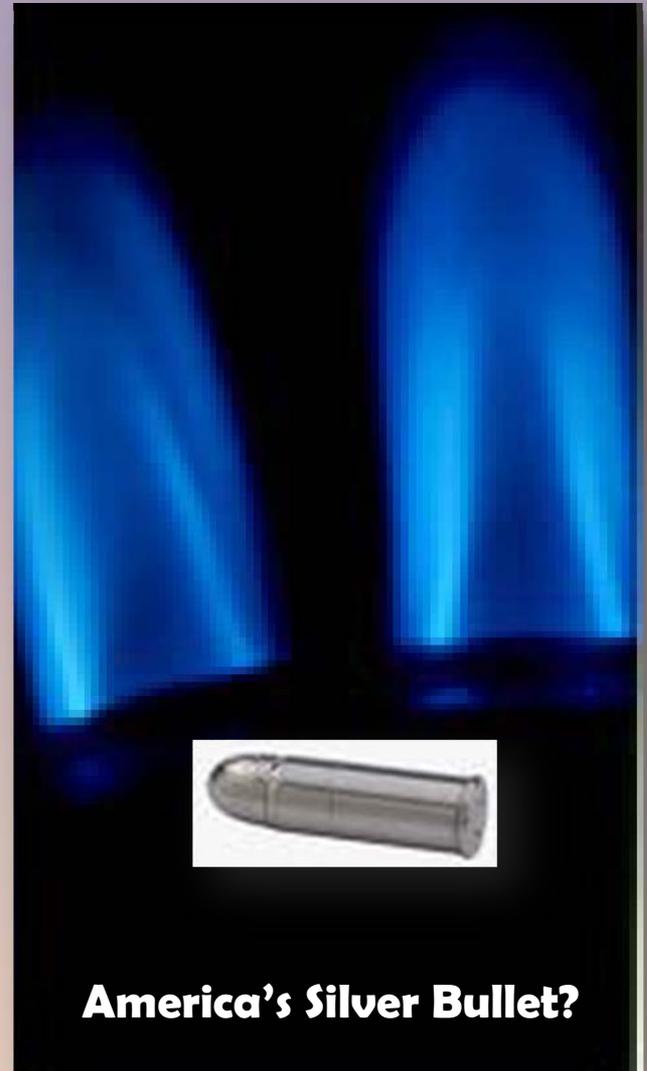
Natural Gas

Clean Burning!

Unlimited Supply!

Cheap!

Low Carbon Footprint!

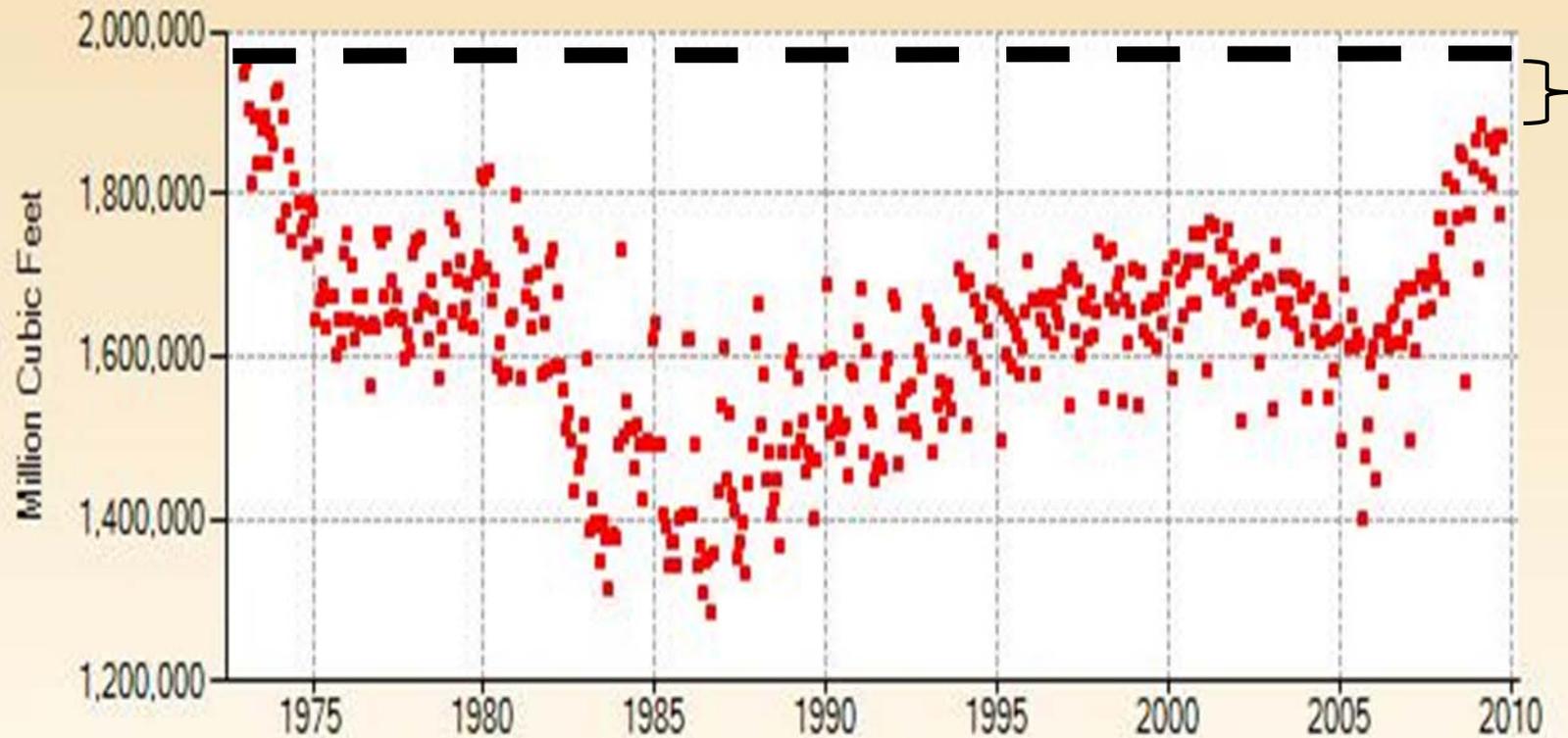


America's Silver Bullet?

