China and India’s Ravenous Appetite for Natural Resources—Their Potential Impact on Colorado

Vince Matthews
Division Director
Colorado Geological Survey
Everything you need to know about Mineral and Energy in Colorado

Colorado Mineral and Energy Industry Activities, 2005

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Colorado Geological Survey • Department of Natural Resources • Denver, Colorado • 2005
Production of Natural Resources is an Important Part of Colorado’s Economy

Until a decade ago, the value of Colorado’s mineral and mineral fuel production was running around $2 billion per year.
Revenue comparison of Colorado’s Important Economic Sectors

- Minerals & Energy: $11.8 Billion
- Tourism: $8.2 Billion
- Agriculture: $6.4 Billion

2005
Distribution of Colorado Mineral & Energy Revenues 2005 ($ Billions)

- CO2: 0.200
- Uranium: 0.007
- Minerals: 1.5
- Coal: 0.8
- Oil: 1.2
- Natural Gas: 8.1
Production of Natural Resources has *Always* been an Important Part of Colorado’s Economy

1800s copper mine in western Colorado

1902 discovery well for Boulder Oil Field
Boulder 1902

Just off 51st Street
Population Comparison

- China
- India
- U.S.
China and India’s human resources are driving the explosive consumption of natural resources

“All the years of socialism and controls had taken us downhill to the point where we had only $1 billion in foreign currency. Today we have $118 billion. We went from quiet self confidence to outrageous ambition in a decade.”

--Tarun Das, Confederation of Indian Industry

“I’ve taken a lot of people to Dalian, and they are amazed at how fast the economy is growing in this high-tech area.

Americans don’t realize the challenge to the extent that they should.”

--Win Liu, Director of U.S./EU projects
Land Area Comparison

China

U.S.

India
GDP Comparison

- U.S.
- China
- India
GDP Growth Comparison

China

India

U.S.

COLORADO GEOLOGICAL SURVEY
China’s economy has grown much more rapidly than Japan’s did during a similar 25 year period of rapid economic growth.
China’s Share of World Mineral Production in 2003

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Percentage</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>Oil</td>
<td>4.7</td>
<td>6</td>
</tr>
<tr>
<td>Cement</td>
<td>42</td>
<td>1</td>
</tr>
<tr>
<td>Fluorspar</td>
<td>55</td>
<td>1</td>
</tr>
<tr>
<td>Rare earths</td>
<td>85</td>
<td>1</td>
</tr>
<tr>
<td>Aluminum</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Antimony</td>
<td>89</td>
<td>1</td>
</tr>
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<td>Copper</td>
<td>12</td>
<td>2</td>
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<td>4</td>
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<tr>
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</tr>
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<td>24</td>
<td>3</td>
</tr>
<tr>
<td>Silver</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Steel, crude</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Tin</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>Tungsten</td>
<td>83</td>
<td>1</td>
</tr>
<tr>
<td>Zinc</td>
<td>22</td>
<td>1</td>
</tr>
</tbody>
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China ranks in the top three of the world’s producers of 15 strategic raw materials. Yet, that is not enough to supply their needs. For instance, they are the #2 copper producer in the world, but they still need to import 43% to fill their consumptive demand.

Source: USGS, Kenzie, et al
China’s Production and Consumption of Copper

Internal supply met demand until the end of the 20th century.

Today, demand outstrips supply.

43% Imported!

Source: USGS, Kenzie, et al
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<td>1</td>
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China is the world’s #1 producer of iron ore.

Again, internal supply met demand until the end of the 20th century.

Source: USGS, Kenzie, et al
Today, China has also become the #1 importer of iron ore in the world.
China’s growth in iron ore consumption in 2005 equaled ½ of the total U.S. production.
Trends in Demand for Steel

Demand for iron ore is driven by the demand for steel.

Source: International Iron and Steel Institute.
World Energy Consumption

BP Statistical Review of World Energy 2006

COLORADO GEOLOGICAL SURVEY
World Energy Consumption

Oil

Source: BP Statistical Review of World Energy 2006
OIL CONSUMPTION - China

Source: BP Statistical Review of World Energy 2006
China’s internal oil production was sufficient to supply her needs until the mid 90s.

Source: Wood McKenzie
OIL- CONSUMPTION India

69% Imported!

Source: BP Statistical Review of World Energy 2006
OIL - U.S. Production


Prudhoe Bay helped lessen the decline.

Today we are producing 1.5 billion barrels per year less than in 1970.

Today, 67% imported!