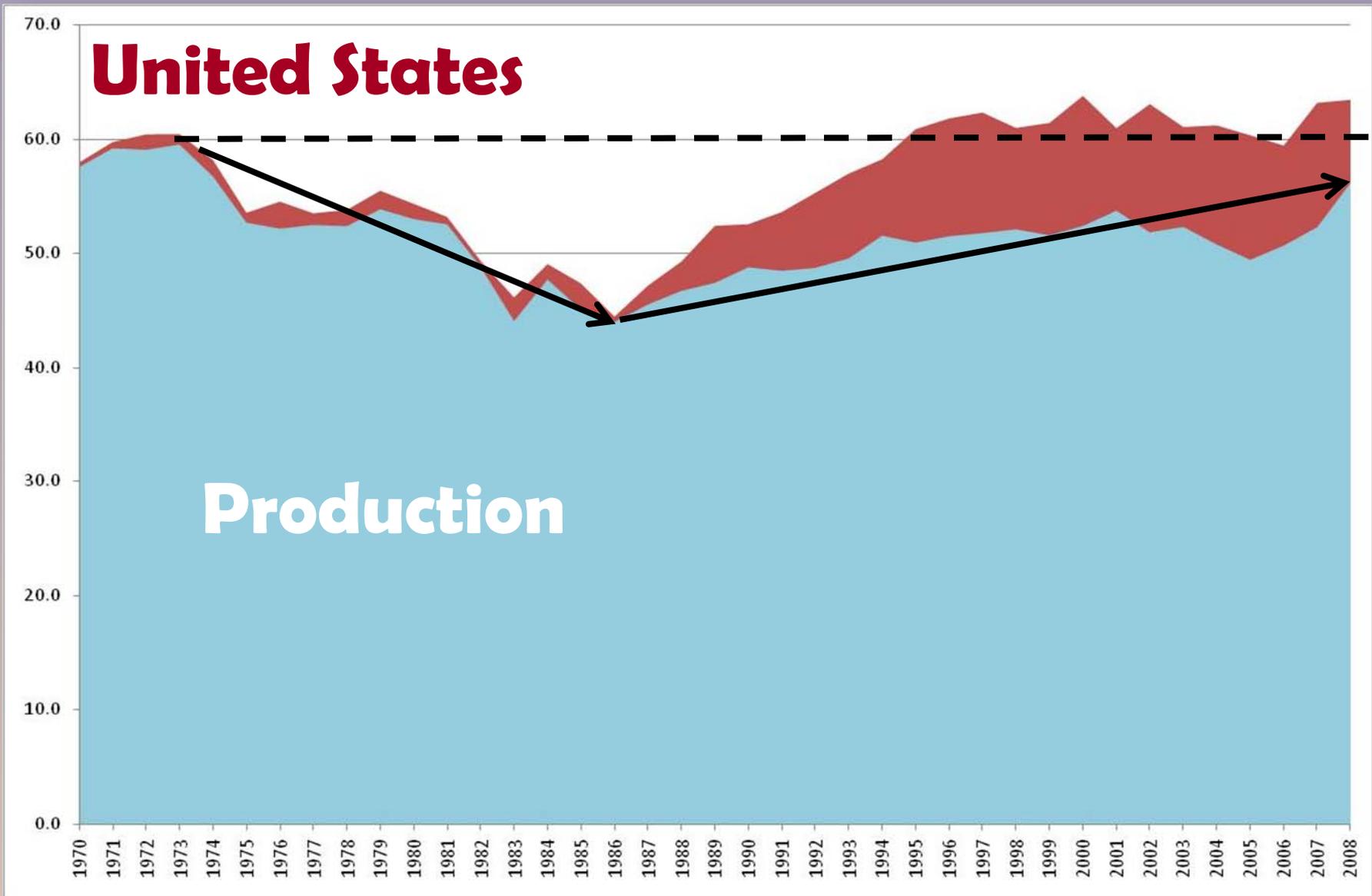
COLORADO GEOLOGICAL SURVEY



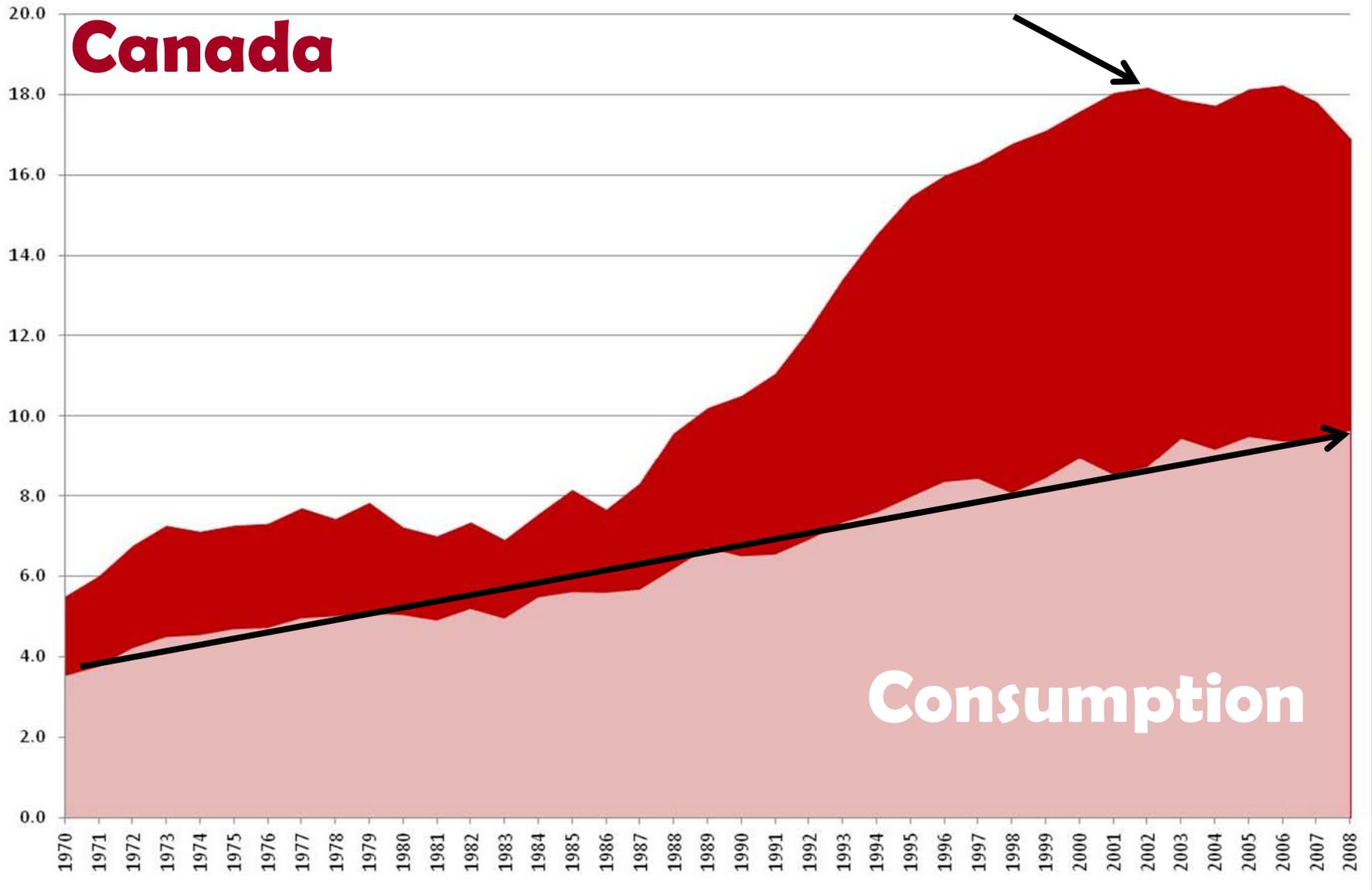
Monthly U.S. Natural Gas Marketed Production



Source: U.S. Energy Information Administration

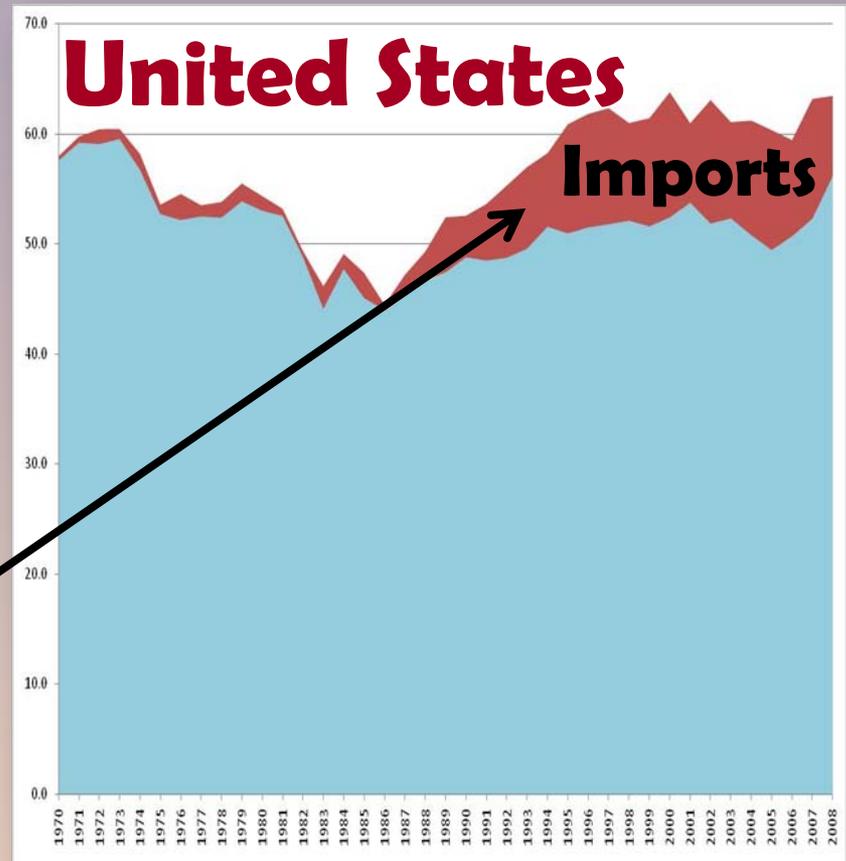
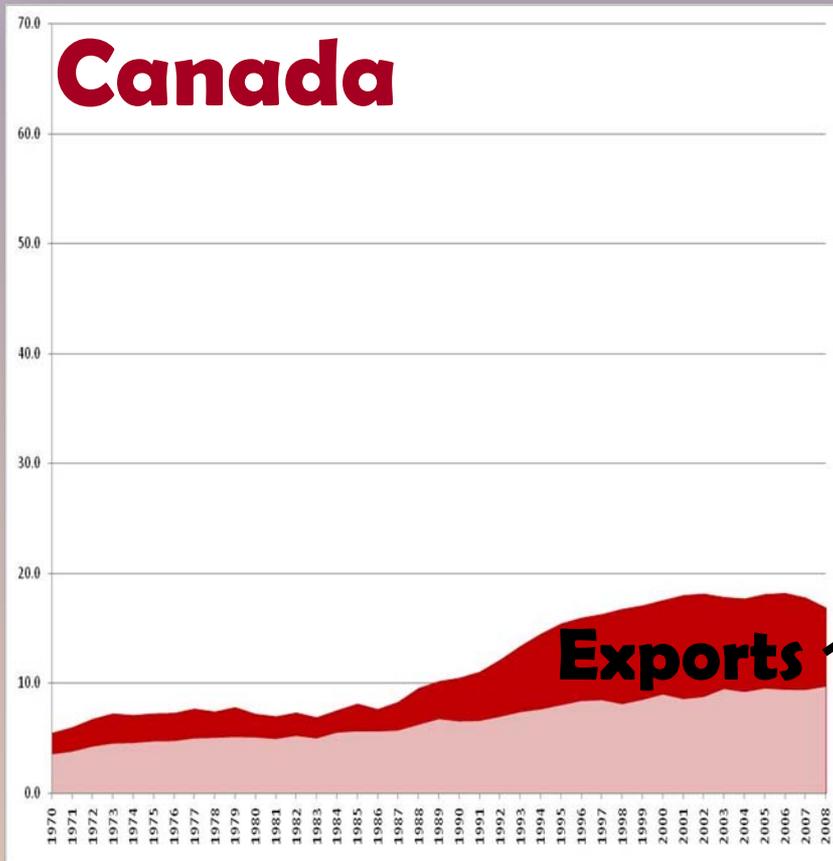