Source: BP
For 20+ years world consumption stayed within an 8-10 million barrel per day range. In 1995 the world’s demand broke out of that narrow band. In the last two years, world demand increased 4.5 million barrels of oil per day.
World oil demand has broken into new territory...

![Graph showing world oil supply and change from 2002 to 2004 million b/d. The graph indicates that Non-OPEC supply has increased significantly, while OPEC supply has remained relatively stable. The change from 2002 to 2004 million b/d is highlighted, showing a notable increase in demand.]
...this has been an enormous challenge...

Simply to cope with the same amount of growth that we have seen between 2002 and 2004 would require the addition of another Iran (plus a bit) or two Venezuelas.
The majors’ recent exploration results have been poor...

![Graph showing exploration results from 1998 to 2004 with categories: WM - Resource, WM - Commercial, SEC Additions, and Production. The graph indicates a decrease in resources and commercial findings over the years.]
In 1956, M. King Hubbert predicted that Lower-48 production would begin declining in 1969. Peak U.S. oil production dropped precipitously when they stopped exploring and developing. Russia’s decline must be actively drilling and developing our reserves in order to prevent a more precipitous decline. The giant Prudhoe Bay discovery was important to slow our decline.
In 1969, M. King Hubbert Predicted that World Production would Begin Declining in 2000.
OIL Price

$70.85
Late-August

$75.12
This Spring

Source: BP Statistical Review of World Energy 2006

COLORADO GEOLOGICAL SURVEY
Wattenberg oil well near Longmont

Wattenberg is the 26th largest oil field in the United States including Alaska and the Gulf of Mexico.
Colorado Impact

Oil prices increased 186% since 2002

Colorado’s production decline reversed in the last 5 years

Wattenburg is the largest oil field west of the Mississippi (outside of CA and TX).

Rangely still has large reserves (57R/65P).

Commerce City refinery will be processing Canadian oil sands.
Oil shale is being seriously re-appraised.

The Mahogany Zone in the Roan Cliffs above Rifle, CO.
Major World Oil Shale Resources

(15 Gallons Per Ton)

<table>
<thead>
<tr>
<th>Country</th>
<th>Billion Barrels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Israel</td>
<td>5</td>
</tr>
<tr>
<td>Estonia</td>
<td>18</td>
</tr>
<tr>
<td>China</td>
<td>25</td>
</tr>
<tr>
<td>Australia</td>
<td>35</td>
</tr>
<tr>
<td>Morocco</td>
<td>58</td>
</tr>
<tr>
<td>Jordan</td>
<td>69</td>
</tr>
<tr>
<td>Brazil</td>
<td>90</td>
</tr>
<tr>
<td>United States</td>
<td>1200</td>
</tr>
<tr>
<td>Total World</td>
<td>1662</td>
</tr>
</tbody>
</table>

COLORADO GEOLOGICAL SURVEY
Colorado has the richest, thickest oil shale resources in the world.
World Energy Consumption

Natural Gas

Source: BP Statistical Review of World Energy 2006
NATURAL GAS CONSUMPTION - China

Source: BP Statistical Review of World Energy 2006
NATURAL GAS CONSUMPTION - India

Source: BP Statistical Review of World Energy 2006
Natural gas consumption increased strongly from 1986 until ‘96 as gas fired electrical generating plants were built. Consumption leveled off in the last decade which is a good thing because . . .

Today we are only capable of producing 82% of that peak.
NATURAL GAS - U.S.

... imports were necessary to fill the increasing demand.

NATURAL GAS: STRUGGLING TO KEEP PACE

U.S. natural-gas reserves are going nowhere fast. As production lags, gas consumption, fueled by gas-fired power plants and a hot economy, is climbing fast. Imports are struggling to fill the gap.

<table>
<thead>
<tr>
<th>Proved Reserves</th>
<th>Production vs. Consumption</th>
<th>Net Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>In trillions of cubic feet</td>
<td>In trillions of cubic feet</td>
<td>In trillions of cubic feet</td>
</tr>
<tr>
<td>200</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>150</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Energy Information Administration

*Preliminary
The price reached $15.50 in December, but dropped back because of mild weather in the northeastern U.S.
All of the U.S. gas producing basins in the U.S. (below the dashed line) are in decline except for the Rockies (CO, WY, NM, UT). If gas production in the U.S. is to just remain flat for the next eight years, then the Rockies must fill the gap for the other declining basins.
Colorado has all, or parts, of seven of the top 50 natural gas fields in the nation!