Canada

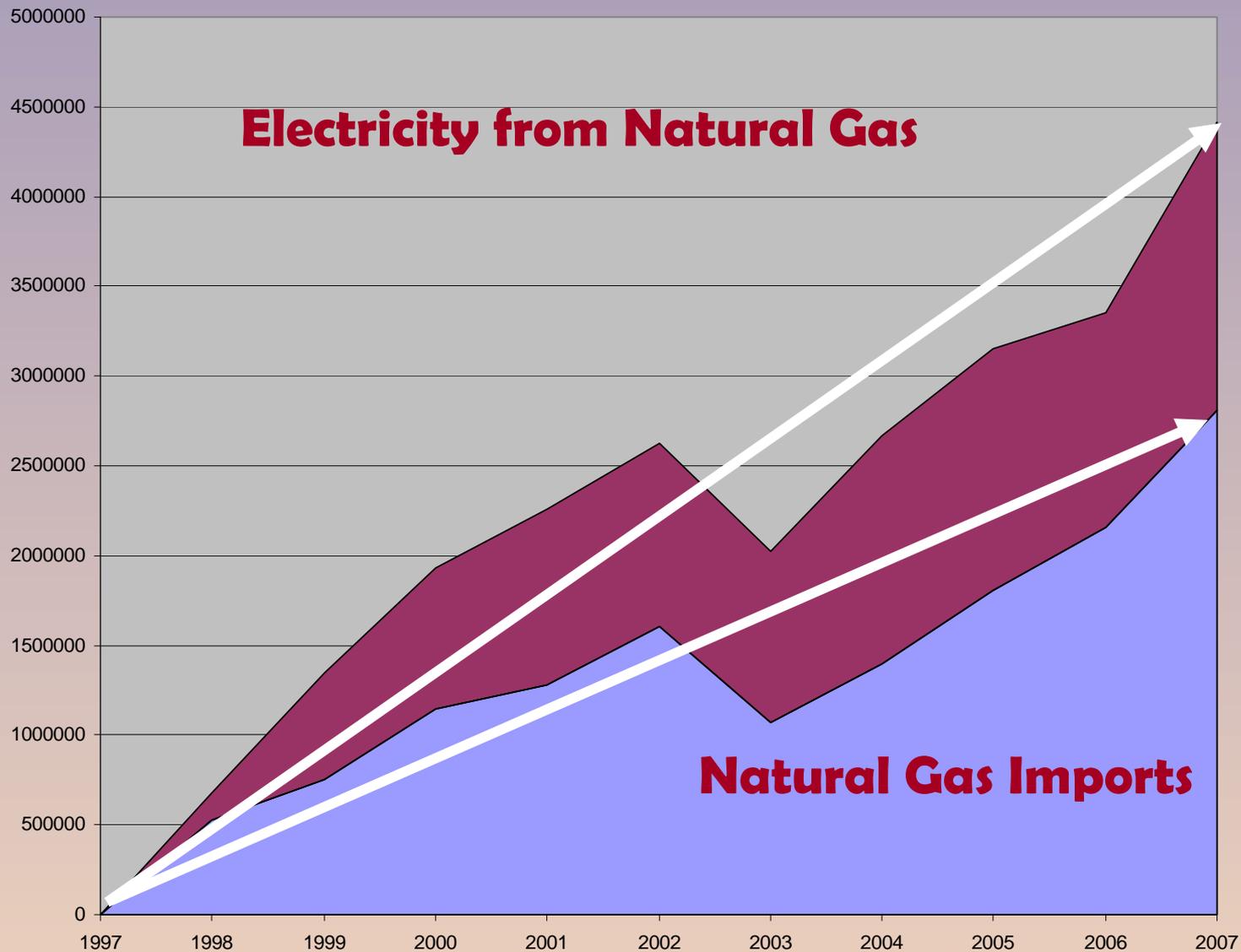


Consumption

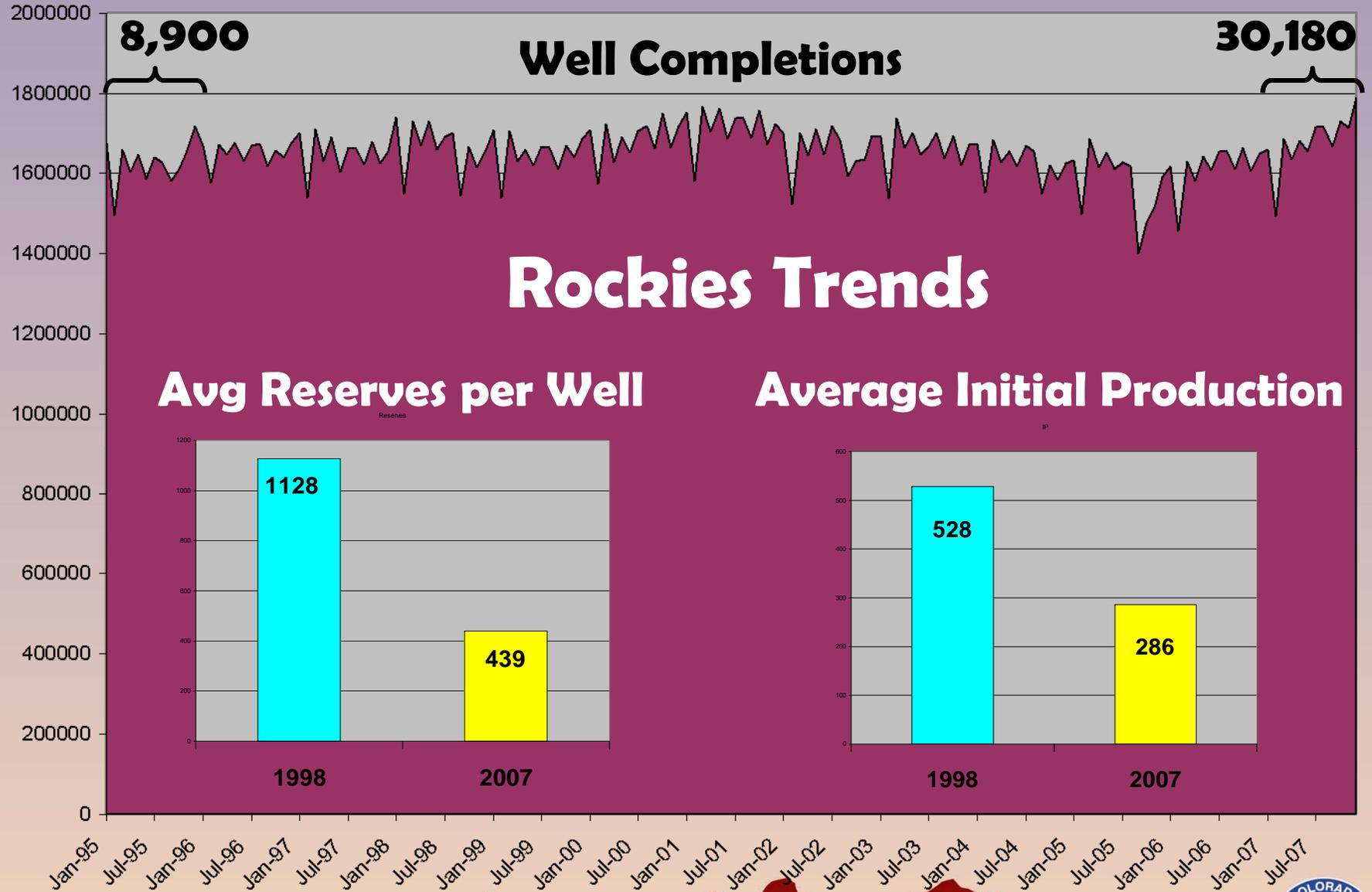




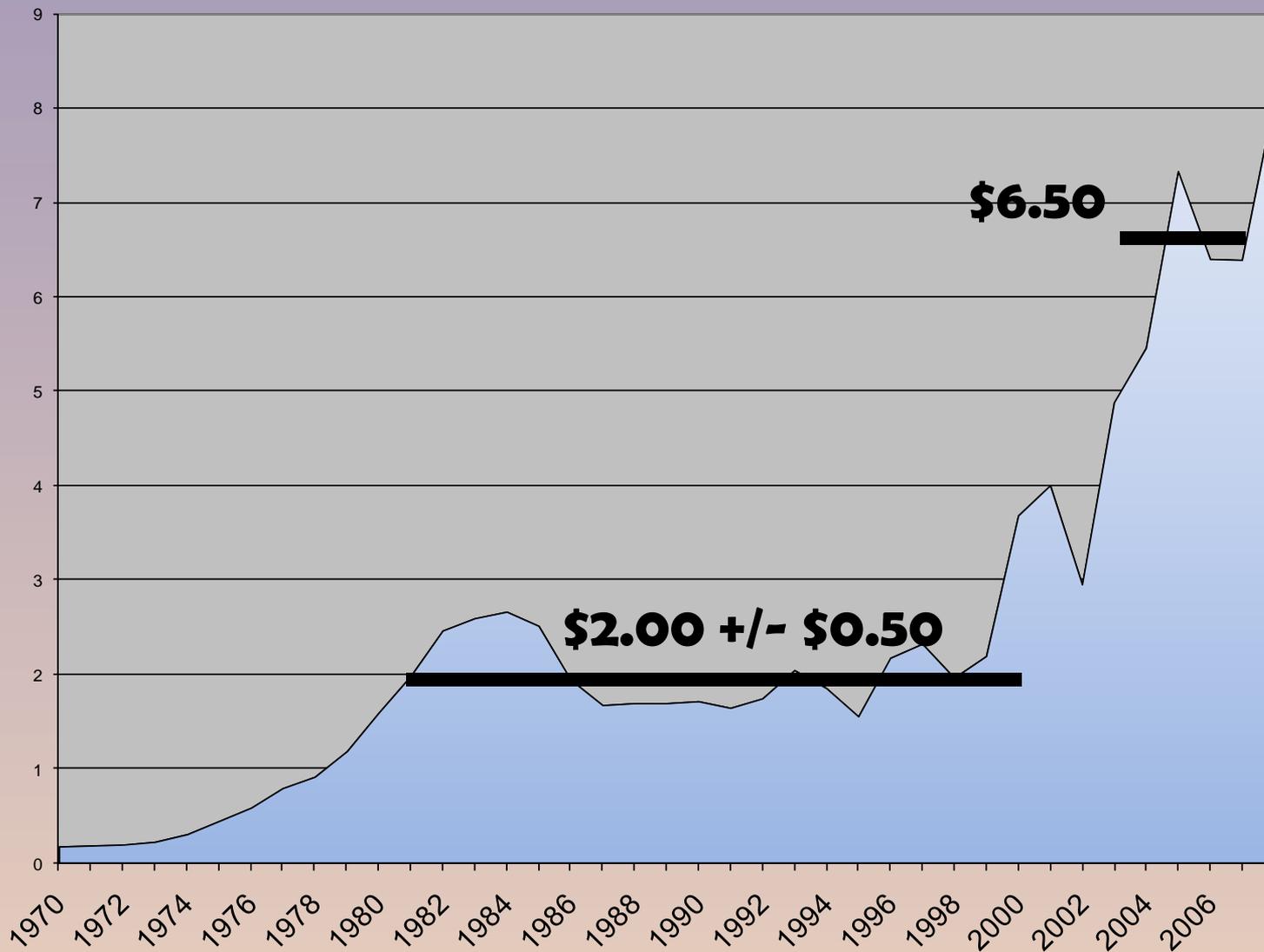
Natural Gas Electrical Generation vs Natural Gas Imports



U.S. Monthly Natural Gas Production

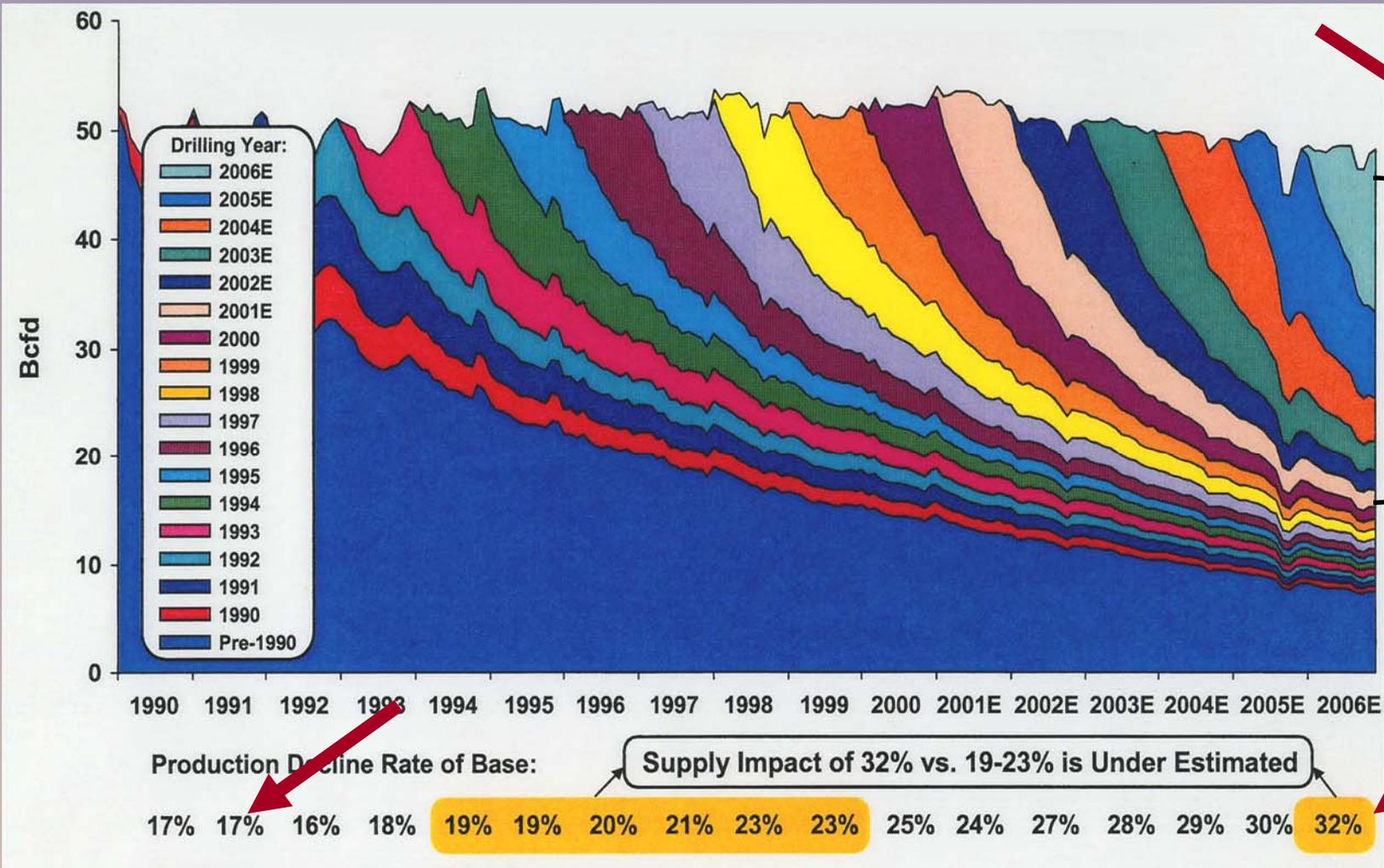


Natural Gas Prices



Natural Gas – America’s Silver Bullet?