Four of the top 50 gas fields in the United States are located along I-70 below the Roan Cliffs.
Location of the 60,000+ wells drilled for oil & gas in Colorado.
Colorado Drilling Permits

93% Increase!
Colorado Impact

Natural gas prices increased 186% since 2002

Colorado has the sixth largest gas producer in the nation.

Colorado has the fifth largest gas reserves in the nation.

Colorado has the largest reserves of coalbed methane in the nation.
COAL - China

BP Statistical Review of World Energy 2006
China’s Production and Consumption of Coal

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal Production (Million metric tons)</th>
<th>Coal Consumption (Million metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1,300</td>
<td>1,500</td>
</tr>
<tr>
<td>1991</td>
<td>1,500</td>
<td>1,700</td>
</tr>
<tr>
<td>1992</td>
<td>1,700</td>
<td>1,900</td>
</tr>
<tr>
<td>1993</td>
<td>1,900</td>
<td>2,100</td>
</tr>
<tr>
<td>1994</td>
<td>2,100</td>
<td>2,300</td>
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<tr>
<td>1995</td>
<td>2,300</td>
<td>2,500</td>
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<td>3,900</td>
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<tr>
<td>2003</td>
<td>3,900</td>
<td>4,100</td>
</tr>
<tr>
<td>2004</td>
<td>4,100</td>
<td>4,300</td>
</tr>
<tr>
<td>2005</td>
<td>4,300</td>
<td>4,500</td>
</tr>
</tbody>
</table>

Colorado Geological Survey
COAL - India

7% imported!

BP Statistical Review of World Energy 2006
COAL U.S.

BP Statistical Review of World Energy 2006

COLORADO GEOLOGICAL SURVEY
China/U.S. Coal

54% of world production.

51% of world consumption.
Colorado’s Coal is becoming increasingly desirable.
Increase in Coal Spot Price

- 2004: $17 per ton
- 2005: $37 per ton

Comparison between 2004 and 2005 coal spot prices.
Because most of Colorado’s coal is sold on fixed-price, long-term contracts, the average price is below the spot price.
Spot prices increased 76% since 2003.

Colorado is the sixth largest coal producer in the nation.

Colorado has the seventh largest bituminous coal reserves in the nation.

Colorado has the largest reserves of compliance coal in the nation.
World Energy Consumption

- Nuclear

Source: BP Statistical Review of World Energy 2006
NUCLEAR - China

BP Statistical Review of World Energy 2006

COLORADO GEOLOGICAL SURVEY
NUCLEAR- India

BP Statistical Review of World Energy 2006
China: 27 new plants by 2020

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.

Last nuclear power plant came online.

BP Statistical Review of World Energy 2006
And, the largest nuclear power generator in the world?
The United States generates as much nuclear energy as France, Germany, Spain, Sweden, and the United Kingdom combined.
The world’s existing 435 nuclear reactors currently need 180 million pounds of uranium each year.
Uranium prices more than quadrupled since 2003
Colorado Impact

Four new mines opened in Colorado in 2004

State Land Board leases in the Maybell district

Western Colorado was in the heart of the uranium booms.

Possible In-Situ in Weld County

Nearly 3,000 new mining claims filed in Colorado in 2005, most for uranium.
U.S. molybdenum exports to China and India

<table>
<thead>
<tr>
<th>Year</th>
<th>China (Kg)</th>
<th>India (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>36,000</td>
<td>800</td>
</tr>
<tr>
<td>2005</td>
<td>94,486</td>
<td>34,400</td>
</tr>
</tbody>
</table>

1,160,000 Kg to China in 2004.
MOLYBDENUM Price

~ $2.00/lb in 2002

$40/lb in July, 2005!

COLORADO GEOLOGICAL SURVEY
As a result of increased demand for molybdenum, the Henderson Mine added an extra shift and is now producing around the clock, the Climax Mine is scheduled for reopening in 2009, and the Mount Emmons deposit near Crested Butte is being evaluated for opening.
Precious Metal Percentage Price Increases

Gold 140%

Silver 207%

Platinum 250%
Base Metal Percentage Price Increases

<table>
<thead>
<tr>
<th>Metal</th>
<th>Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>408%</td>
</tr>
<tr>
<td>Copper</td>
<td>390%</td>
</tr>
<tr>
<td>Zinc</td>
<td>385%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>142%</td>
</tr>
<tr>
<td>Lead</td>
<td>222%</td>
</tr>
</tbody>
</table>
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