(data copyright IHS Energy, Diagram prepared and copyright by EOG Resources Inc., 2006)



Natural Gas – America’s Silver Bullet?





Oil



Conservation



Natural Gas



Wind



Solar



Biomass



Geothermal



Efficiency



Coal



Hydro



Nuclear

Geothermal Energy

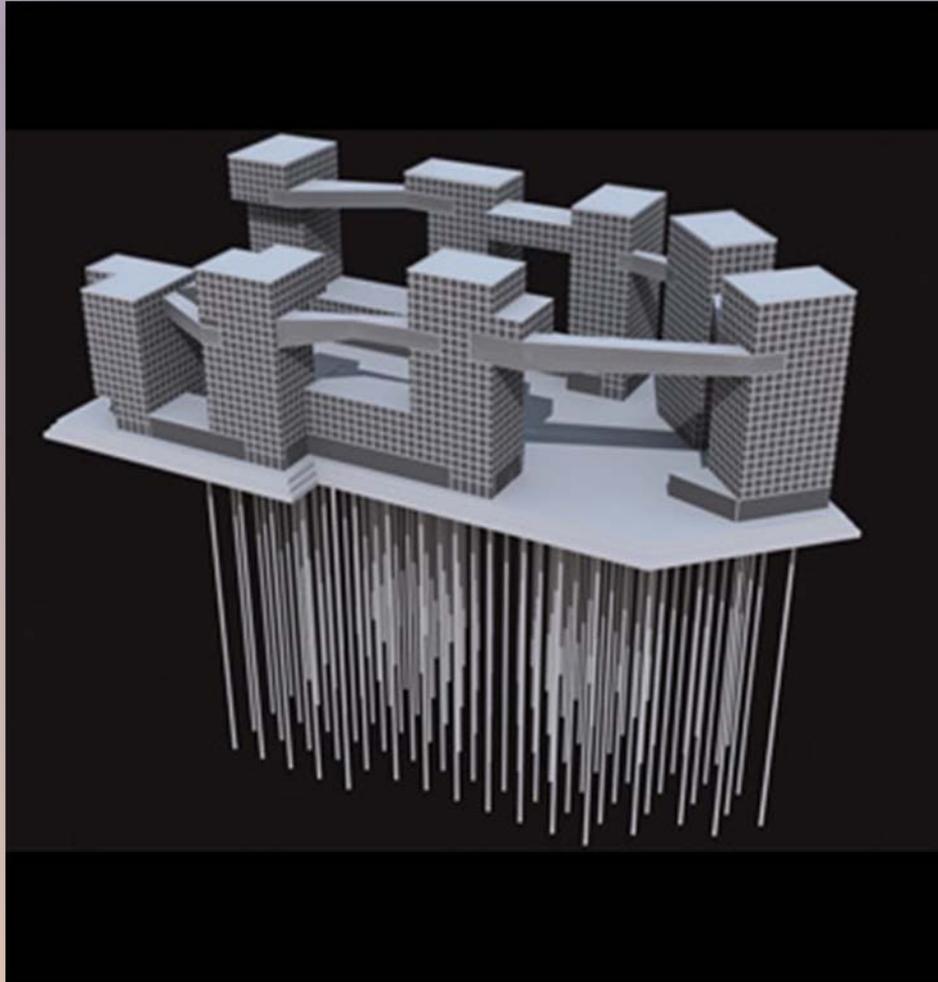
Direct Use

Electric Generation



Geoexchange Heat Pumps

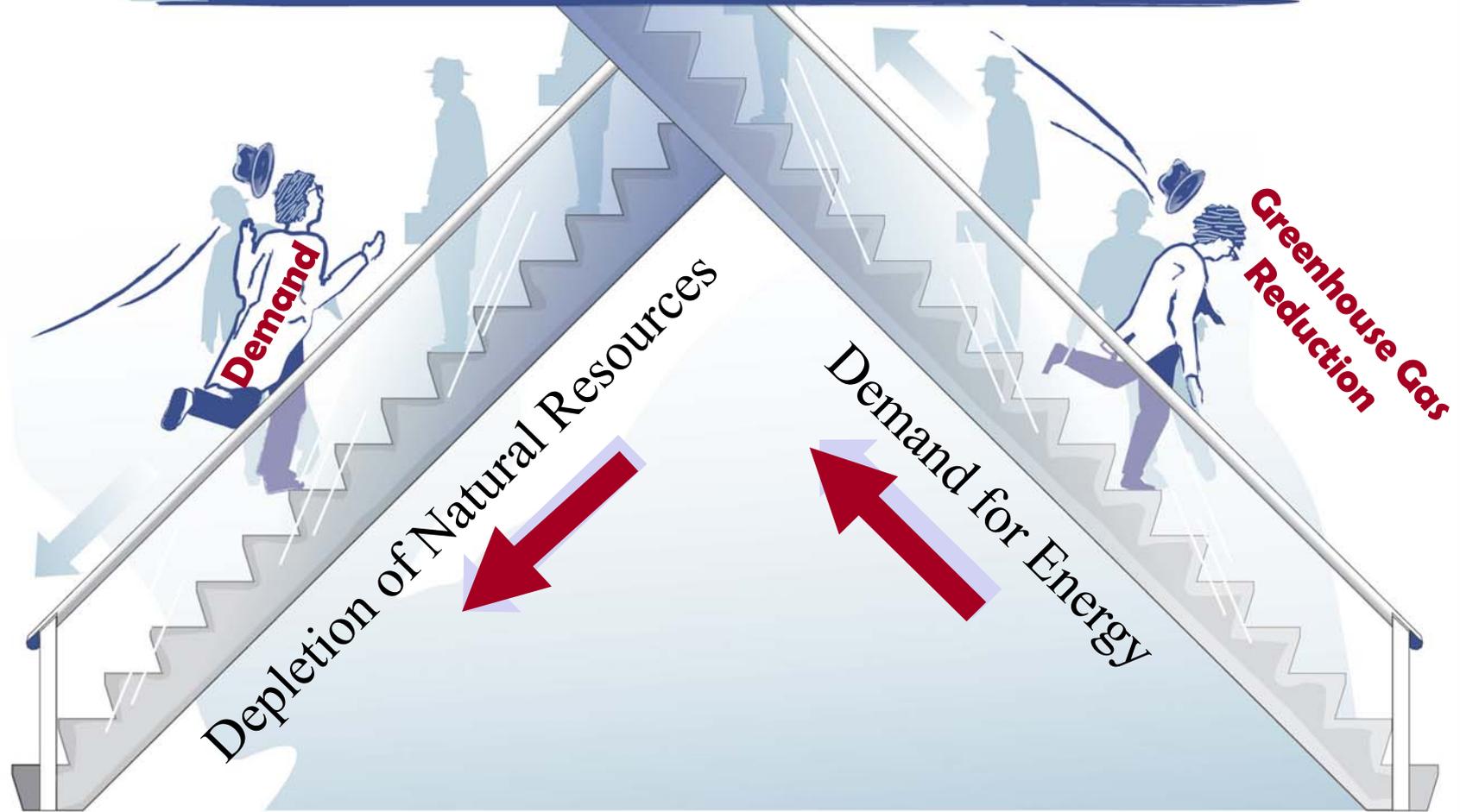
THE LARGEST GEOTHERMAL HOUSING COMPLEX



Below the 690 apartments—not to mention the gyms, bars, dry cleaners and movie theater—that make up the 15-acre Linked Hybrid residential complex in Beijing, China, are 660 geothermal wells that eliminate the need for air conditioners and boilers. Each well funnels water 325 feet beneath the ground into bedrock, where the constant 55°F temperature either heats or cools it before it's pumped back to the surface and piped through the building's concrete floors. The system will reduce energy costs by up to 30 percent in the summer and up to 40 percent in the winter.

The Escalator Dilemma

Natural Forces are Working Against Our Goals



The future is here!

Are we ready?

COLORADO GEOLOGICAL SURVEY



“The world is a football field now and you’ve got to be sharp to be on the team which plays on that field.

If you’re not good enough, you’re going to be sitting and watching the game. That’s all.”

--Rajesh Rao, founder and CEO of Dhurva Interactive

The End!

Of the talk, that is.

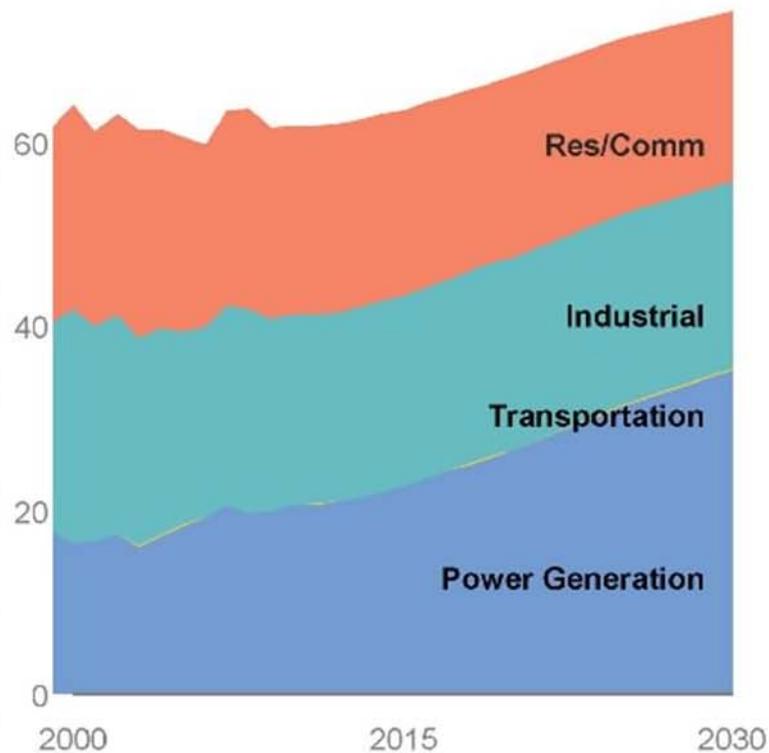
COLORADO GEOLOGICAL SURVEY



Gas Demand by Sector

BCFD

80

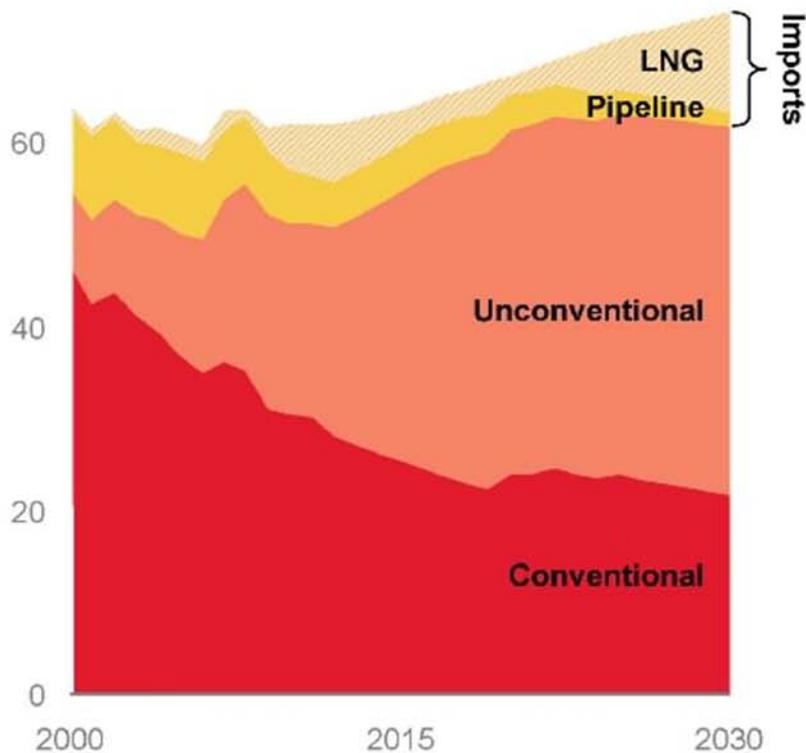


Gas Supply

BCFD

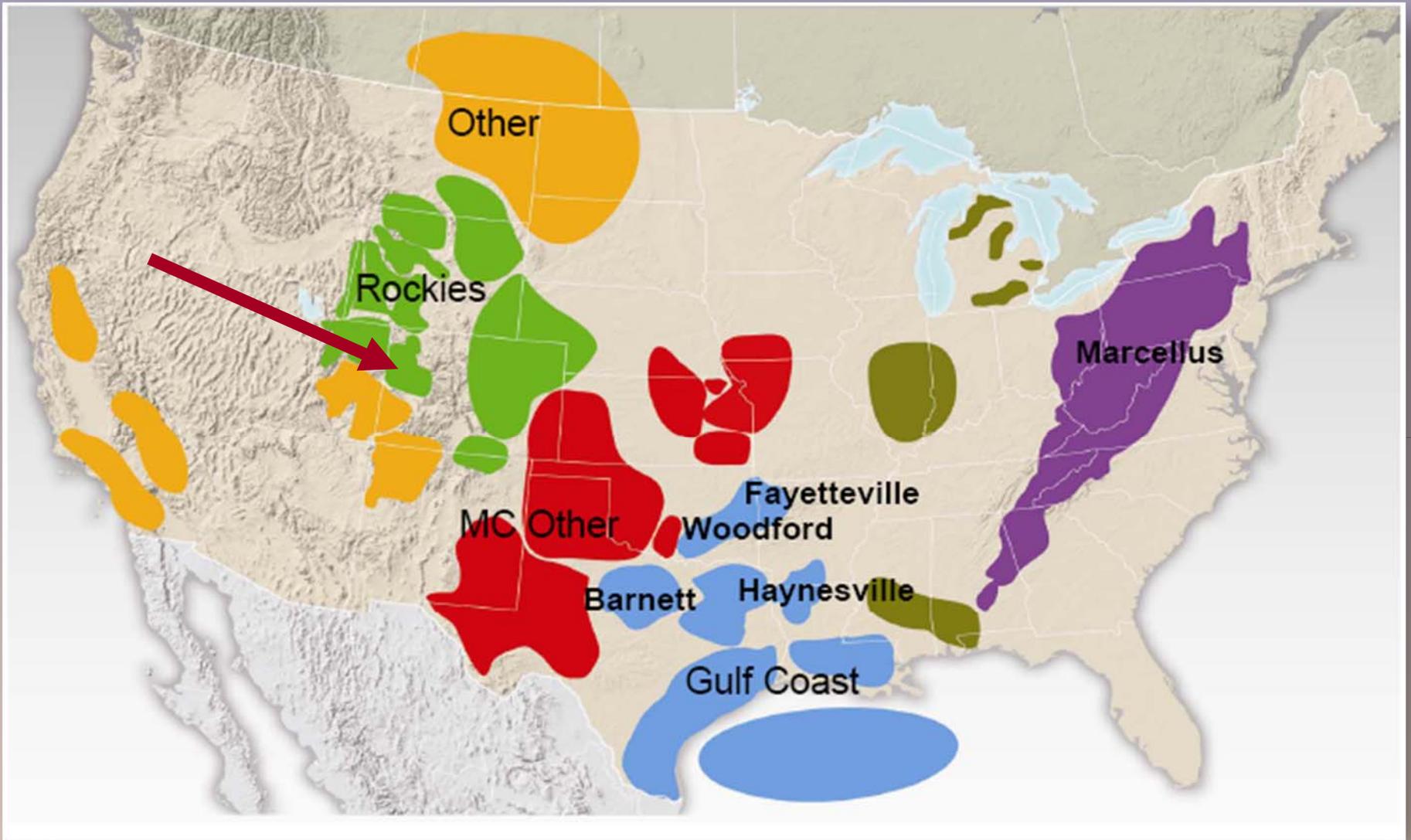
80

Growth 2005-2030
0.8% Per Annum



ExxonMobil

Figure 4. U.S. gas demand and supply (From ExxonMobil - Global Gas Perspective, Bank of America Conference, New York, November 18, 2009).



Colorado has all, or parts, of seven of the top 50 natural gas fields in the nation!

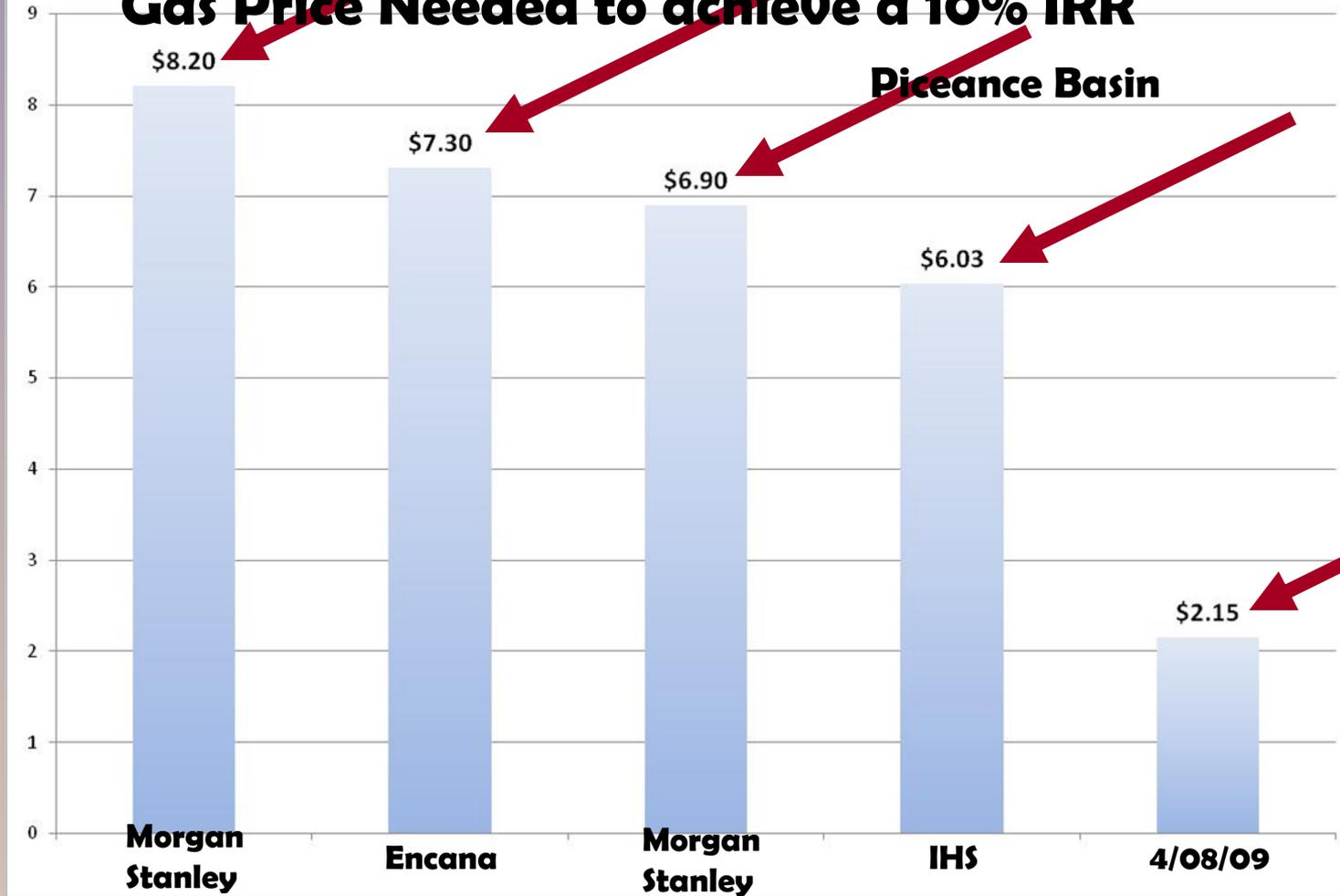


COLORADO GEOLOGICAL SURVEY



Gas Price Needed to achieve a 10% IRR

Piceance Basin



Hydro Generation - China

